International Journal of Advanced Engineering Research and Science

(IJAERS)
An Open Access Peer-Reviewed International Journal

IJAERS

International Journal of Advanced Engineering Research and Science

Editor in Chief

Dr. Swapnesh Taterh

Chief Executive Editor

S. Suman Rajest

International Editorial/ Reviewer Board

Detail with DOI (CrossRef)
Transparency as a Tool in Building Efficient Public Institutions: A Bibliometric Study   *Josué de Lima Carvalho, Tânia Suely Azevedo Brasileiro*   *DOI:* *10.22161/ijaers.94.1*   *Page No: 001-007*
Modeling the hydrodynamic behavior of facultative pond using computational fluidodynamic tool   *Leandro Conti Garcia, Flávia Aparecida Reitz Cardoso, Flávia Vieira da Silva Medeiros, Thiago Morais de Castro, Eudes José Arantes*   *DOI:* *10.22161/ijaers.94.2*   *Page No: 008-016*
A 1-year follow-up case report of a biomimetic no post/no crown fiber-reinforced restoration of a structurally compromised tooth   *José Antonio Castro Klenner, Priscilla Cardoso Lazari-Carvalho, Tomás Felipe Labarca Galecio, Marco Aurélio de Carvalho*   *DOI:* *10.22161/ijaers.94.3*   *Page No: 017-023*
Productivity Optimization by Optimal Allocation of Human Resources with Application in Real Case at the Wagons Maintenance of Iron Ore Rail Transport   *Clóvis Bôsco Mendonça Oliveira, Jonas Fontes de Carvalho, Antônio José Silva Oliveira*   *DOI:* *10.22161/ijaers.94.4*   *Page No: 024-045*
Implementation of Condition-Based Maintenance (CBM) in a central air conditioning unit by using microcontroller and open-source monitoring platforms   *Danilo Augusto Santana de Souza, Matheus Damaceno Artur, Diogo de Souza Rabelo, Fernando Nunes Belchior*   *DOI:* *10.22161/ijaers.94.5*   *Page No: 046-063*
Pleurotus ostreatus mushroom productivity in different substrates of agro-industrial residues generated in the southern region of Tocantins, Brazil   *Ana Luiza Santiago Pereira, Aloisio Freitas Chagas Junior, Marcos Giongo, Gessiel Newton Scheidt, Jader Nunes Cachoeira, Augustus Caeser Franke Portella*   *DOI:* *10.22161/ijaers.94.6*   *Page No: 064-068*
Establishing the initial benchmark for the sustainability of Arabica coffee-growing householders in a highland region, Brazil   *David Brunelli Viçosi, Cecília Uliana Zandonadi, Victor dos Santos Rossi, Wesley Zambom da Silva, Fabiano Tristão Alixandre, Cesar Abel Krohling, Cleber Cássio Ferreira, Evaldo de Paula, Marx Bussular Martinuzzo, Douglas Gonzaga de Souza, Maurício Lorenção Fornazier, Lúcio Herzog De Muner, Ricardo Dias Alixandre, Higor Alixandre Macette, David dos Santos Martins, Luiz Fernando Favarato, Maurício José Fornazier, Rogério Carvalho Guarçoni*   *DOI:* *10.22161/ijaers.94.7*   *Page No: 069-082*

Transparency as a Tool in Building Efficient Public Institutions: A Bibliometric Study

Josué de Lima Carvalho[1], Tânia Suely Azevedo Brasileiro[2]

[1]Mestrando do Programa de Pós-graduação em Sociedade, Ambiente e Qualidade de Vida - PPGSAQ, Centro de Formação Interdisciplinar/UFOPA, Santarém/Pa, Brasil.

Email: josuecarvalho911@gmail.com

[2]Docente na graduação e pós-graduação (PPGSAQ, EDUCANORTE e SND), UFOPA, Santarém/PA, Brasil.

Email : brasileirotania@gmail.com

Abstract— *We aim to identify aspects of public transparency in the literature and its influence on the efficiency of public management. For this purpose, a bibliometric study of works published in scientific journals available in the Scopus database was carried out. Initially, 74 academic works were identified using the keywords "transparency", "public governance" and "efficient institutions" after this first filtering, it was restricted only to scientific articles aligned with the theme, generating the final base of 27 articles that were analyzed. quantitatively and qualitatively using the frequency count of the data, finally a word cloud and similarity analysis was carried out with the support of the Iramuteq textual analysis software. Among the main contributions of this article, the understanding of how the works of different origins, years and authors came together in an academic collection that allows us to understand how the authors see public governance and transparency in the construction of efficient institutions.*

I.   INTRODUCTION

Public management has improved a lot in recent decades, external and internal users (stakeholders) are increasingly informed and participating in the decisions and accountability process in the Public Administration, in all governmental spheres, whether in municipalities, in the federative units or in the union. In view of the assumption, Rodrigues and Cougo (2016) state that the application of public resources in Public Administration is closely linked to the questioning arising from the efficient execution and transparency of Accountability, in the financial disbursement in public works.

Transparency is closely linked to efficiency and effectiveness regarding public finances, given that they reflect what happens within public management, public finances are mirrors of political and administrative decisions. According to the National Treasury Manual (2012), cost information in the public sector, by materializing the Accountability process, improves transparency, as it allows society as a whole to understand more clearly the use of public resources. Given this context, the New Public Management (NPM) guides changes in public management in order to increase efficiency and effectiveness and spend greater efforts in the decision-making process based on innovations in accounting and Accountability management systems (PARKER AND GOULD, 1999: PÉREZ-LÓPEZ, PRIOR AND ZAFRA-GOMES, 2015). Accountability inserted in public management encourages good practices in the rendering of

accounts to society, seeking efficiency and effectiveness, making managers responsible for their actions as public servants, conditioning them to evidence the accounts referring to the cycle of their management through the portals electronic devices, as provided for in the law on access to information. Heyer (2011) expresses in his work that the tendencies of the new public management (NPM) behave as a strategy for the democratic political reform, in the countries in transition of development. For the author, the philosophy of NPM moves towards a governance approach that emphasizes transparency, performance management and accountability of public sector employees and managers. Peters (2013) attributes that the fundamental meaning of governance is to direct the economy and society towards collective goals. The governance process involves finding ways to identify goals and then identifying ways to achieve those goals.

Based on the above-grounded construction, it is intended to relate the concepts of public governance and transparency with the objective of sustainable development number 16 - SDG 16 (UNITED NATIONS ORGANIZATIONS, 2015) which aims to build efficient institutions in the fight against corruption , transparency, and efficiency in public spending. This research is justified by the need to adapt and expand sustainable practices considered important in all spheres of public organizations, incorporating sustainability into their management models in order to promote changes in organizational culture related to transparency and efficiency. Therefore, the objective of this work is to verify the role of transparency and efficiency in public management and the relationships with the construction of efficient institutions in the perspective of works published in periodicals in the Scopus database. Having as a problem question: What is the perspective on transparency and efficiency related to public management in the construction of efficient institutions in journal publications in the Scopus database?

II.   MATERIALS AND METHODS

The research carried out is characterized as bibliometric, as it is a systematic review of the literature, which was carried out from a survey of material already prepared, consisting of scientific articles published in the Scopus database. Severino (2014, p.122) states that "bibliometric research is similar to bibliographic research, and bibliographic research is one that can be carried out based on transcripts available in previous works, from documents that are printed, such as books, articles, theses, among others. And bibliometric research is related to the same characteristics, with the differential of the systematic application of data and the approach that is mainly related

to quantitative data.

Within the bibliometric construction of this work, it was idealized to relate the perspectives between public governance, transparency in accordance with the objective of sustainable development 16 - SDG 16 (UNITED NATIONS ORGANIZATIONS, 2015). After evaluating the theme and carrying out a previous research, three main keywords were identified that were used in the construction of the base of the bibliometric study. These are: Transparency, Public Governance and Efficient Institutions.

According to the aforementioned facts, the database chosen for the research was the Scopus database, using the Capes Periodicals platform with login and password linked to the graduate program. From the first search, 74 articles were identified that corresponded to the keywords used, clarifying that the terms within the keywords that were composed of more than one word were unified in the search through the use of quotation marks. When evaluating these 74 articles, it was noticed that there were several data sources that were not intended to be evaluated, according to the objective outlined for this work, such as books, conference papers, book chapters, among others. Therefore, the limitation was carried out from only articles published in journals, from this cut, the base was limited to 41 articles, after this cut, another cut was made, excluding the year 2021, the justification for this last cut is found in the fact that the year is still in progress, so it is not possible to map the publications carried out with accuracy.

With the result of the last cut, the result of 40 articles was reached, which were extracted from the base, read and analyzed, after reading the abstracts and some total texts of the articles, the number of 27 articles was reached, excluding thirteen for do not fit the research topic. Continuing, the analyzes were initiated according to quantitative data, such as total citations, countries that are most publicized on the subject, main authors and main affiliations of the authors. After analyzing the quantitative data, a qualitative analysis was carried out, relating the approaches adopted by the authors, the main results, contributions, among other characteristics. It is reiterated that the temporal cut was only carried out in the exclusion of the year 2021.

Within the proposal of qualitative analysis, the Content Analysis proposed by Bardin (2016) was used, where the data was characterized according to the objective, analyzing commonalities among the authors, the Iramuteq software was also used as a support tool, which is an analysis software textual. Textual analysis is a specific type of data analysis, in which we deal with transcribed material, that is, texts (NASCIMENTO-SCHULZE AND CAMARGO, 2000). In order to carry out the textual

analysis, the abstract content of the 30 articles was extracted, transforming them into a textual corpus. For Camargo and Justo (2013, p.2), The corpus is constructed by the researcher. It is the text set to be analyzed. In a probable example within a documentary research, if a researcher decides to analyze the 3 articles that appeared in the health section of a newspaper, in a certain period of time, the corpus would be the set of these articles. Therefore, the corpus analyzed in Iramuteq is composed of 27 abstracts, of the 27 articles based on this research.

Therefore, the textual corpus is the junction of the 27 abstracts of the researched articles, which through Iramuteq were analyzed in two different types of analysis, the Word Cloud Analysis and the Similitude Analysis. The following paragraphs describe in greater detail the specificities of the models proposed above. The word cloud method represents for Camargo and Justo (2013) a way of grouping words, organizing them graphically according to their frequency. In the authors' view, it represents a simpler, but graphically interesting, lexical analysis.

Therefore, in order to relate the terms more frequently in the abstracts and the different approaches of the authors, the Word Cloud was the first method of analysis. After this method, an analysis of Similitude was carried out, which will be conceptualized in the next topic of this work.

After the Word Cloud, the abstracts of the articles were analyzed in the "similarity" mode of the Iramuteq textual statistical analysis software that is linked to the R statistical software, the "similarity" analysis allows the researcher to understand how the words of a given textual set relate to groups and divisions of groups. In the words of Melo (2017), the analysis of similitude allows to show in a graph the words that present a link in the textual body, from this analysis it is possible to infer the structure of construction of the text and themes of relative importance.

This type of analysis is based on the graph theory proposed by Marchand and Ratinaud (2012), and is frequently used by researchers of social representations (social cognition). It makes it possible to identify the competitions between the words and its result brings indications of the connectedness between the words, helping to identify the structure of the representation.

III.   3. RESULTS

In the construction of the results of this research, it is firstly worth highlighting the bibliometric data of a quantitative nature that were obtained through the research described in the methodology, a posteriori the qualitative

data will be presented and discussed according to the main results.

The first step of the analysis was to characterize the main data of the research, regarding the authors, title of the works, main results, year of publication and amount of citation, the complete table with the data can be found in complementary documents. In view of the discussions developed by the authors, it is clear that works such as Hoekman (1998) who evaluated how the voluntary rules of the World Trade Organization on government procurement are a useful mechanism to ensure that public procurement procedures are efficient, and Townsend and Eyles (2004) who studied the importance of purchasing inputs to guarantee the supply of potable water. followed a line of reasoning linked to efficiency in public spending and the relationship of these expenditures with transparency, Shirley (1994) assesses the importance of joint work between the public and private spheres in government procurement practices, related the importance of actions that integrate the public and private initiative, Aigul (2013), Alam and Teicher (2012) and Silva (2016) evaluated dictatorial regimes and how their performance may be linked to the lack of transparency and the inability to fight corruption.

Aigul (2013) assesses the scenario in Kazakhstan in the face of a new scenario of building corporate governance with principles linked to sustainable development, access to justice and the responsive role of public institutions, clearly guidelines linked to SDG 16, Silva (2016) assesses the historical restructuring of the democratic regime in Chile, the work is based on Goal 16.5 and Goal 16.6 SDGs, which refer to the reduction of corruption from bribery and the development of responsive and transparent institutions. Alam and Teicher (2012) Analyze the complicated state of governance in Bangladesh and how military dictatorships affected state institutions, developing a symbiotic relationship with the state.

Among the surveyed works, works such as Paul (2007), Dikopoulou and Mihiotis (2012), Mohammed and Ibrahim (2015) and Capezi and Lorenzi (2020) were also identified, which relate the use of information and communication technologies (ICT's) in promotion of public governance through E-government, and how these tools can be used in knowledge management, social control and accountability of financial and budgetary information of public management. The works raise common objectives related to Target 16.10, which seeks to ensure public access to information and the protection of fundamental freedoms, the strengthening of national institutions (Target 16.a) and the guarantee of responsive decision-making (Target 16.7).

Carlos (2006) Discusses the role of parliaments in

contributing efficiently to budget processes while preserving fiscal discipline. Vivanco (2013) discusses that anti-corruption agencies are born as essential instruments in the transparency and integrity strategy carried out by several Latin American countries within the scope of their public policies. Vacca (2014) analyzes the functions of the European Court of Auditors and an internal Court of Auditors, the Italian one, to underline the importance of performance auditing in the fight against corruption and mismanagement in public administration.

From the graphic information obtained, it can be seen that the period from 1994 to 2002 represents a period with few publications and with a longer period of time in which nothing was published. From 2003 onwards, the publications were more constant, with only the year 2008 represented because there was no publication. In turn, 2013 was the year with the most publications (3 articles), followed by the other years that are in the graph by two or one publication.

The only institution that had more than one author linked was the Universiteit van Amsterdam, the other authors had different affiliations. In a close relationship, the nationality of the authors' institutions is presented below.

Most institutions are nationalized in the United States, followed by a tie, between Germanic, Dutch and UK-born authors. Authors from Canada, Italy and Spain ranked third in a tie with two authors from each country, and finally the other authors did not obtain similarity between nationality. From this data, it can be seen that most of the works on the subject within the Scopus database follow an empirically understood trend, that is, they come from American or European origin. The last analysis on these quantitative aspects graphically provides evidence on which areas of knowledge the articles based on this analysis were published.

Through the analysis of the areas of publication, the social sciences are configured as the area that obtained the highest frequency among the areas, which demonstrates the interdisciplinary role of the theme addressed, reiterating the chosen theme and in the search for an answer to the objective in which it was intended. recognizing the main areas and their relationships, it is clear that the second highest frequency is in the area of economics, followed by administration/business and environmental science. In this way, it is understood that this bibliometrics fits the proposal objectified and contextualized by the title, other areas also obtained a certain important participation, such as computer science and engineering, especially in articles that dealt with E-government.

After this quantitative analysis, the 27 abstracts were extracted from the articles so that the data could be

rotated with the help of the Iramuteq software, as proposed in the methodology. The following topic exposes the results.

As outlined as a methodological tool, the Iramuteq software was used, which is linked to the R statistical platform to create a wordcloud, this cloud presents below the most frequent terms within the abstracts of the 27 articles removed and previously analyzed from the database. Scopus. The following figure presents the main results.

Fig.1 – Word cloud.

Source: by the author/ Iramuteq (2021).

The word cloud adds value to bibliometrics, as it exposes the most frequent terms in the abstracts of the articles studied, and through this summary in graphic form, it presents us as the most frequent term the term "public", followed by "transparency", "institution", "efficient", "governance" and "effective", these terms are directly related to the keywords traced within the bibliometric research. The term "management" can be understood as related to governance, terms such as "budget" and "financial" if demonstrated at a relevant frequency, which reiterates the role of governance and management in building effective institutions and fighting corruption, according to the subtopics of sustainable development objective number 16 - SDG 16 (UNITED NATIONS, 2015). are related, such as parliament, governmental responsibility, reform, economy and control. Within this context, the relationship between the authors' results and the promotion of the rule of law can be seen, nationally and internationally, and guarantee equal access to justice for all; also in substantially reducing corruption and bribery in all its forms; in the Development of effective, accountable and transparent institutions at all levels; and in responsive, inclusive, participatory and representative decision making

at all levels. Next, the data are analyzed in the form of similarity according to the methodology.

Continuing with the analysis, the abstracts of the 27 articles were exposed to similarity analysis, which is based on graph theory (MARCHAND; RATINAUD, 2012). As already defined in the methodology, this type of analysis makes it possible to understand the co-occurrences between the terms, which means that the words are listed in a matrix that produces an algorithm that reveals the relationship between the words through lines, and the thicker the line, the stronger the relationship between the words. The following figure demonstrates the result.
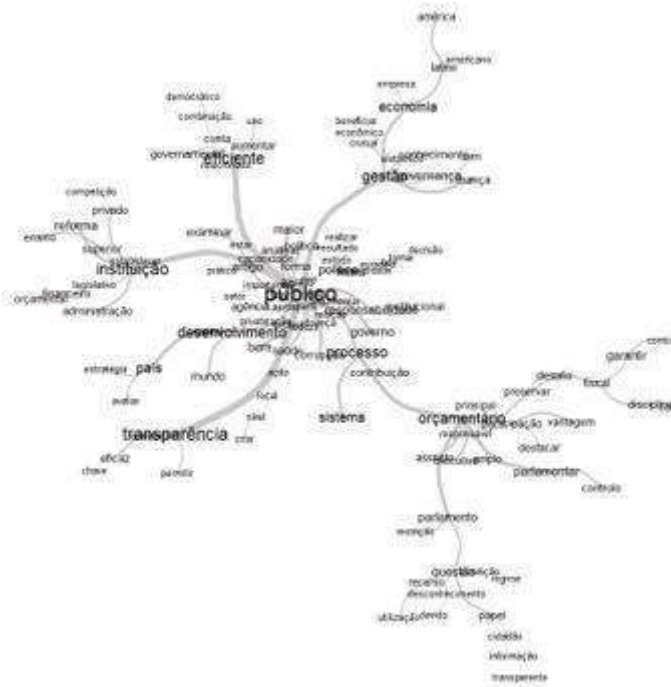
Fig.2 - Similitude Analysis.

Source: by the author/ Iramuteq (2021).

The similarity analysis allowed us to understand the term "public" as a central term obtained from the analysis of the 27 abstracts of the 27 articles, linked directly to the main term, there are 5 key terms, namely: "transparency", "institution", "efficient", "management" and "budgetary". The line connecting the key terms to the central term is the thickest of all, with the exception of the term "budgetary" which is linked to the central term by a line of median thickness. the terms linked to the keywords used to carry out the research, therefore, in the authors' view, the public figure (government) needs to be linked to transparency, efficiency and good management (governance). account of the thinnest line that generates this link. Management is linked to governance, finance, benefit, economics, among others such as technology and knowledge, this relationship can be explained by the

authors' main results table, where whenever they addressed governance , related it directly to the benefit, the management of financial resources, the management of knowledge and other adjectives that link the term to good management.

The term efficient, in turn, relates to governmental, increase, democratic, among others, and is also related to the term use, that is, the use of efficiency within the governmental environment. Transparency is related to the terms "key", "effective" and "allow", this relationship allows us to understand how transparency is a key term of effectiveness in public management, and how its permissibility is fundamental for the implementation of effective institutions. . Budget, in turn, is linked to several terms, among them: Control, challenge and parliament, thus demonstrating the subjects of action and how control should be implemented within the budgetary context.

In a final discussion about the research data, it can be seen how the 27 articles used as a basis for this analysis promoted a conversation among themselves, and how it was possible to identify that Governance, Transparency and Efficient Institutions are terms that promote a discussion on the role of public management in building sustainability. Hoekman (1998) deals in his construction with how governments, how public management can promote change in government purchases in promoting sustainability. Silva (2016) builds a dialogue using Chile as a locus on the government's role in fighting corruption, Jacobs and Ploeg (2006) propose a fairer and more transparent way of managing European public higher education institutions. And although it seems that the three articles have different approaches, their purpose is very similar in order to promote transparency, social inclusion, and efficiency in public spending as a tool for building efficient and effective public institutions, which consequently promotes the sustainability in public management. Not only the highlighted authors, but from the union of the abstracts of the articles in the analysis of word cloud and analysis of similitude, that the findings are directly connected with each other, generating a central nucleus around the term public in its relationship with the key terms that allow us to reach the discussions already arranged. Finally, we conclude with the main research findings and contributions.

IV.   CONCLUSIONS

Rescuing the objective of identifying in the literature aspects of public transparency and its influence on the efficiency of public management. Through a structured process, 27 works were selected that are related to the theme: transparency as a tool in the construction of efficient public institutions.

From the 27 articles, a bibliometric analysis was carried out, identifying origin, authors, publications per year, among other information. The analysis of the abstracts of the works made it possible to identify similarities and distinctions, it was also possible to understand how the objectives outlined by the authors relate to SDG 16 and its goals.

The articles dealt with topics about equity, public health, social control, technology applied to decision-making, perception of corruption in countries and regimes, among other things. However, the works were mainly discussed when relating Public Management and Governance, Transparency and Effective Institutions.

Therefore, it was possible to understand that in the view of the base of articles used to build efficient, effective institutions that promote inclusion, the conscious expenditure of government resources, and efficiency in decision-making, the figure of transparency through governance is inseparable. The Word Cloud and Similitude analyzes corroborated this result, presenting a central concept based on the term public and key concepts that were directly related to the term, projecting a figure that represented an agreement among all 27 articles, from the most different authors. As for the origin and number of authors surveyed, some similarities were noticed, but mostly their disparities. For future publications, it is suggested to search different databases together with the Scopus base used in this article, so that you can have a broader understanding of the data.

Among the main contributions of this article is the understanding of how the works of different origins, years and authors came together in an academic collection that allows us to understand how the authors see public governance and transparency in the construction of efficient institutions.

REFERENCES

[1] ABU-RASHED, J.; BERTAUX, N.; OKUNOYE, A. Knowledge management and economic development in developing countries: an examination of the main enablers. **Global Business and Economics Review**, v7, n1, pp. 85-99, 2005.

[2] AIGUL, M. Control as a method for ensuring quality of public services in the Republic of Kazakhstan | [Kontrolė kaip viešųjų paslaugų kokybės kontrolės metodas Kazachstano Respublikoje]. **Public Policy and Administration**, v. 12, n. 2, pp. 212-225, 2013.

[3] ALAM, Q.; TEICHER, J. The state of governance in Bangladesh: The capture of state institutions. **South Asia: Journal of South Asia Studies**, v.35, n. 4, pp. 858-884, 2012.

[4] BALL, R.T.; HAIL, L.; VASVARI, F.P. Equity cross-listings in the U.S. and the price of debt. **Review of Accounting Studies**, 23(2), pp. 385-421, 2018

[5] BARDIN, L. **Análise de Conteúdo.** São Paulo: Edições 70, 2016.

[6] CAMARGO, B. V.; JUSTO, A. M. **Tutorial para uso do software de análise textual IRAMUTEQ**. 01. ed. rev. Florianópolis/SC: Laboratório de Psicologia Social da Comunicação e Cognição –LACCOS/UFSC, 2016. 18 p. v. 02. Disponível em: http://www.iramuteq.org/documentation/fichiers/tutoriel-en-portugais. Acesso em: 5 ago.2020.

[7] CAPECE, G.; LORENZI, F. Blockchain and healthcare: Opportunities and prospects for the ehr. **Sustainability (Switzerland)**,12(22),9693, pp. 1-17, 2020.

[8] CARLOS, S. For better or for worse? The role of parliament in the budgetary process ofdeveloping countries | [Pour le meilleur ou pour le pire? le rôle du parlement dans le processus budgétaire des pays en développement Études]. **Revue Francaise d'Administration Publique**, v.117, n.1, pp. 149-185, 2006.

[9] CROSS, et al. Government stewardship of the for-profit private health sector in Afghanistan. **Health Policy and Planning**, v. 32, n.3, pp. 338-348, 2017.

[10] DIKOPOULOU, A.; MIHIOTIS, A. The contribution of records management to goodgovernance. **TQM Journal**, v. 24, n.2, pp. 123-141, 2012.

[11] HEISENBERG, D. Cutting the bank down to size: Efficient and legitimate decision-makingin the European Central Bank after enlargement**. Journal of Common Market Studies**, v41, nº3, pp. 397-420, 2003.

[12] HEYER, G. NEW PUBLIC MANAGEMENT: A STRATEGY FORDEMOCRATIC POLICE REFORMIN TRANSITIONING AND DEVELOPING COUNTRIES. **Policing An International Journal of Police Strategies and Management** 34(3):419-433, 2011.

[13] HOEKMAN, B. Using international institutions to improve public procurement. **WorldBank Research Observer**, v 13, nº2, pp. 249-269, 1998.

[14] JACOBS, B., VAN DER PLOEG, F. Guide to reform of higher education: **A European perspective. Economic Policy**, v.21, n.47, pp. 535-592. 2006.

[15] KRISTENSEN, F.B. et al. European network for health technology assessment, eunethta:Planning, development, and implementation of a sustainable european network for health technology assessment. **International Journal of Technology Assessment in Health Care**, 25(SUPPL.S2), pp. 107-116, 2009.

[16] KONONKOVA, N.P.; SHAIMUKHAMETOVA, J.R. LATIN AMERICAN EXPERIENCE OF STATE-PRIVATE PARTNERSHIP. **Iberoamerica** (Russian Federation), (2), pp. 26-48, 2020.

[17] MARCHAND, P.; P. RATINAUD. **L'analyse de similitude appliqueé aux corpus textueles**: les primaires socialistes pour l'election présidentielle française. Em: Actes des 11eme Journées internationales d'Analyse statistique des Données Textuelles. JADT 2012.(687–699). Presented at the 11eme Journées internationales d'Analyse statistique des Données Textuelles. JADT 2012., Liège, Belgique, 2012.

[18] MOHAMMED, F.; IBRAHIM, O.B. Drivers of cloud

computing adoption for E- government services implementation. **International Journal of Distributed Systems andTechnologies** v., n.6(1), pp. 1-14

[19] MELO, C. **IRAMUTEQ-Análise de similitude**. [S. l.]: LEPP-Saúde, 2017. Disponível em: https://www.youtube.com/watch?v=F47NgaAbipI. Acesso em: 29 maio 2021.

[20] MERGER, E.; PISTORIUS, T. Effectiveness and legitimacy of forest carbon standards in the OTC voluntary carbon Market, **Carbon Balance and Management** v.6, n.4, 2011.

[21] NASCIMENTO-SCHULZE, C. M.; CAMARGO, B. V. (2000). Psicologia social, representações sociais e métodos. **Temas de psicologia**.Ribeirão Preto, 8 (3), 287-299,2000.

[22] NORTON, D.A.; ISAAC, R.M. Endogenous production technology in a public goods enterprise. **Research in Experimental Economics** 13, pp. 131-163, 2010.

[23] ORGANIZAÇÃO DAS NAÇÕES UNIDAS. **Agenda 2030.** objetivo 16. Disponível em:http://www.agenda2030.com.br/. Acesso em: 20 mar. 2021.

[24] PARKER, L.; D.; GOULD, G. **Changing public sector accountability critiquing new directions**, Accountability forum. p.109-135, 1999.

[25] PAUL, S. A case study of E-governance initiatives in India**. International Informationand Library Review**, v. 39, n.4, pp. 176-184, 2007.

[26] PETERS, B. G. O que é Governança? **Revista do TCU**, nº 127, 2013

[27] PÉREZ-LOPES, G.; PRIOR, D.; ZAFRA-GÓMEZ, J, L. Rethininking new public management delivery forms and efficiency: long-term effects in Spanish local govermment. **Journal of public Administration Research and Theory,** 25 (4),1157-1183, 2015.

[28] RÍOS, P.R.; RIVERA, A.G.; OROPEZA, I.R.; RIVAS BOCANEGRA, R.E. Análisis del

[29] Proceso de Actualización de Medicamentos en el Cuadro Básico y Catálogo de Insumosdel Sector Salud. **Value in Health Regional Issues**, v. 2, n. 3, pp. 387-391, 2013.

[30] RODRIGUES, D. M.; COUGO, R. L. ACCOUNTABILITY NA ADMINISTRAÇÃO PÚBLICA: ENFOQUE NA GESTÃO FINANCEIRA DAS OBRAS PÚBLICAS NA SECRETARIA MUNICIPAL DA FAZENDA DE BAGÉ.**Revista do CCEI**: URCAMP,[S. l.], v. 20, n. 35, ed. 53, 2016.

[31] RISSLAND, J. Surveillance of hygiene by local public health authorities - Recommendations (not only) for the public health service in Rhineland-Palatinate | [Infektionshygienische Überwachung durch Gesundheitsämter - Empfehlungen (nicht nur)für den ÖGD in Rheinland-Pfalz]. **Gesundheitswesen,** V. 73, N.11, pp. 737-743, 2011.

[32] SEVERINO, A. J. **Metodologia do trabalho científico**.São Paulo. Ed. rev. e atual: Cortez,2007.

[33] SHABAN-NEJAD, et al. A Semantic Framework for Logical Cross-Validation, Evaluation and Impact Analyses of Population Health Interventions. **Studies in Health Technology and Informatics**, 235, pp. 481-485, 2017.

[34] SHIRLEY, M. M. Privatization in Latin America: Lessons for transitional Europe. **WorldDevelopment**, v.22, 9, pp. 1313-1323, 1994.

[35] SILVA, P. 'A Poor but Honest Country': Corruption and Probity in Chile. **Journal ofDeveloping Societies**, V. 32, N.2, pp. 178-203, 2016.

[36] SVARD, P. The impact of information culture on information/records management: A case study of a municipality in **Belgium. Records Management Journal**, v.24, n.1, pp. 5-21

[37] TOWNSEND, K.; EYLES, J. Capacity and transparency of potable water regulation inTijuana, Mexico: Challenges for ensuring water quality at community level. **Health Promotion International**, v19, n1, pp. 77-83, 2004.

[38] TRUNOV, A.; BEGLYTSIA, V. Synthesis of a trend's integral estimate based on a totalityof indicators for a time series data. **Eastern-European Journal of Enterprise Technologies**, 2(4-98), pp. 48-56, 2019.

[39] VACCA, A. Court of Auditors' performance auditing as a tool to enhance economy, efficiency, effectiveness and transparency in the public administration, an Italian perspective: Strengths and weaknesses. **International Journal of Public Law and Policy**,v. 4, n.2, pp. 103-119, 2014.

[40] VIVANCO, M.S. Anti-corruption agencies and independence: From augurs to haruspices. A roadmap for Latin America | [Agencias anticorrupción e independencia: ¿augures o arúspices? Una hoja de ruta para Latinoamérica]. **Reforma y Democracia**, v. 56, pp. 59-98,2013.

Modeling the hydrodynamic behavior of facultative pond using computational fluidodynamic tool

Leandro Conti Garcia, Flávia Aparecida Reitz Cardoso[*], Flávia Vieira da Silva Medeiros, Thiago Morais de Castro and Eudes José Arantes

Post-Graduation Program of Technological Innovation (PPGIT), Federal University of Technology – Paraná (UTFPR), Campo Mourão, 87301-005, Brazil
*reitz@utfpr.edu.br

Abstract— The stabilization pond system this which is efficient in removing organic pollutants but can present operational problems such as sediment accumulation due to lack of maintenance or operational errors, negatively influencing the efficiency of the treatment. Based on these considerations, this work evaluated the hydrodynamic behavior of an facultative pond. The hydrodynamic evaluation was carried out through the computational dynamics of the fluids, from which the main operational problems and areas of occurrence were identified. Five main regions were verified in the pond bed, with the effects of recirculation, dead zone, and short circuit zone occurring in these places. It was concluded with this study that the irregular accumulation of sediments in the pond beder and the irregular shape of the pond geometry, which contributes to the fluid is associated with the velocity of entry of the wastewater not flowing in an orderly way throughout the bed.

I. INTRODUCTION

The most popular effluent treatment model in Brazil is composed of stabilization ponds. This system is formed by a set of ponds that have the function of removing most of the pollutants found. In this set of ponds, the facultative aerated ponds, aerated ponds of the complete mixture with decanters, anaerobic ponds with facultative or facultative ponds can be found. Each of these treatment cells has different objectives and efficiencies, which complement each other to result in an efficient treatment in the removal of physical, chemical, and biological contaminants (Chávez-Vera, 2017; Shilton; Bailey, 2006).

Von Sperling (2014) points out that the efficiency of the effluent treatment units can be compromised by the lack of maintenance in the stabilization ponds, given the high rates of sediment accumulation causing the change in the bed geometry. This situation compromises the flow of the fluid during the treatment, changing the design calculations for the hydraulic retention time, and directly influencing the pollutant removal rates.

Some of the consequences of the accumulation of sediments in ponds are the formation of dead zones, the development of short circuits, and also the expansion of thermal stratification. These phenomena can develop in parallel, and they are linked to the result found in the treated effluent (Metcalf; Eddy, 2015; Daigger, 2011).

Several studies have been carried out to solve such problems, such as the characterization of the hydrodynamic behavior of the fluid within the treatment beds and possible identification of the origin of the problem. Authors such as Passos (2017), Francener et al. (2015), Teixeira et al. (2014),Shih et al. (2017), Coggins et al. (2018),Passos, Von Sperling and Ribeiro (2014),Frederick and Lloyd (2006), and Souza et al. (2012)

use mathematical modeling applied to computational fluid dynamics to describe the movement of the fluid in the treatment ponds to find the dead zones or short circuits and other problems characteristic of sediment accumulation. Such simulation results in numerical and graphic data that corroborated the development of specific solutions and adapted to treatment systems already in operation.

According to Souza et al. (2012), during the elaboration of the projects for an effluent treatment station and dimensioning of its ponds, the ideal flow phenomena are considered. Through the characteristics pre-established in the literature, the dimensions of the project are defined. The authors also emphasize that the lack of real information on the flow of the effluent to be used does not constitute a successful operation.

Experimental data collection can often prove not to be a technically and economically feasible option, limiting the development of actions. One of the ways to obtain the necessary parameters for the correct dimensioning of the effluent treatment units is with the use of mathematical modeling (Oliveira; Teixeira, 2015).

In this respect, there is computational fluid dynamics (CFD) able to make inferences about the hydrodynamic behavior of fluids. Francener (2015) defines it as a mathematical and computational tool capable of analyzing the hydrodynamic behavior of a fluid within a predetermined volume, or outside it, in addition to relating it to aspects external to the fluid in question, such as the external environment, turbulence, pond geometry, etc.

The computational fluid dynamics function occurs through the generation of a knotted mesh established on the geometry to be analyzed. Through this mesh, equations and calculations of interest will be developed to obtain the desired result. The boundary conditions are included in the analysis platform, information referring to the type of fluid, mass movement, and inlet and outlet points, in addition to the composition material of the geometry perimeter so that the roughness and friction rates are considered (Peter, 1999).

Passos (2017) also complements the role of modeling in CFD, which: "the results obtained can be analyzed numerically and visually, (...) and compared with experimental data for calibration and validation" (Passos, 2017, p.77). The author also points out that this mathematical modeling process has advantages in relation to the others due to the reduction in the execution time of the models and projects, the cost of the study, and its high applicability in different situations involving fluid dynamic analysis.

Based on these considerations, this study proposed to solve the problem of an effluent treatment station by developing a hydrodynamic behavior model (CFD) of the facultative pond so that it was possible to analyze the points where the occur accumulation of sediments, dead zones and short circuits throughout the treatment flow.

II.   MATERIAL AND METHODS

The facultative pond, object of this study, is located in the northeastern region of a city in the interior of the state of Paraná-Brazil. The treatment station where the pond is located consists of a system consisting of preliminary, primary, secondary and post-treatment. The main component responsible for the pollutants load reduction is an anaerobic reactor of the UASB type, followed by an facultative pond.

From the data obtained in the bathymetry, a three-dimensional surface was developed that characterizes the situation found at the bottom of the facultative pond. For this operation, Surfer 8® software was used. In order to be able to replicate the situation found in the pond, it was necessary to offer a treatment to the collected data, assigning values to the X, Y and Z coordinates.

Thus, the geometry of the pond was replicated in the AutoCAD® software, where it was possible to draw the collection lines and locate the points on each of the lines. After completing the design of the perimeter and collection lines, the geometry was aligned to the Cartesian axis (0.0), thus allowing the coordinates of each of the collection points to be found. Thus, the points started to have X, Y and Z dimensions.

The cartesian information generated in AutoCAD® was inserted in the Surfer spreadsheets and then made it possible to develop the lower surface of the pond. Using the tools of this software, it was possible to manipulate the generated image, grading it according to the height of the sludge layer. The three-dimensional geometry of the pond was replicated in the solid creation platform available in the Ansys 14.5® software, a high-performance program used for computer simulation.

This procedure was carried out by applying the actual dimensions of the pond for length, width, and depth, thickness, and shape of the inlet and outlet pipes. Information such as the roughness of the side and bottom walls and fluid characteristics were added to the boundary conditions provided by the *software*.

After the creation and characterization of the solid that represents the treatment pond, the Ansys® software generated a structured mesh of triangulated points with the following characteristics:

number of nodes: 369618

number of elements: 1927308

tetrahedra: 1927308

extents: min x, max x: -4.50646e-17 [m], 164.919 [m]; min y, max y: -15.4678 [m], 68.2293 [m]; min z, max z: 0 [m], 2.5 [m]

max edge length ratio: 3.59602

volume: 26913 [m^3].

To determine if the conditions of the simulation were adequate, the Courant number close to one (1) was used to prevent the fluid from passing a greater distance than the mesh size in one step of time. The details of the mesh can be better seen in Figure 1. Each node in this mesh was assigned an equation, according to the information previously provided. Also, the *software* allowed the implementation of mathematical modeling on the flow characteristics of the fluid used. The interaction of the equations in each of the points of the mesh with the fluid flow model allowed to attribute to the set (pond + effluent) the hydrodynamic behavior of the fluid along with the treatment flow, attributing to the flow a vector characterization that represents the direction, direction, and velocity of the liquid across the pond bed.
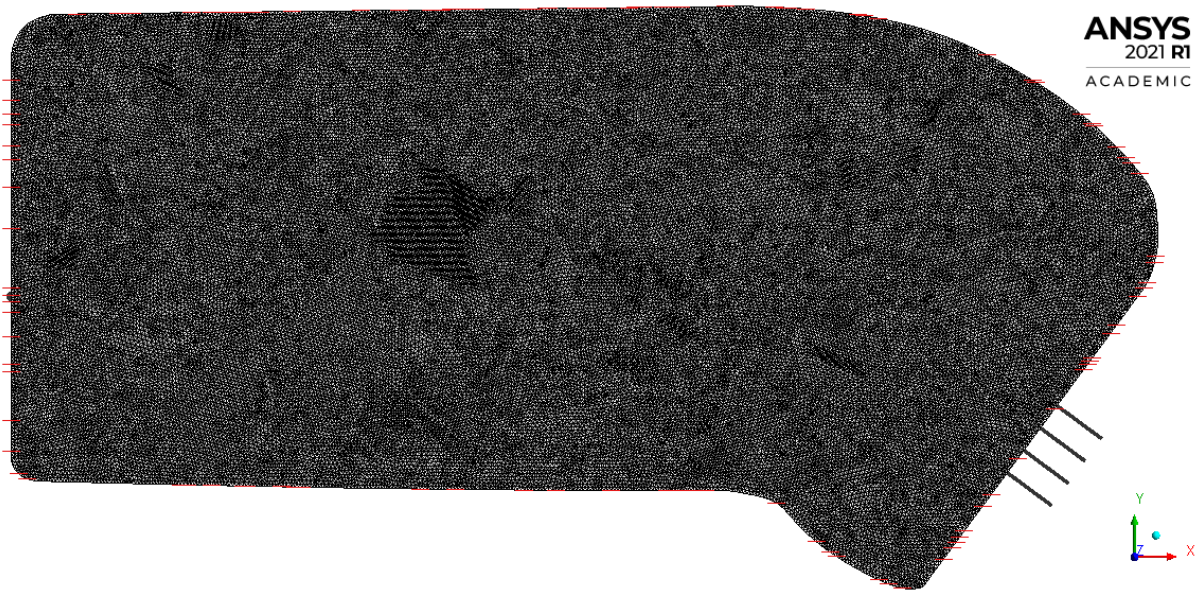
(a)
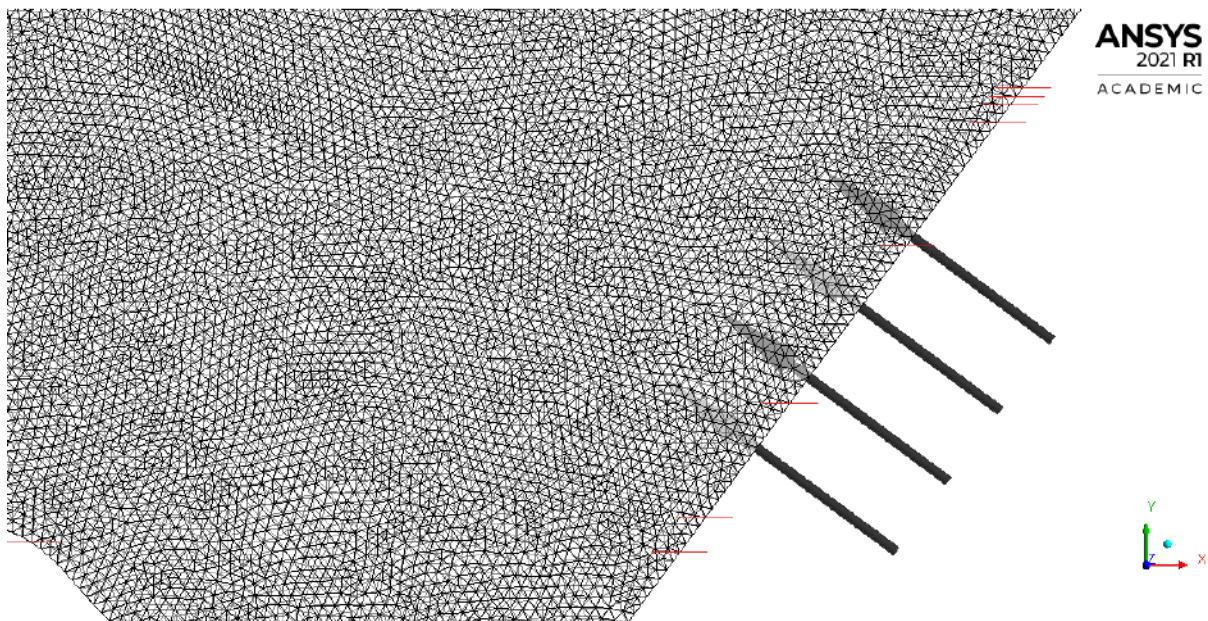
(b)

Fig.1 - Mesh details in their discretization

The results obtained in this operation were numerical (velocity reached by the fluid) and graphics (vector characterization of the fluid behavior), allowing an analysis of the existence of differences in the fluid behavior, as well as a visual analysis of the hydrodynamic vector composition. The values found refer to the fluid velocity ranges along the pond bed. This velocity range was established according to the different settings of the baffles, and already in the images, it was possible to identify the regions of short-circuit, recirculation, retrocirculation, and dead zones, which were confronted with the data collected in the field.

III.   RESULTS AND DISCUSSION

From the coordinated bathymetric data, the flat (Figure 2) and three-dimensional (Figure 3) model of the sediment layer deposited at the bottom of the pond was made. Initially, a flat image was generated, representing the elevation levels found in the bed of the unit, and then a three-dimensional image of the sludge bank was created (Garcia et al., 2020).
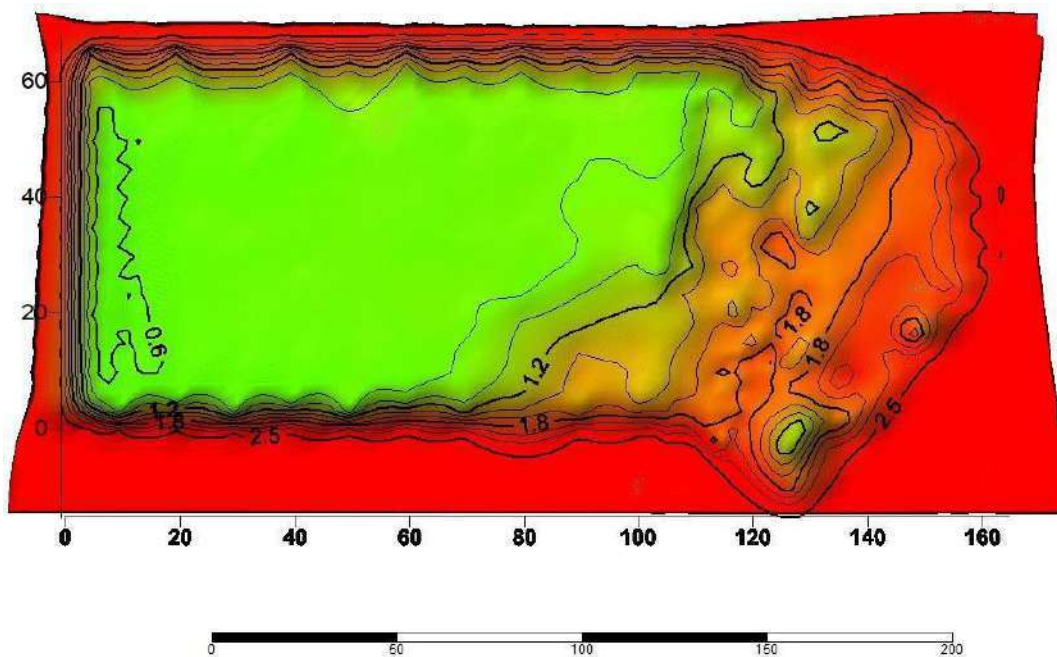
Fig.2 - Elevations of the sediment layer deposited in the bed of the facultative pond

Fonte: Garcia et al., 2020, p. 180.

Figure 2 shows that the sediment has its highest sedimentation rate at the beginning of the pond, close to the inlet ducts, reaching these points at a height of 2.5 m, the same depth as the pond (Garcia et al., 2020). The deposition pattern follows parallel to the entrance margin, in the form of a slope, where the slope gradually declines until reaching a height that varies between 0.8 and 0.6 m from the middle of the pond. It should also be noted that the sedimentation of the sludge accompanies the slope declivity, proving to be more intense close to the margins (Figure 3), as mentioned by Ortiz and Matsumoto (2013).
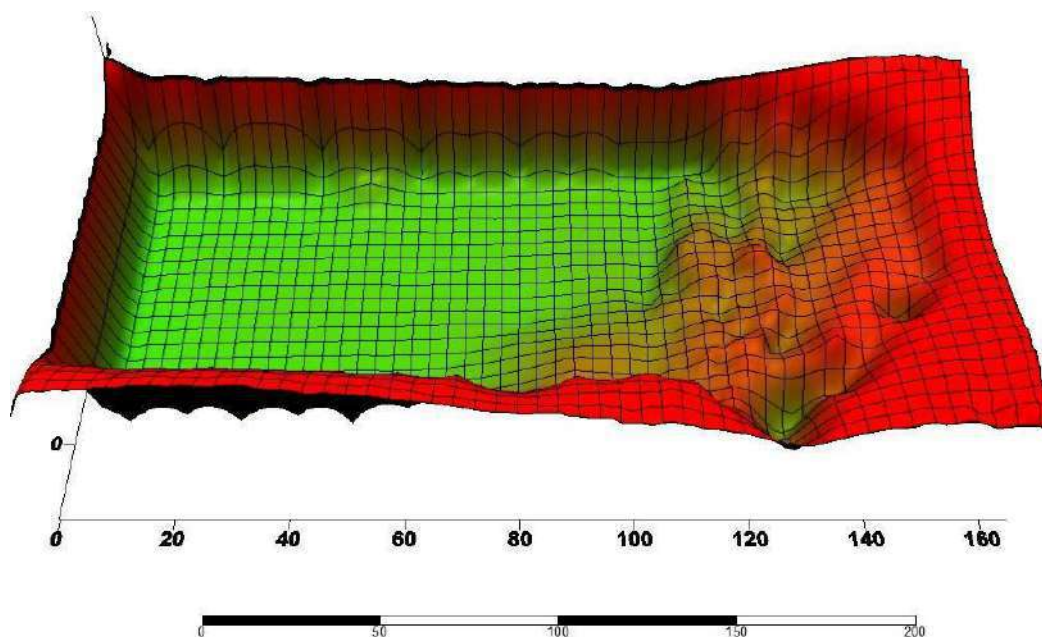
Fig.3 - Three-dimensional image and overlapping elevations of the sediment layer deposited in the bed of the facultative pond.

Fonte: Garcia et al., 2020, p. 181.

The level curves model found from the bathymetry points out that the biggest influence for the accumulation of sludge at the beginning of the pond is its irregular shape (Figure 3). This situation, based on Souza et al. (2012), is due to the fact that the curved margin becomes a barrier to the flow emitted by the inlet ducts, thus, when the liquid enters the facultative pond, it does not have a free longitudinal flow. When colliding with the curved margin, the flow rate is drastically reduced and the flow is redirected to form backmix zones. In this situation, the volume of solids thickens, conditioning sedimentation and the formation of sludge bed (Casarotti, Matsumoto; Albertin, 2012).

As in a decanter, a common primary treatment, when the fluid is able to flow through the pond, towards the outlet, the concentration of suspended solids is considerably lower, allowing the flow to occur without high sediment deposition rates. and formation of very thick sludge layers. This situation is observed in the second half of the pond, closest to the outlet ducts (Von Sperling, 2014).

Then, using computational fluid dynamics, the results obtained in this operation were numerical (velocity reached by the fluid) and graphics (vector characterization of the fluid's behavior), allowing an analysis of the existence of differences in the fluid's behavior, as well as a visual analysis of the hydrodynamic vector composition. The values found refer to the fluid velocity ranges along the pond bed and already in the images obtained, that show the behavior of the fluid at each instant of its stay inside the bed, from the inlet to the outlet, it was possible to identify the regions of short-circuit, recirculation, retrocirculation and dead zones, which were confronted with the data collected in the field.

The comparison of the surface generated by Surfer with the flow model generated by Ansys allowed to verify the reliability of the fluid dynamic modeling in the projection of the fluid current lines inside the pond, in the recirculation zones and also dead zones, places with the lowest gradients of velocity.

The velocity scale ranged from zero to 0.568 m/s. However, it remained mainly between 0.097 and 0.148 m/s. As a boundary condition of the modeling, the value of 0.137 m/s was used as the inlet velocity, calculated through the average inlet flow of the effluent, which is 28.99 L/s, thus showing that the flow velocity remains regular inside the pond, changing only when under the influence of geometry.

Figure 4 shows the intense movement of the fluid on the right margin of the pond, as well as in the space between the internal and external curves of the perimeter. These places have a lighter cyan color and increase fluid velocity. It is also observed that in the rectangular region of the pond, close to the lower margin, the vectors have a darker color, and the spacing between the posts is greater, characterizing the region as a place where the loss of flow velocity occurs (Passos, 2017).
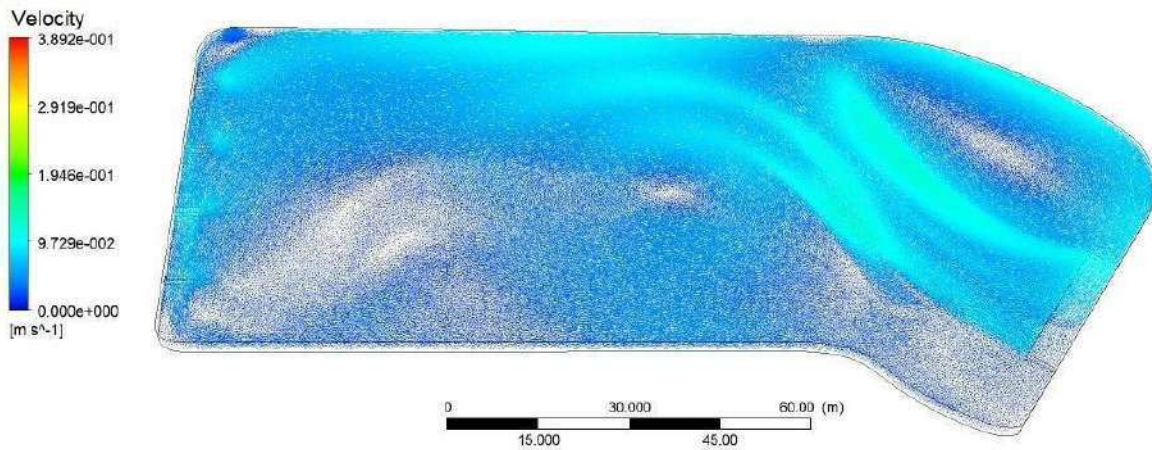
Fig.4 -Vector characterization of the flow within the facultative pond

Decomposing the vector analysis in flow lines (Figure 5), it is possible to notice with greater visibility the phenomena that affect the pond. These situations were numbered for a better explanation of each case, which can elucidate the main causes for the loss of efficiency of the treatment system in the facultative pond, as well as for the high sedimentation level near the inlet to the sewer.
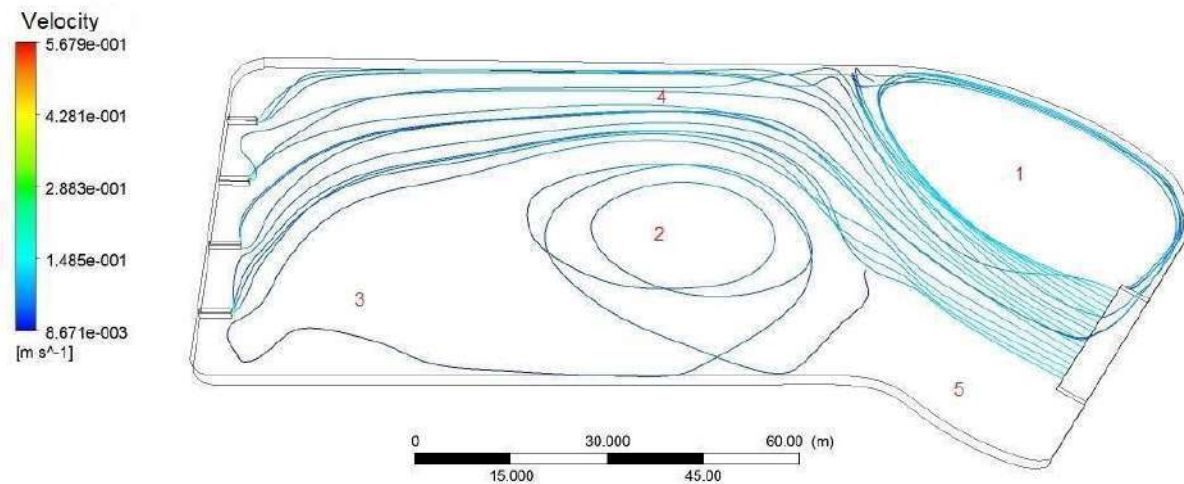
Fig.5 - Characterization of the current lines within the facultative pond

These conditions are evidence of design problems found at the site. The velocity change is caused mainly by the geometry of the location, which also determines the direction of the flow. The results demonstrate the values of velocity and stream lines, indicating the existence of dead zones and re-mixing, among others. These low velocity regions indicate hydrodynamic conditions so that the deposition occurs.

Discriminated by the number 1 (Figure 5), there is a region of retromixing, in which a portion of the liquid remains in cyclic movement until it is dragged back to the current. During this movement, there is the action of gravitational forces on the suspended solids, leading to the collision of the particles, densification of the solids, and formation of a layer of sediments. With the increase of sediments in this site, the direction of the fluid is accentuated, perpetuating this cyclical condition and therefore intensifying the adversities arising from the accumulation of sediments (Kellner; Moreira, 2009).

Another portion of the fluid, more voluminous, when finding the slope of the pond, is directed to the outlet, region number 4. In this case, the liquid follows the

barrier imposed by the pond and goes to the outlet ducts. In a pond project, the calculation for the retention time of the liquid in its interior considers that the entire volume introduced must pass through the entire bed with constant velocity to be then overflowed. When the fluid spends less time in the pond than calculated in the project, a short circuit situation is observed, where part of the fluid goes to the path with fewer obstacles to reach then the outlet (Metcalf; Eddy, 2015).

The pond analyzed has a short circuit zone (4), and even so, the operational detention time is longer than calculated. This contradiction occurs because, even though part of the fluid is directed towards the outlet more quickly than calculated, the rest of the liquid that remains in the pond has a greater volume, and this remains in it for longer than expected. One characteristic does not prevent the other from developing, as the hydraulic detention time is influenced by all other operational processes found in the pond (Jordão; Pessoa, 2014).

It is also possible to see in Figure 5 two regions of the pond where there is little or no presence of current lines. These regions received the numbers 3 and 5, and are the dead zone regions responsible for raising the hydraulic detention time above the projected. The dead zone phenomenon is characterized by a region where the fluid has a flow rate lower than the design velocity. In this case, the dead zone begins to form when the flow in the short circuit produces a centripetal force that directs the fluid to the lower margin, in a circular motion. This water flow is then guided by the slope until it finds the inlet current, which again suffers from the centripetal force produced by the short circuit. In this situation, three scenarios are obtained (Passos, 2017).

The first of them is the large area of low velocity (3), where the fluid remains almost inertial, being directed to the outlet ducts by external influence, such as the wind. The second scenario is the recirculation zone found in the middle of the pond (2). In this location, the flow that is there in a circular motion is constantly accelerated by the action of the short circuit zone, therefore having a continuous movement. The formation of the sediment layer in this region is not as intense as in the region (1), because the liquid that is in recirculation has a lower concentration of suspended solids since most of these sedimentated at the beginning of the pond (Naval, Queiro; Silva, 2002).

The third scenario is formed by a region filled with liquid, but without flow (5). At this point in the pond, there are no areas of retromixing, recirculation, or short circuit regions, and the liquid mass present there flows with almost zero velocity. In this region, can there is a

large accumulation of sediments because there are characteristics similar to that of a decanter, allowing gravitational forces to act on the solid particles without the interference of the velocity gradients that would drag them to the center of the pond (Von Sperling, 2017).

The formation of this dead zone (5) is motivated by two main factors:

- The direction of the inlet flow, which conducts the fluid up to five meters into the bed of the pond and directs it in the opposite direction to that of the region.

- The recirculation region (2), which, due to its velocity greater than the fluid present in (3) and (5), does not allow a connection between these regions.

Other factors that have not been applied in the CFD simulation that may influence the gain or loss of velocity are: the concentration of sediments in the pond, the density and thickness of the sludge layer, the thermal stratification, and the intensity and direction of the winds. The factors external to the pond are capable of altering the flow close to the surface, thus influencing the way the sediments behave (Casarotti, Matsumoto; Albertin, 2012).

In cases of thermal stratification, as well as high-intensity winds, the fluid is influenced by a vertical movement, revolving the bottom sludge layer, causing the already deposited sediments to return to the suspended state, as stated by Jordão and Pessoa (2014). In the surveyed scenario, there was no evidence of the wind or thermal influence on the pond. The place where it is installed is surrounded by a curtain of large vegetation, preventing high-velocity gusts from reaching the pond, as well as protecting it from great amplitudes in the temperature variation. Historically, the city has mild temperatures, averaging around 20ºC, with positive peaks in the summer, above 35ºC, a characteristic that makes the thermal stratification effect rare (Ipardes, 2018).

The layer of sediment deposited at the bottom of the pond does not behave like a solid. The particulate material suspended in the liquid, when losing velocity, goes against the bottom of the pond, and as this process intensifies, the amount of particles increases. However, these particles remain separate from each other, so there is a space for the fluid to circulate between them. The greater the number of particles that reach the bottom of the pond, the denser the sludge, and the greater the pressure that the fluid between the particles undergoes (Kellner, Moreira; Pires, 2009).

When considering the atmospheric pressure that reaches the surface of the pond, the velocity and

turbulence of the fluid in the inlet duct, the fluid has a limited path to follow. In the analyzed pond, this path has the highest concentration of solid, the influence of these particles being the reason for the fluid velocity gain (Vos Sperling, 1996). It is important to highlight that in this specific model there are no data in the literature to corroborate the information obtained by computer simulation.

IV. CONCLUSIONS

From the analysis of the results obtained in this research, it was possible to verify the hydrodynamic behavior of the sanitary sewage in a facultative pond, in addition to the relationship between the geometry of the pond, the deposition of sediments and the development of design problems that negatively influence the efficiency rate of the pollutant removal. It was noted that the main factor influencing the deposition of solids and the formation of the sludge layer is the shape of the pond. The inlet duct directed to one of the margins conditions the collision of particles in suspension against the slope of the pond, causing a recirculation zone at the inlet of the pond and increasing the volume of sediments deposited in this region.

The collection of bathymetric data allowed the projection of the sediment layer on a three-dimensional surface, which showed the uneven concentration of solids caused by the geometry of the system. Through the bathymetry, the operational situation of the pond was actually known, and it is then possible to attest to the veracity of the mathematical model produced by the computational fluid dynamics software.

The result of computational fluid dynamics generated visual data where the main design problems can be observed, in addition to serving as a basis for decision making by the company responsible for the station for the development of mitigating activities, which enable the reduction of sediment accumulation in critical areas found here. From the development of the methodology, the main operational problems and areas of occurrence were identified, thus conditioning the choice of configurations for the future disposition of baffles.

References

[1] CASAROTTI, E.G.; MATSUMOTO, T.A.; LAZZARI, L. Avaliação da influência do ventonacirculação de umalagoa de estabilização. **EngenhariaSanitária Ambiental**, v.17, p.401-412, 2012.

[2] CELIK, I. B.; GHIA, U.; ROACHE, P. J.; FREITAS, C. J.; COLEMAN, H.; RAAD, P. E. 2008. Procedure for Estimation and Reporting of Uncertainty Due to Discretization in CFD Applications. **JournalofFluids Engineering**,v. 130, n. 7, 2008.

[3] CHÁVEZ-VERA, I.G. Diseño e implementación de un sistema de tratamiento de Aguasresiduales.**Dominio de Las Ciencias**, v.3, p.536-560, 2017.

[4] COGGINS, L. X.; SOUNNESS, J.; ZHENG, L.; GHISALBERTI, M.; GHADOUANI, A. Impact of hydrodynamic reconfiguration with baffles on treatment performance in waste stabilisation ponds: full-scale experiment. **Water**, v. 10, n. 2, p. 109-130, 2018.

[5] DAIGGER, G. T. A practitioner's perspective on the uses and future developments for wastewater treatment modeling. **Water Science and Technology**,v.63, n.3, p.516-526, 2011.

[6] FRANCENER, S.F.; SOUZA, V.A.S.; PEREIRA, E.S.; BRUCHA, G.; SILVEIRA, A. Estudo da influência da hidrodinâmica no perfil de remoção de matériaorgânicaemlagoas de estabilizaçãoanaeróbia da amazôniaocidental: estação de tratamento de esgotosanitário do município de Cacoal - RO. **Engenharia Ambiental**, v.12, p.31-40, 2015.

[7] FREDERICK, G.; LLOYD, B. An evaluation of retention time and short-circuiting in waste stabilisation ponds using Serratia marcescens bacteriophage as a tracer. **Water Science and Technology**, v.33, n.7, p.49-56, 1996.

[8] GARCIA, L. C.; CARDOSO, F. A. R.; KRUGER, F. R.; GUERRA, V. S.; ARANTES, E. J. Análise do acúmulo de sedimentos por batimetriaemlagoafacultativa no município de Campo Mourão/PR. **RevistaIbero Americana de CiênciasAmbientais**, v. 11, n.1, p. 177-183, 2020.

[9] Instituto Paranaense de DesenvolvimentoEconômico e Social (Paraná). **Perfilavançado do município de Campo Mourão**. Availabe in: <http://www.ipardes.gov.br/perfil_municipal/MontaPerfil.php?codlocal=332>. Added in: 25 out. 2018.

[10] JORDÃO, E.P.; PESSOA, C.A. **Tratamento de esgotosdomésticos**. 7.ed. Abes, Rio de Janeiro, 2014.

[11] KELLNER, E.M.; VIANA, J.F.; PIRES, E.C. Influência da estratificaçãotérmica no volume útil e no comportamentohidrodinâmico de lagoa de estabilização: determinação experimental e teórica. **EngenhariaSanitária Ambiental**, v.14, p.129-138, 2009.

[12] METCALF, L.; HARRISON, E.P. **Wastewater engineering**. 5.ed. Mcgraw-Hill, New York, 2015.

[13] NAVAL, L.P.; QUEIRO, S.C.B.; SILVA, V.M. Estratificaçãotérmicaemlagoas de estabilização: influência da sazonalidade no fenômeno. In: SimpósioÍtaloBrasileiro de EngenhariaSanitária e Ambiental. **Anais...** .Abes, 2002.

[14] OLIVEIRA, D.S.; TEIXEIRA, E.C. Modelagemfluidodinâmicacomputacionalaplicadaaoprojeto de unidades de floculação. **Sodebras**, v.10, p.121-124, 2015.

[15] ORTIZ, I. S.; MATSUMOTO, T. Estudio de Batimetría y eficiencia de un sistema de lagunas de estabilización.**Revista de CiênciasAgrícolas**, v. 30, n. 1, p.65-78, 2013

[16] PASSOS, R. G.; VON SPERLING, M.; RIBEIRO, T. B. Hydrodynamic evaluation of a full-scale facultative pond by computational fluid dynamics (CFD) and field measurements. **Water Science & Technology**, v. 70, n. 3, p.569-575, 2014.

[17] PASSOS, R. G.; DIAS, D. F. C.; VON SPERLING, M. Review of practical aspects for modelling of stabilization ponds using Computational Fluid Dynamics. **Environmental Technology Reviews**, v. 5, n. 1, p.78-102, 2016.

[18] PASSOS, R.G.**Estudos e modelagem do comportamentohidrodinâmico de lagoas de polimento**.Tese. Universidade Federal de Minas Gerais, Belo Horizonte, 2017.

[19] PETER K. **Ansys**:theory reference. Canonsburg: Ansys, Inc., 1999. 1286 p.

[20] SHIH, S.; ZENG, Y.; LEE, H.; OTTE, M. L.; FANG, W. Tracer experiments and hydraulic performance improvements in a treatment pond. **Water**, v. 9, n. 2, 137-145, 2017.

[21] SHILTON, A.; BAILEY, D. Drogue tracking by image processing for the study of laboratory scale pond hydraulics. **Flow Measurement and Instrumentation**, v. 17, n. 1, p. 69-74. 2006.

[22] SOUZA, V.A.S.; HELBEL, A.F.; JANZEN, J.G.; DIAS, R.H.S.; COLTRE, H.C.S. Simulaçãocomputacional do comportamentohidrodinâmicoemlagoasfacultativas com chicanas. **Ciência&Engenharia**, v.21, p.15-21, 2012.

[23] TEIXEIRA, J.C.; OLIVEIRA, G.S.; VIALI, A.M.; MUNIZ, S.S. Estudo do impacto das deficiências de saneamentobásicosobre a saúdepública no Brasil no período de 2001 a 2009. **EngenhariaSanitária Ambiental**, v.19, p.87-96, 2014.

[24] VON SPERLING, M. **Lagoas de estabilização**.3.ed. UFMG,Belo Horizonte, 2017.

[25] VON, S.M. **Introdução à qualidade das águas e aotratamento de esgotos**.4.ed. UFMG, Belo Horizonte, 2014.

Regional development of free trade areas in the context of the tax incentive policy of the Manaus free trade zone – Amazonas, Brazil

Fabio Robson Casara Cavalcante[1], Carlos Alberto Paraguassú-Chaves[2], Ana Maria Morais da Fonseca Cavalcante[3], Fabrício Moraes de Almeida[4], Lenita Rodrigues Moreira Dantas[5], Carla Dolezel Trindade[6], Simão Aznar Filho[7], Ruy Drummont Smith[8], Simão Dolezel Aznar[9], Márcia Maria Rodrigues Uchôa[10], Marcélio Rodrigues Uchôa[11]

[1]PhD in Sciences: Socio-environmental development - NAEA / UFPA. Associate Professor, Federal University of Rondônia – UNIR.

[2]PhD in Health Sciences -University of Brasília - UnB, Brazil; Post-Doctor in Health Sciences - UnB and Degli Studi D'Aquila University - Italy. Full Professor at the Rio de Janeiro Institute Faculty, Brazil

[3]Master in Agronomy from the Federal University of Pernambuco (UFPE), Brazil. Voluntary researcher at the Higher Institute of Health Sciences and the Environment of the Amazon – AICSA.

[4]PhD in Physics (UFC), with post-doctorate in Scientific Regional Development (DCR/CNPq). Researcher of the Doctoral and Master Program in Regional Development and Environment (PGDRA/UNIR).

[5]Geographer expert and lawyer. Researcher of the Institute of Health Sciences and the Amazon environment - AICSA.

[6]PhD in Law - Universidad Nacional de Lomas de Zamora (Argentina). Post-doctorate - Universita deli Studi di Messina (Italy). Full Professor at the University Institute of Rio de Janeiro - IURJ, Brazil.

[7]PhD in Law - Universidad Nacional de Lomas de Zamora (Argentina). Post-doctorate - Universita deli Studi di Messina (Italy). Full Professor at the University Institute of Rio de Janeiro - IURJ, Brazil.

[8]Master in Legal Sciences from the Autonomous University of Lisbon. Adjunct Professor at the Faculty Instituto Rio de Janeiro, Brazil.

[9]Graduated in Law. Master of Law Student, Specialist in Law. Professor at the University Institute of Rio de Janeiro, Brazil.

[10]PhD in Social Sciences from the Pontifical Catholic University (PUC/SP). Adjunct Professor at the Federal University of Rondônia, Brazil.

[11]PhD in Education from the Pontifical Catholic University of São Paulo (PUC/SP). Associate Professor at Faculdade Instituto Rio de Janeiro, Brazil.

Abstract— *The research brings in its scope the need to analyze the socioeconomic development of the municipalities of Tabatinga (Amazonas), Guajará-Mirim (Rondônia), Boa Vista and Bonfim (Roraima), Macapá and Santana (Amapá) and Brasiléia (Acre), with extension for the municipality of Epitaciolândia, and Cruzeiro do Sul (Acre), which are subject to the fiscal incentive policy, in the form of Free Trade Areas, linked to the Superintendence of the Manaus Free Trade Zone - SUFRAMA. The general objective of the research was to analyze the regional development of the nine cities covered by the SUFRAMA policy in comparison with other nine Amazonian municipalities not covered by this policy, in order to identify the municipal performances achieved in the face of the Brazilian Amazonian reality. The research method used was hypothetical-deductive. The research data were submitted to the multivariate factor model to extract the scores for the construction of the indices, using the SPSS statistical tool, version 22. The data were submitted to the necessary requirements for the sieve of*

factorial studies, through the tests of Bartlett's sphericity and the adequacy of the Kaiser-Meyer-Olkin (KMO) sample. In this way, it was possible to build socioeconomic development indexes and, with that, proceed with the due analysis intrinsic to the epistemological question of this work. The data showed adequacy to factor studies and allowed us to observe, in general, the low level of socioeconomic development of the surveyed municipalities, however, with a more favorable situation for the municipalities covered by the SUFRAMA policy.

I. INTRODUCTION

Understanding the Amazon and its multiple interrelationships requires objectivity and clarity that permeates the logic of delimiting the theme, space and temporality in which the phenomena to be observed can be seen and analyzed within a rational and scientific construction. Thus, the theme of regional development, from the perspective of economic and social development, within the context of free trade areas linked to the Manaus Free Trade Zone (SUFRAMA) policy, allows us to understand aspects of the Amazonian reality, its multiple forms and identities that portray the regional challenges in promoting actions aimed at institutional strengthening and their own trajectory resulting from choices and decision-making under the aegis of collective or even institutional behavior, from public policies directed to the region.

The Amazon development challenge is not new. Its socio-environmental complexity has always been the scene of discussions and often seen as an obstacle under the more orthodox logic of economic growth, where more conventional models, such as agricultural production, especially in the 1960s, 1970s and 1980s, were driven by colonization. Agriculture in some regions of northern Brazil, such as Pará and Rondônia, allowed the rapid process of consolidation of these activities as a standardized style of development marked by agricultural culture. On the other hand, the immense Amazon biome and the need to preserve these natural environments allowed us to think of more heterodox forms of development and for such models to take into account perspectives and values based on aspects of sustainable development, a vision that is institutionalized worldwide, the from the Brundtland Report or Our Common Future Report, which served as the basis for the second UN Conference on environment and development, held in Rio de Janeiro, in 1992. In this sense, it is worth highlighting the observations brought by José Eli da Veiga when pointing to the difficult measurement of sustainable development, when signaling that it is not a concept, as much as social justice, but a utopian expression that is here to stay [1].

According to the same author, GDP per capita has always been used as an indicator of economic growth, signaling a scenario whose interpretation points to the economic strength of a region, of a country, for example, where the term "development" has been used for a long time, was closely identified only with economic growth. When trying to illustrate this situation in a more routine and empirical way, José Eli da Veiga quotes Cambridge professor, economist Joan Robinson, who made the following statement "development is like the elephant, very difficult to define, but very easy to recognize" [1].Thus, according to this author, the rupture between growth and economic development would only be possible if an alternative indicator to GDP per capita emerged. A fact, according to him, occurred when the United Nations - UN, through one of its organizational structures, the UNDP - United Nations Development Program, organized an immense collective effort that culminated in the creation of the HDI (Development Index) Human), which combines per capita income with the best health and education indicators. In this sense, it is worth highlighting the work of the Nobel Prize winner, Amartya Sen, in his work entitled "Development as freedom", in which he reveals that there is a distinction between income inequality and economic inequality [2].

According to Santos et. al[3] this work by Amartya Sen calls into question the simplistic view that analyzed development only from the perspective of income, with a predominant view in the interpretations of the various schools of economic thought. Building on these same authors, Amartya Sen particularly focuses on the roles and interrelationships between certain instrumental freedoms that he considers crucial, including economic opportunity, political freedoms, social facilities, guarantees of transparency, and protective security. It also highlights, among other things, the mismatches observed between income and longevity in several countries [3]. In this way, the vision of development and sustainable development, contextualized here, walk exactly in the perspective of the complexity that goes far beyond that brought by a certain and unique indicator as a universal explanation factor of the degree of development. However, this is not intended

to be a standard model to be followed. We only signal a scientific path to better understand the scenario object of the present research, from a quantitative approach.

In this context, the Amazon reality was chosen as the scenario of the present study because this is the main region of biodiversity in the world and that there is an international attention in relation to economic activities in the perspective of sustainable development, which requires the government to carry out technical studies that can serve as a subsidy for the strategies and actions of the federal executive in the elaboration of effective public policies, which, among others, are the result of research that can shed light on the understanding and interpretation of the Amazon as an element of national economic integration. Thus, faced with such a scenario, Brazil created the policy of the Superintendence of the Manaus Free Zone (SUFRAMA) as a strategy to boost economic growth and regional development, without giving up environmental preservation and social justice.

Some questions arise that need to be answered: a) how to determine the level of regional development of municipalities in the Amazon based on the reality of SUFRAMA? b) how to carry out a comparative study between them and between other municipalities without access to such a policy? c) which indicators should be taken into account for this study? Thus, the epistemological problem raised in this study focuses on questioning whether the municipalities, objects of the present research, inserted in the Free Trade Areas contemplated by the SUFRAMA policy, present satisfactory socioeconomic aspects in terms of regional development, in comparison with the economic indicators and social aspects of municipalities not covered by the SUFRAMA policy, based on the theory of endogenous development and regional development poles associated with the institutionalist theory of Douglass North.

The hypotheses raised by the work, in turn, aimed to allow the construction of epistemological beacons and assumptions that allow conducting this work within the academic and scientific rigor. Thus, two hypotheses were raised in this study, namely: **H0**: If the economic and social development indices achieved by the municipalities in the LAC present a satisfactory performance and/or superior to the municipalities not served by the aforementioned policy, then it is understandable that the fiscal incentive policy linked to SUFRAMA has been giving positive results and deserves to be stimulated as a strategic and sustainable development path for the Amazon region, not implying, therefore, the need for intervention measures and adjustments of said public policy. **H1**: If, on the other hand, the economic and social development

indexes achieved by the LAC municipalities present an unsatisfactory performance and/or inferior to the municipalities not covered by the aforementioned policy, then the fiscal incentive policy linked to SUFRAMA deserves to be analyzed in a in loco, aiming to determine the bottlenecks and challenges inherent to the policy in question, indicating the need for adjustments and adaptations, in order to make it effective, effective and efficient.

Regarding the general objective, it consisted of analyzing, based on economic and social indicators, the degree of regional development of the 9 (nine) municipalities in the Amazon selected and covered by the tax incentives policy of the Manaus Free Trade Zone, linked to the Free Trade Areas , as well as other 9 (nine) municipalities in the western Amazon not covered by the aforementioned policy, based on quantitative data available from official sources, in order to understand the current situation of the regions selected in this study and discuss the effectiveness of this policy as a vector of regional development based on the theoretical foundations of the research.

Thus, given the context of economic globalization and the need to establish national policies to stimulate the development of regions with a significant presence of legally protected areas, such as the Brazilian Amazon and the Manaus Free Trade Zone policy, this work demonstrates its importance to the to analyze a regional context based on a vision of a pole of development inserted in a reality of economic freedom, which indicates the existence of an important paradox to be analyzed and discussed within science. With this, we seek to fill a fertile space in terms of analysis of regional economic development policies in the country, based on solid theoretical and methodological foundations capable of bringing light and contributions to the debates around this theme.

II.   RESEARCH METHODOLOGY

2.1 TYPE OF SEARCH

This is a quantitative research of the experimental type, which will seek to raise indicators for later calculation of the index for purposes of comparison between the municipalities selected for this study.

2.2 UNIVERSE AND SAMPLE

Within the universe of 92 municipalities located on the border strip in the Brazilian Western Amazon [4],9 municipalities covered by the Free Trade Areas policy were surveyed, namely: Tabatinga (Amazonas), Guajará-Mirim (Rondônia), Boa Vista and Bonfim (Roraima),

Macapá and Santana (Amapá) and Brasiléia, with extension to the municipality of Epitaciolândia, and Cruzeiro do Sul (Acre) and 9 more municipalities, for comparison purposes, not covered by the aforementioned policy, namely: Feijó, Sena Madureira and Taraucá (Acre), Barcelos, Benjamin Constant and Boca do Acre (Amazonas) and Buritis, Nova Mamoré and Pimenta Bueno (Rondônia), totaling a sample of 18 municipalities along the border of the Western Amazon that participated in this study, with the years 2010 and 2018 being the two periods chosen for data collection. For this, the following acronyms of the municipalities selected in this work were adopted in order to facilitate the process of calculation and

presentation of data, as follows: Tabatinga (TAB), Guajará-Mirim (GUA), Boa Vista (BOA), Bonfim (BOM), Macapá (MAC), Santana (SAN), Brasiléia (BRA), Epitaciolândia, (EPI), Cruzeiro do Sul (CRU), Feijó (FEI), Sena Madureira (SEN), Taraucá (TAR), Barcelos (BAR), Benjamin Constant (BEN), Boca do Acre (BOC) and Buritis (BUR), Nova Mamoré (NOV) and Pimenta Bueno (PIM).

2.3 DATA COLLECTION

The economic and social indicators collected from institutional sources are shown in Table 1 below.

Table 1: Initial survey of quantitative data for the preparation of the regional development index

THEME	INDICATORS	SOURCE
economic index	Gross Domestic Product per capita, at current prices (R$ 1.00)	IBGE (Statistics)
	Share of gross value added at current prices of agriculture in the gross value added at current prices of agriculture in the federation unit (%)	IBGE (Statistics)
	Share of gross value added at current industry prices in gross value added at current industry prices in the federation unit (%)	IBGE (Statistics)
	Share of gross value added at current prices of services, administration, defence, education and public health and social security, in added value	IBGE (Statistics)
	Share of gross value added at current prices total in gross value added at current prices total of the federation unit (%)	IBGE (Statistics)
	Gross Domestic Product, at current prices (R$ 1,000)	IBGE (Statistics)
	number of cattle	IBGE (Municipal livestock research)
	Rice production (% in relation to the state)	IBGE (municipal agricultural production)
	Coffee production (% in relation to the state)	IBGE (municipal agricultural production)
	Value of Production of Brazil Nuts (thousand BRL)	IBGE (Production of plant extraction and forestry)
	Value of the production of round wood (Thousand BRL)	IBGE (Production of plant extraction and forestry)
social index	Population served with water supply (%)	IBGE (demographic census)
	Unit No. Health (per thousand inhabitants)	DATASUS
	Number of beds (per thousand inhabitants)	DATASUS
	Number of doctors (per thousand inhabitants)	DATASUS
	IFDM Consolidated	Firjan

IFDM Employment & Income	Firjan
IFDM Education	Firjan
IFDM Health	Firjan
IDEB - Elementary school (early years)	INEP
IDEB - Elementary school (final years)	INEP

Source: Own elaboration

Table 2: Survey of quantitative data effectively worked on for the preparation of the regional development index of the present study

THEME	INDICATORS	SOURCE
economic index	Gross Domestic Product per capita, at current prices (R$ 1.00)	IBGE (Statistics)
	Share of gross value added at current prices of agriculture in the gross value added at current prices of agriculture in the federation unit (%)	IBGE (Statistics)
	Share of gross value added at current industry prices in gross value added at current prices of industry in the federation unit (%)	IBGE (Statistics)
	Share of gross value added at current prices of services, administration, defence, education and public health and social security, in added value	IBGE (Statistics)
	Participação do valor adicionado bruto a preços correntes total no valor adicionado bruto a preços correntes total da unidade da federação (%)	IBGE (Statistics)
	Gross Domestic Product, at current prices (R$ 1,000)	IBGE (Statistics)
	number of cattle	IBGE (Municipal livestock research)
	Coffee production (% in relation to the state)	IBGE (municipal agricultural production)
	Value of the production of round wood (Thousand BRL)	IBGE (Production of plant extraction and forestry)
social index	Population served with water supply (%)	IBGE (demographic census)
	Unit No. Health (per thousand inhabitants)	DATASUS
	Number of beds (per thousand inhabitants)	DATASUS
	Number of doctors (per thousand inhabitants)	DATASUS
	IFDM Consolidated	Firjan
	IFDM Employment & Income	Firjan
	IFDM Education	Firjan
	IFDM Health	Firjan
	IDEB - Elementary school (early years)	INEP

Source: Own elaboration

2.4 DATA PROCESSING

This is a factor analysis study. The model in question follows the calculation reasoning proposed or applied by Reis [5]; Hair et al [6]; Santana [7] and Santana [8]; Gama et al. [9]; Santana [10]; Fávaro and Belfiore [11].This model has already been tested and applied in other studies, such as Cavalcante [12], Paraguassu-Chaves

et.at [13]; Paraguassu-Chaves et.at [14]; Paraguassu-Chaves et.at [15]; Paraguassu-Chaves et.at [16]; Paraguassu-Chaves et.at [17]; Paraguassu-Chaves et.at [18], where it was possible to build indexes within this methodological perspective. According to Hair et.al [6] factor analysis is a generic name given to a class of multivariate statistical methods whose main purpose is to define the underlying structure in a data matrix. Complementing this reasoning, the aforementioned authors also reveal that when summarizing the data, the factor analysis obtains latent dimensions that, when interpreted and understood, describe the data in a much smaller number of concepts than the original individual variables. The logic of construction of the social and economic indices, proposed here, therefore follows this reasoning.

These authors reveal that although there is still much debate about which factor model is the most appropriate, empirical research has shown similar results in many cases. Continuing with this reasoning, the authors state that in most applications, both principal component analysis and common factor analysis arrive at essentially identical results if the number of variables exceeds 30, or if the commonalities exceed 0.60 for most of the variables.

Therefore, factor analysis can identify the structure of a set of variables, as well as provide a process for data reduction [6]. In this study, we adopted the same methodological procedures already experienced by the authors in other research experiences. Thus, the factor analysis model adopted here is very similar to the principal components model, according to Santana [7] and Santana [8]. Also according to this author, the principal components model with m components and p variables ($q < p$), can be written based on the description presented by Dillon; Goldstein (1984), in which the model is presented in matrix form (Equation 1):

$$CP_1 = Y_{11}X_1 + Y_{12}X_2 + \cdots + Y_{IP}X_P$$
$$CP_2 = Y_{21}X_1 + Y_{22}X_2 + \cdots + Y_{2P}X_P$$

Equation (1)

$$CP_q = Y_{m1}X_1 + Y_{m2}X_2 + \cdots + Y_{qp}X_p$$

On what:

CPi = are the i-th principal components (i = 1, 2, ..., q);

ij = are the coefficients related to each variable;

Xj = are the jth variables (j = 1, 2, ..., p).

On the other hand, the basic model of factor analysis, according to Santana [7] and Santana [8], expresses each variable in terms of common latent factors and a single factor or specific factor. The algebraic representation of the model is given by equation 2:

$$X_1 = \lambda_{11}FC_1 + \lambda_{12}FC_2 + \cdots + \lambda_{Iq}FC_q + \varepsilon_1$$
$$X_2 = \lambda_{21}FC_1 + \lambda_{22}FC_2 + \cdots + \lambda_{2q}FC_q + \varepsilon_2$$

Equation (2)

$$X_p = \lambda_{p1}FC_1 + \lambda_{p2}FC_2 + \cdots + \lambda_{p.q}FC_q + \varepsilon_{mp}$$

On what:

Xi = are the i-th variables (i = 1, 2, ..., p);

ij = are the coefficients related to each common factor;

FCj = are the jth common factors (j = 1, 2, ..., q);

i = are the i-th specific factors.

Thus, according to the author in question, the basic model of common factors is usually expressed in matrix form as in equation 3, according to Dillon; Goldstein [19]:

$$.X = \alpha F + \varepsilon \quad \text{Equation (3)}$$

Being,

X = the **p-dimensional**, vector transposed of the observable variables, denoted by $X = (x_1, x_2,..., x_p)$;

F = the **q-dimensional**, vector transposed of unobservable variables or latent variables called common factors, denoted by $F = (f_1, f_2,..., f_q)$, being that q < p;

ε = the **p-dimensional** vector transposed of random variables or single factors, denoted by ε = (e₁, e₂,..., eₚ);

α = the matrix (p,q) of unknown constants, called factor loadings.

In the factor analysis process, an important aspect to be submitted to the data is the rotation of factors, through a factorial rotation tool, according to Hair e.al [6]. In practice, according to the same authors, the objective of all rotation methods is to simplify the rows and columns of the factor matrix to facilitate interpretation. Thus, it is assumed that in the factor analysis model the specific factors are orthogonal to each other, with all the common factors, where it is normally adopted that: E (ε) = E (F) = 0 and Cov (ε, F) = 0, according to Gama et.al., 2007 and Santana, 2007a. According to these authors, the initial structure used to determine the factor loading matrix, in general, may not provide a significant pattern of variable loadings, thus indicating that there is not something that signals a definitive way for this to occur. Thus, the confirmation or not of this initial structure can be done through various methods of factor rotation, according to Dillon; Godstein [19]; Johnson and Wichern [20]. For the purpose of the present construction of the regional development performance index, the VARIMAX method was adopted, considered one of the most popular methods

of orthogonal rotation of factors [6]. The VARIMAX method is a process in which the reference axes of the factors are rotated around the origin until some other position is reached. The objective is to redistribute the variance from the first factors to the others and reach a simpler and theoretically more significant factor pattern (HAIR et al [6]; SANTANA [7] and SANTANA [8]; GAMA et al [9]; SANTANA [21]; SANTANA[22].

The choice of factors, in turn, is performed using the latent root technique. According to Hair et.al.[6]latent root is the column sum of factor loadings squared for a factor. Also called eigenvalue, it corresponds to the amount of variance explained by a factor. According to these authors, a factor is understood to be the linear combination (statistical variable) of the original variables. The factors also represent the latent dimensions (constructs) that summarize or explain the original set of observed variables. Thus, the factor loading matrix that measures the correlation between common factors and observable variables is determined through the correlation matrix, according to Dillon; Goldstein[19]. Therefore, to determine the performance indices of economic and social development, we used the matrix of factor scores estimated by the factorial orthogonal rotation process, as pointed out by Santana[21]. The factor score, by definition, places each observation in the space of common factors. For each factor f_j, extracted factor score is defined by F_{ij}, expressed as follows (equation 4) [19]:

$$F_{IJ} = b_1 x_{i1} + b_2 x_{i2} + b_p x_{ip} \text{Equation (4)}$$

Being that:

$b_i =$ are the estimated regression coefficients for the **n** common factor scores.

$x_{ij} =$ are the **n** observations of the **p** observable variables.

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

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

Gama et al [9] and Santana [22] show the evolutionary sequence of the formulas from the previous equation, which allows arriving at the equation that represents the regional development performance index of the municipalities object of the present study. Thus, according to the authors, it appears that although the variable F_{ij} is not observable, it can be estimated using factor analysis techniques, using the matrix of observations of the vector x of observable variables. In factorial notation, equation 5 becomes:

$$F_{(n,q)} = X_{(n,q)} b_{(p,q)} \text{Equation (5)}$$

According to Santana[22], in equation 5, F is the regression matrix estimated from the n factor scores, which can be affected both by the magnitude and by the measurement units of the x variables. To get around this type of problem, the variable x is replaced by the standardized variable w, (equation 6), given by the ratio between the deviation from the mean and the standard deviation of x, as follows:

$$w_{ij} = \text{Equation (6)}$$

With these values, equation 6 is modified making equation 7 possible, as follows:

$$F_{(n,q)} = w_{(n,q)} \beta_{(p,q)} \text{Equation (7)}$$

Based on equation 7, the beta weight matrix (β) with q standardized regression coefficients, replaces b, given that the variables are standardized on both sides of the equation. Pre-multiplying both sides of equation 6 by the value $\frac{1}{n}w'$, where n is the number of observations and w' is the transposed matrix of w, makes it possible to arrive at equation 8 [22]:

$$\frac{1}{n}w'_{(p,n)}F_{(n,q)} = \frac{1}{n}w'_{(p,n)}w_{(n,p)}\beta_{(p,q)} = R_{(p,p)}\beta_{(p,q)}\text{Equation (8)}$$

According to Santana[22]the matrix $\frac{1}{n}w'w$ it is constituted in the matrix of inter-correlated variables or matrix of correlation between the observations of the matrix x, designated by R. The matrix $\frac{1}{k}w'F$ represents the correlation between factor scores and the factors themselves, denoted by Λ. Thus, rewriting Equation 9, we have that:

$$\Lambda_{(p,q)} = R_{(p,p)}\beta_{(p,q)}\text{Equation (9)}$$

The same author continues revealing that if the matrix R is non-singular, one can pre-multiply both sides of equation 10 by the inverse of R, obtaining:

$$\beta = R^{-1}\Lambda \text{Equation (10)}$$

Thus, substituting the β vector in equation 4, we obtain the factor score associated with each observation (equation 11), as follows:

$$F_{(n,q)} = w_{(n,p)}R^{-1}_{(p,p)}\Lambda_{(p,q)}\text{Equation (11)}$$

Thus, the main formula for the socioeconomic performance index (IDSE) of the municipalities studied is arrived at, from the perspective of the perception of regional development, which is defined as a linear combination of these factor scores and the proportion of variance explained by each factor in relation to to the common variance. The mathematical expression is now represented by the following formula (equation 12), which was based on Santana[22]:

$$IDL_i = \sum_{j=1}^{q}\left(\frac{\lambda_j}{\sum_j \lambda_j}FP_{ij}\right)\text{Equation (12)}$$

Where,

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

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

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

The factor score was standardized (FP) to obtain positive values from the original scores and allow the ranking of performances to be determined by the index in question, which ranges from 0 to 1. The formula that allows this hierarchy can be seen by equation 13:

$$FP_i = \text{Equation (13)}$$

It is thus seen that F_{min} e F_{max} are the maximum and minimum values observed for the factor scores associated with the performance of the socioeconomic development index (IDSE) from the perspective of the perception of regional development adopted for the present study.

With this, with multiple potential for use, due to the wide capillarity of studies linked to the interest in better understanding and analyzing, in practice, the theme of socioeconomic development and the scenarios of the local and regional reality around the Brazilian western Amazon region, which the analysis of economic and social indicators based on the multivariate method of data, using the technique of factor analysis and statistical tools from SPSS, allows the construction of a critical view of SUFRAMA's policy and its reflection in the perspective of regional development.

It is hoped, therefore, that this work can help in debates in terms of public policies for regional development, considering the economic and social focus as the axis of analysis. Thus, in the current scenario, where the issue of the Amazon has been more effectively demanded at the negotiation tables for the conclusion of bilateral or multilateral agreements in the spheres of economic and social integration, such as economic blocs, common markets, cooperation between countries, channel efforts to the field of academic debate, from the critical view applied to the process of understanding and interpreting the regional reality, its internal dynamics and the trend of its historical trajectory, thus allowing to build a clear and objective perception of the reality object of the present study, in order to bring new elements and new bases for discussion in the context of SUFRAMA's policy focused on aspects of economic and social development.

2.5 DATA ADEQUACY CRITERIA FOR FACTOR ANALYSIS

According to Santana[22], the two main tests that assess data adequacy for factor analysis are the Bartlett sphericity tests, which assess the general significance of the correlation matrix, that is, it tests the null hypothesis that the correlation matrix correlation is an identity matrix;

and the Kaiser-Meyer-Olkin (KMO) test, which is based on the principle that the inverse of the correlation matrix approximates the diagonal matrix, in order to compare the correlations between the observable variables. Such models can be expressed in mathematical formulas. Said mathematical formulas of these tests are based on Dillon; Goldstein [19]; Reis [5], Santana [22].

a) Bartlett's test

According to Santana [22], in particular, the Bartlett test of sphericity tests the null hypothesis that the variables are independent, against the alternative hypothesis that the variables are correlated with each other, as can be represented as follows, according to the said author:

$$H_0: R = Iou H_0: \lambda, = \lambda_2 = \cdots = \lambda_P, \text{ (Equation 14)}$$
and is given by:

$$X^2 = -\left[n - 1 - \frac{1}{6}(2p + 5)\right] . \in \left|R\right| \text{ (Equation 15)}$$
ou

$$X^2 = -\left[n - 1 - \frac{1}{6}(2p + 5)\right] . \sum_{i=1}^{p} . \in . \lambda_i \text{(Equation 16)}.$$

On what:

|**R**| is the determinant of the sample correlation matrix;

λ is the variance explained by each factor;

n is the number of observations; and

p is the number of variables.

The statistic has an asymptotic distribution of x^2 com [0,5.p.(p-1)] degrees of freedom.

b) Kaiser-Meyer-Olkin (KMO) test

The mathematical formulas for these tests were based on Dillon; Goldstein [19], Reis [5], according to Santana [22]:

$$KMO = \frac{\sum_i \sum_j r_{ij}^2}{\sum_i \sum_j r_{ij}^2 + \sum_i \sum_j a_{ij}^2} \text{(Equation 17)}$$

On what:

rij is the sample correlation coefficient between variables xi and xj;

aij is the partial correlation coefficient between the same variables that is, simultaneously, an estimate of the correlations between the factors, eliminating the effect of the other variables.

The **a**ij should assume values close to zero, since the factors are assumed to be orthogonal to each other. Values of this test below 0.5 are unacceptable [6].

c) Commonality

In addition to the two previous tests, there is also commonality as an important criterion for testing the suitability of data for factor analysis. In this sense, commonality is the proportion of common variance present in a given variable. Thus, on a scale of zero to one, a variable that does not present specific variance or error would have a commonality of 1, while a variable that does not share variance with any other variable would have a commonality of value 0. In general, the literature indicates a minimum value of 0.5 for commonality to be considered satisfactory. Therefore, for a variable to work well in a factor analysis, it needs to have a large proportion of common variance (HAIR et.al [6]; MATOS and RODRIGUES [23]). In the specific case of this study, the cumulativeness met the requirements for factor analysis.

2.6 SCALE ADOPTED FOR ANALYSIS OF SOCIAL AND ECONOMIC INDICES

Below is table 3, which illustrates the description of the scale adopted for this study.

Table 3: Index scale and description

Scale	Description
0.801 to 1.000	Very high
0,601 to 0,800	High
0,401 to 0,600	Regular
0,201 to 0,400	**Weak**
< 0,200	**Very weak**

Source: Authors

III.   DATA ANALYSIS AND DISCUSSION

3.1 Determination of the economic index of municipalities with SUFRAMA: 2010 and 2018

The economic development index for the municipalities assisted by the SUFRAMA policy in 2010. The highest rates found corresponded to the municipalities of Macapá (0.717) and Boa Vista (0.652), capitals of the States of Amapá and Roraima, respectively. Next, the municipality of Brasiléia (Acre) presented an index of 0.307, followed by the municipality of Santana (Amapá) of 0.239. The other municipalities presented indexes below 0.200, which here was classified as having very low performance.

In 2018, the economic development index was higher in Boa Vista (Roraima) with an index of 0.713 and in Macapá (Amapá) with an index of 0.626, followed by Brasiléia (Acre) with 0.319, Bonfim (Roraima) with 0.243 and Epitaciolândia (Acre) with 0.224, and the other

municipalities presented performances below 0.200. The municipality with the highest growth rate in the IDEC in the period in question were the municipalities of Bonfim (Roraima) with 57.3% growth, Epitaciolândia (Acre) with 35.4% and Guajará-Mirim (Rondônia) with 13.1%. The municipalities that presented the highest negative growth rates were: Santana (Amapá) with -21.3% and Macapá (Amapá) with -12.8%.

3.2 Determination of the social index of municipalities with SUFRAMA: 2010 and 2018

From the point of view of social development based on the year 2010, the two capitals continue to stand out in relation to the other municipalities assisted by the SUFRAMA policy, with Macapá (Amapá) reaching an index of 0.581 and Boa Vista (Roraima) of 0.580. Next, in descending order, come the municipalities of Santana (Amapá) and Brasiléia (Acre), which reached, respectively, social development indices of 0.402 and 0.388. Then, also in descending order, are the municipalities of Cruzeiro do Sul (Acre) with 0.319; Guajará-Mirim (Rondônia) with 0.310; Epitaciolândia (Acre) with 0.303; Bonfim (Roraima) with 0.258 and Tabatinga (Amazonas) with an index below 0.200.

According to the IDSO results for the year 2018 in relation to the municipalities assisted with the SUFRAMA policy, the highest IDSO was observed in the municipality of Boa Vista (Roraima) with a performance of 0.700. Next come the municipalities of Cruzeiro do Sul (Acre) with 0.508; Brasilândia (Acre) with 0.487; Macapá (Amapá) with 0.447; Guajará-Mirim (Rondônia) with 0.373; Epitaciolândia (Acre) with 0.342; Tabatinga (Amazonas) with 0.338; Bonfim (Roraima) with 0.322; Santana (Amapá) with 0.319.

From the point of view of growth in the analyzed period (IDSO-2010 and IDSO-2018), it appears that only 22.2% of the municipalities assisted by the SUFRAMA policy had negative growth rates and this reality was observed exclusively in the municipalities of Amapá participating in this study, where the municipality of Macapá presented a rate of -23.0% and Santana with -20.7% of growth in the period. The other municipalities showed positive growth rates, especially Tabatinga (Amazonas) which achieved the highest growth rate in the period (222.6%). The others showed the following growth rates, in descending order, Cruzeiro do Sul (Acre) = 59.3%, Bonfim (Roraima) = 35.1%, Boa Vista (Roraima) = 20.7%, Guajará-Mirim (Rondônia) = 20.6% and Epitaciolândia (Acre) = 12.9%.

3.3 Determination of the economic index of municipalities without SUFRAMA: 2010 and 2018

The IDEC of the municipalities that are not assisted by the SUFRAMA policy reached a performance considered "low" for 40% of them and "very low" for the other 60%. In descending order, the performance found follows the following sequence: Pimenta Bueno (Rondônia) = 0.329, Sena Madureira (Acre) = 0.229. The other municipalities presented results below 0.200.

The distribution of performances in 2018 followed practically the same trends observed for 2010. Thus, in descending order, the performance of IDEC 2018 corresponded to the following sequence: Pimenta Bueno (Rondônia) = 0.326, Buritis (Rondônia) = 0.283, Nova Mamoré (Rondônia) = 0.248 and Sena Madureira (Acre) = 0.202. The other municipalities presented results below 0.200.

Thus, these results allow analyzing the growth rate in the period in question, that is, between 2010 and 2018, in relation to the IDEC. As a result, a negative growth rate was observed in 60% of the municipalities, namely: Barcelos (Amazonas) =-100%, Benjamin Constant (Amazonas) = -42.1%, Sena Madureira (Acre) = -11, 9%, Tarauacá (Acre) = -2.8% and Pimenta Bueno (Rondônia) = -0.9%. On the other hand, the other municipalities showed positive growth rates, namely: Boca do Acre (Acre) = 179.1%, Feijó (Acre) = 13.1%, Buritis (Rondônia) = 7.7% and Nova Mamoré (Rondonia) = 5.4%.

3.4 Determination of the social development index of municipalities without SUFRAMA: 2010 and 2018

Graph 1 illustrates the results of the IDSO-2010 for the municipalities without SUFRAMA surveyed.

Graph 1: Social development index of municipalities without Suframa: 2010
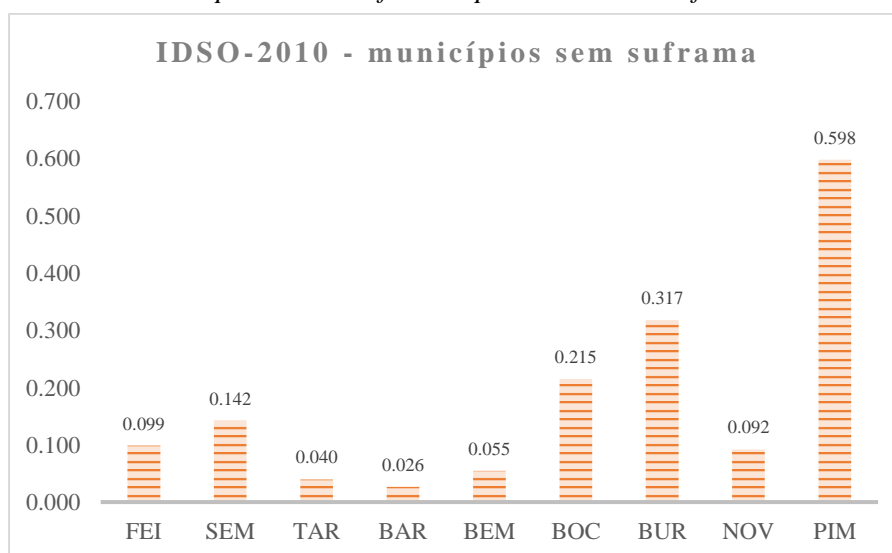
Source: Determined by research.

The IDSO - 2010 for the municipalities without SUFRAMA, illustrated by graph 1, with the exception of the municipality of Pimenta Bueno (Rondônia) which achieved the highest performance among the other municipalities, however with a scale level classified as "regular" performance, when reaching the IDSO of 0.598, corresponding to approximately 10% of the representation of the municipalities, indicates a scenario of either very low performance, as was the case of almost all municipalities in this performance range, that is, approximately 70% of them, or of low performance , for

the remaining 20% of the municipalities (Graph 2). Thus, the municipalities with low performance were: Buritis (Rondônia) = 0.317 and Boca do Acre (Amazonas) = 0.215. The municipalities with very low performance, in descending order, were: Sena Madureira (AC) = 0.142, Feijó (Acre) = 0.099, Nova Mamoré (Rondônia) = 0.092, Tarauacá (Acre) = 0.040 and Barcelos (Amazonas) = 0.026 . Graph 2 presents the results of the social development index for the year 2018 for the municipalities not covered by the SUFRAMA policy.

Graph 2: Social development index of municipalities without Suframa: 2018
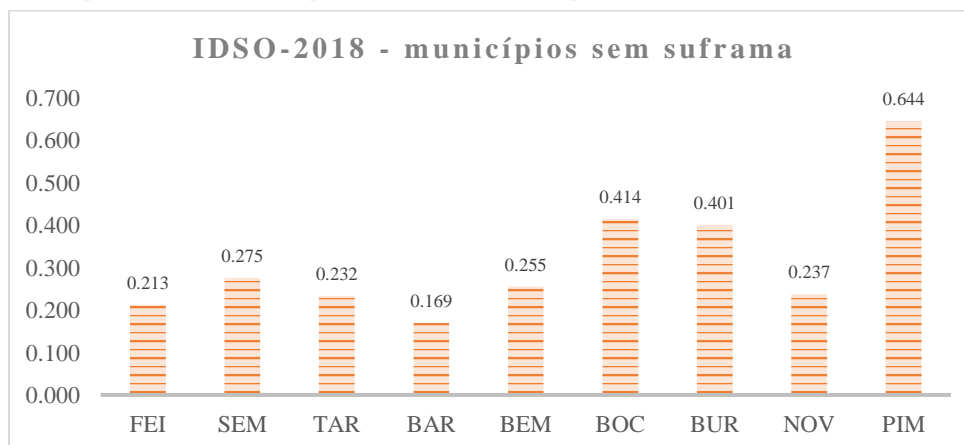
Source: Determined by research.

Chart 2 shows a trend in the behavior of the results similar to that shown in the previous chart, which corresponded to 2010 data. Thus, in descending order, it is noted that the highest performance was achieved by the municipality of Pimenta Bueno (Rondônia) with 0.644, followed by the municipalities of Boca do Acre (Amazonas) with 0.414, Buritis (Rondônia) with 0.401, Sena Madureira (Acre) with 0.275, Benjamin Constant (AM) with 0.255, Nova Mamoré (Rondônia) with 0.237,

Tarauacá (Acre) with 0.232 and Feijó (Acre) with 0.213. The municipality of Barcelos (Amazonas) was the only one to have a performance below 0.200 in this analysis.

Table 4 presents all the results found for the social and economic indices for the years 2010 and 2018, along with the respective growth rates observed in the period.

Table 4: Socioeconomic indices determined by the survey for the municipalities surveyed for the years 2010 and 2018 and the growth rates in the period.

Municipalities	IDSO-2010	IDSO-2018	Growth rate %	IDEC-2010	IDEC-2018	Growth rate
TAB	0,105	0,338	222,6	0,024	0,023	-4,8
GUA	0,310	0,373	20,6	0,116	0,131	13,1
BOA	0,580	0,700	20,7	0,652	0,713	9,3
BON	0,238	0,322	35,1	0,154	0,243	57,3
MAC	0,581	0,447	-23,0	0,717	0,626	-12,8
SAN	0,402	0,319	-20,7	0,239	0,188	-21,3
BRA	0,388	0,487	25,4	0,307	0,319	3,7
CRU	0,319	0,508	59,3	0,169	0,166	-2,1
EPI	0,303	0,342	12,9	0,166	0,224	35,4
FEI	0,099	0,213	115,7	0,112	0,126	13,1
SEN	0,142	0,275	93,5	0,229	0,202	-11,9
TAR	0,040	0,232	487,2	0,125	0,121	-2,8
BAR	0,026	0,169	542,9	0,015	0,000	-100
BEN	0,055	0,255	367,1	0,023	0,013	-42,1

BOC	**0,215**	**0,414**	92,9	**0,063**	**0,176**	179,1
BUR	**0,317**	**0,401**	26,3	**0,263**	**0,283**	7,7
NOV	**0,092**	**0,237**	157,7	**0,235**	**0,248**	5,4
PIM	**0,598**	**0,644**	7,7	**0,329**	**0,326**	-0,9

Source: Search result..   Subtitle:

	Municipalities WITH SUFRAMA
	Municipalities WITHOUT SUFRAMA

Based on this table, it was possible to organize the results found for the IDEC and IDSO indexes grouped in the two groups of municipalities studied in this study: with SUFRAMA and without SUFRAMA.

Thus, associating the respective indices with the scale adopted in this study, tables from 5 to 6 were prepared with the objective of distributing the results found by the cities surveyed according to the parameters adopted. Table 5, in turn, deals with the IDSO-2010 and IDSO-2018 for the municipalities assisted by the SUFRAMA policy.

Table 5: Classification of municipalities with SUFRAMA according to the scale of this research based on the social index.

Scale	Description	IDSO-2010	IDSO-2018
0,801 – 1,000	**Very high**	-	-
0,601 – 0800	**High**	-	BOA
0,401 – 0,600	**Regular**	BOA, MAC, SAN	MAC, BRA, CRU
0,201 – 0,400	**Weak**	GUA, BOM, BRA, CRU, EPI	TAB, GUA, BOM, SAN, EPI
<0,200	**Very weak**	TAB	-

Source: Search result.

The municipalities of Boa Vista (Roraima), Macapá (Amapá) and Santana (Amapá), in 2010, reached the same level of performance, classified as "regular". The municipalities of Guajará-Mirim (Rondônia), Bonfim (Roraima), Brasiléia (Acre), Cruzeiro do Sul (Acre) and Epitaciolândia (Acre) achieved a performance considered weak in this study. O pior desempenho foi registrado para o município de Tabatinga (Amazonas) que teve um desempenho muito ruim. In 2018, the situation improves for the municipality of Boa Vista (Roraima), which achieves a performance considered "high". The municipality of Macapá (Amapá) remains at the same performance level as it was in 2010, that is, it remains at the "regular" level of performance in 2018. The municipality of Santana (Amapá) also recorded a drop in the period from 2010 to 2018, going from a "regular" performance to a "poor" performance in the last year of analysis. With the exception of the municipality of Cruzeiro do Sul (Acre), which rose in the performance category in 2018, upon reaching the high performance scale, all other municipalities that had a "poor" performance in 2010 remained in the same performance range in the year 2018. Added to this list of municipalities with poor performance was the municipality of Tabatinga (Amazonas), which in the previous year had a performance considered very weak (Table 5).

Table 6 deals with the IDEC-2010 and IDEC-2018 for the municipalities covered by the SUFRAMA policy.

Table 6: Classification of municipalities with SUFRAMA according to the scale of this research based on the economic index.

Scale	Description	IDEC-2010	IDEC-2018
0,801 – 1,000	Very high	-	-
0,601 – 0800	High	BOA, MAC	BOA, MAC
0,401 – 0,600	Regular	-	-
0,201 – 0,400	Weak	SAN, BRA	BOM, BRA, EPI
<0,200	Very weak	TAB, GUA, BOM, CRU, EPI	TAB, GUA, SAN, CRU

Source: Search result.

From table 6 it is possible to observe that the municipalities of Boa Vista (Roraima) and Macapá (Amapá) remained in the same high performance category of the IDEC in both analyzed years, no municipality was observed in the category of very high or regular performance. In 2010, only the municipalities of Santana (Amapá) and Brasilândia (Acre) had regular performance. However, in 2018, only Brasilândia (Amapá) remains in this category, along with the municipalities of Bonfim (Roraima) and Epitaciolândia (Acre) that increased in performance, since in 2010 both municipalities were in the range of very poor performance. Thus, in 2018, the municipality of Santana (Amapá) falls into the range of very poor performance, in addition to the municipalities of Tabatinga (Amazonas), Guajará-Mirim (Rondônia) and Cruzeiro do Sul (Acre) that remained at this level of very poor performance in the period from 2010 to 2018.

Tables 7 and 8 refer to municipalities not covered by the SUFRAMA policy for IDS0 2010-2018 and IDEC 2010-2018, respectively.

Table 7: Classification of municipalities without SUFRAMA according to the scale of this research based on the social index.

Scale	Description	IDSO-2010	IDSO-2018
0,801 – 1,000	Very high	-	-
0,601 – 0800	High	-	PIM
0,401 – 0,600	Regular	PIM	BOC, BUR
0,201 – 0,400	Weak	BOC, BUR	FEI, SEM, TAR, BEM, NOV
<0,200	Very weak	FEI, SEM, TAR, BAR, BEM, NOV	BAR

Source: Search result.

In relation to table 7, it is possible to observe, with the exception of the municipality of Barcelos (Amazonas) which remained in the same category of very poor performance in the two years surveyed, the other municipalities rose in performance category in the period from 2010 to 2018. Thus, the municipality of Pimenta Bueno (Rondônia), which was in the regular performance range in 2010, moves to the high performance category in 2018. In the same way that the municipalities of Boca do Acre (Amazonas) and Buritis (Rondônia) that were in the low performance range in 2010 reach, in 2018, the regular performance range. And the municipalities of Feijó (Acre), Sena Madureira (Acre), Tarauacá (Acre), Benjamin Constant (Amazonas) and Nova Mamoré (Rondônia), which were in the range of very poor performance in 2010, moved up to the range of weak performance in 2018.

Table 8: Classification of municipalities without SUFRAMA according to the scale of this research based on the economic index.

Scale	Description	IDEC-2010	IDEC-2018
0,801 – 1,000	Very high	-	-
0,601 – 0800	High	-	-
0,401 – 0,600	Regular	-	-
0,201 – 0,400	Weak	SEM, NOV, PIM, BUR	SEM, NOV, PIM, BUR
<0,200	Very weak	FEI, TAR, BAR, BEM, BOC	FEI, TAR, BAR, BEM, BOC

Source: Search result.

Table 8, in turn, illustrates the result for the performance of the economic development index for the municipalities not covered by the SUFRAMA policy. Based on this table, it is possible to observe that the two scenarios inherent to the performance of IDEC-2010 and IDEC-2018, there was no change in the period. Thus, the municipalities of Sena Madureira (Acre), Nova Mamoré (Rondônia), Pimenta Bueno (Rondônia) and Buritis (Rondônia), which were in the low performance range in 2010, remained in the same range in 2018. Likewise, the municipalities of Feijó (Acre), Tarauacá (Acre), Barcelos (Amazonas), Benjamin Constant (Amazonas) and Boca do Acre (Amazonas) remained in the range of very poor performance for the two analyzed periods. In this way, it can be seen that there was a concentration of municipalities in the range of "weak" or "very weak" performance for the year 2010 and 2018, unchanged.

Municipalities of Macapá (Amapá) and Boa Vista (Roraima) compare themselves in comparison with other surveyed municipalities present the highest social and economic performances for the year 2010. Pimenta Bueno (Rondônia) also stands out for presenting a relatively high social index, the other municipalities surveyed had average performances with a tendency to weak or very poor performance for the two indexes surveyed, considering the scale adopted in this work.

The results point to the high performance of the municipalities of Boa Vista (Roraima) and Macapá (Amapá) for the IDEC-2018 and the high performance of the IDSO-2018 for the municipalities of Boa Vista (Roraima) and Pimenta Bueno (Rondônia). In view of this context, the other municipalities were distributed in a range either with regular performance or with weak and very poor performance, in general.

Thus, analyzing the data presented so far, the complex reality of the Amazonian municipalities calls attention, which, not infrequently, tends to demonstrate a scenario that still lacks a regional development process that can in fact lead to a perspective of institutional change, according to North[24]and that, therefore, can lead them to new trajectories, to new scenarios, to new levels. However, what is evident in this work is that although there is a certain dynamic among the cities surveyed, in general, such dynamics are located at a critical level, where the signal is alarmed. This indicates that there is a need for greater attention from the government as an agent of change through public policies, within a context of endogenous or local development. However, there is another aspect that has not been researched, but that is essential for such a change to occur. It is about social capital as a collective mechanism for the convergence of forces, in order to enhance what there is of aptitude in the region, within an internal social perspective based on the context of endogenous development.

Such results indicate that development is still something difficult to be perceived within the Amazon regional context. Thinking about the Amazon with its peculiarities and complexities is the best way to go. However, in general terms, this is not what happens in practice. And the result ends up producing scenarios with multiple variables that end up interfering in some way in the local and regional dynamics. Understanding and interpreting such a complex reality is the challenge that continues to be projected in time and space, owing, even, to the economy, the challenge of contributing to the explanation of the phenomena that tend to have increasingly complex behaviors of reality. For this, it is necessary to find orthodox and/or heterodox economic forms of development capable of pulling up this scenario observed by the surveyed municipalities, which still tend to rest their dynamics on the lowest levels of development, with reflections, including, on the quality of local and regional life.

Graph 3, below, illustrates the results found for the IDSO-2010 and IDSO-2018 for all the municipalities surveyed. Based on it, it is possible to verify a certain improvement in the social development index, both for 2010 and 2018.

Graph 3: Social performance index of the surveyed municipalities.
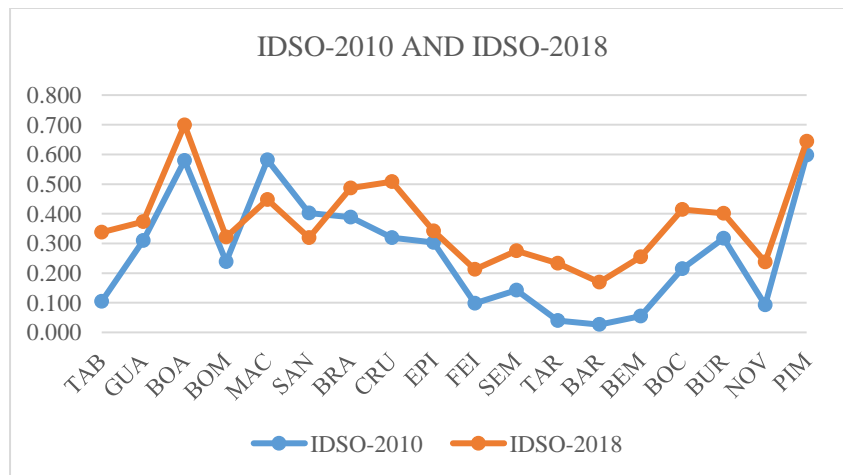
Source: Search result.

Thus, it can be seen from graph 3 that 70% of the municipalities assisted by the SUFRAMA policy showed improvements in their performance from 2010 to 2018 and, in the same way, 100% of the municipalities not served by this policy had their rates improved from 2010 to 2018. Graph 4, in turn, concerns IDEC-2010 and IDEC-2018.

Graph 4: Economic performance index of the surveyed municipalities.
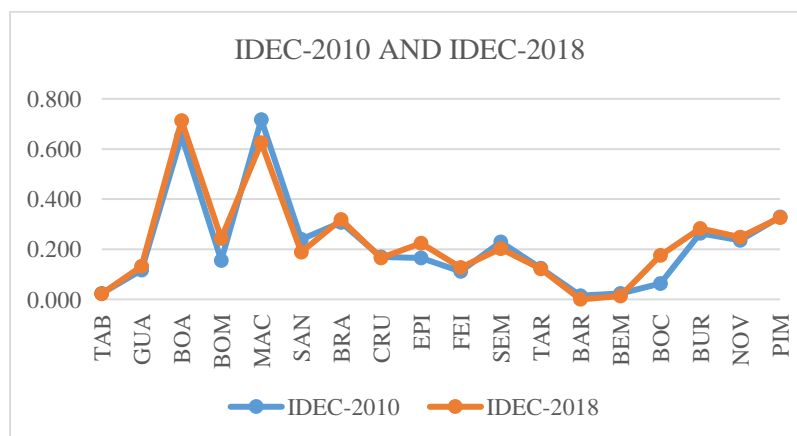
Source: Search result.

Based on this graph, it appears that there was almost no change in performance in the two years surveyed. However, 50% of the municipalities assisted by the SUFRAMA policy had a small and slight improvement in 2018 when compared to 2010. Regarding the municipalities without SUFRAMA, it was observed that approximately 30% of the municipalities had a slight improvement in performance. Aiming to obtain new perspectives of analysis, tables 9 and 10 were constructed that deal with the distribution and frequency of the indexes for a certain level of scale for the municipalities with SUFRAMA and without SUFRAMA, respectively. It can be observed that 66.7% of the municipalities served by SUFRAMA that participated in this research presented "weak" and "very weak" performance for the social development index for the year 2010. For 2018 this index was even higher, reaching 77.8% with low performance level.

Table 9: Distribution and relative frequency of the socioeconomic indices of the municipalities WITH SUFRAMA determined by the survey.

Scale	Description	IDSO-2010		IDSO-2018		IDEC-2010		IDEC-2018	
		qde	%	qde	%	Qde	%	qde	%
0,801 – 1,000	Very high	-	-	-	-	-	-	-	-
0,601 – 0,800	High	-	-	1	11,1	2	22,2	2	22,2
0,401 – 0,600	Regular	3	33,3	3	33,3	-	-	-	-
0,201 – 0,400	Weak	5	55.6	5	55,6	2	22,2	3	33,3
➢ 0,200	Very weak	1	11,1	-	-	5	55,6	4	44,5
Total	-	9	100%	9	100%	9	100%	9	100%

Source: Search result.

Although the SUFRAMA policy is a reality for these municipalities, it is noticeable from the data and indices analyzed that such a scenario could be even worse if such a policy did not exist. This allows us to point out that it is not simply a matter of denying the importance of the aforementioned regional development policy, but of stating that there is a need to redirect the strategic focus so that SUFRAMA's policy can be felt more strongly by society in general, especially those residing in local level

In this sense, it is worth noting, in general, the fact that the taxes generated by economic activities in these municipalities assisted by the policy of influence of the Manaus Free Trade Zone are normally directed to the federal government treasury, with no possibility of part of this amount being applied in the region covered by the said policy. Thus, the return of part of these values transferred to the treasury to be applied in local public policies seems to us to be a fair measure for strategic planning in favor of local and endogenous development. Thus, strengthening the internal social capital and the natural vocation of these regions that could focus their planning in favor of actions that aim to guarantee greater investments in infrastructure, health, education, etc. In relation to the municipalities unassisted by the SUFRAMA policy, the result was even worse. (Table 10).

Table 10: Distribution and relative frequency of socioeconomic indices of municipalities WITHOUT SUFRAMA determined by the survey.

Scale	Description	IDSO-2010		IDSO-2018		ÍDEC-2010		ÍDEC-2018	
		qde	%	qde	%	qde	%	qde	%
0,801 – 1,000	Very high	-	-	-	-	-	-	-	-
0,601 – 0,800	High	-	-	1	11,1	-	-	-	-
0,401 – 0,600	Regular	1	11,1	2	22,2	-	-	-	-
0,201 – 0,400	Weak	2	22,2	5	56,6	4	44,4	4	44,4
➢ 0,200	Very weak	6	66,7	1	11,1	5	55,6	5	55,6
Total	-	9	100%	9	100%	9	100%	9	100%

Source: Search result.

In this sense, 88.9% of these municipalities were at the "weak" and "very weak" level of development, both in 2010 and 2018. Regarding the economic development index for the year 2010, it was observed that 100% of the municipalities presented "weak" and "very weak" performances for both 2010 and 2018.

Although these results have been reached, further research and deeper analysis is necessary due to the multiple variables that may be acting and interfering in the

dynamics observed in this study. Anyway, the present study signals a worrying scenario in terms of regional development, seen here based on economic and social indices, which allows new abstractions regarding the Brazilian Amazon region. By taking the average of the indexes between the municipalities with SUFRAMA and without SUFRAMA, with the objective of verifying, in a comparative way, the two samples of municipalities surveyed, we arrive at graph 5.

From this graph, it is possible to notice that in all scenarios the average of the indices presented by the municipalities with SUFRAMA exceed the average of the municipalities without SUFRAMA. The fact that the capitals of Roraima and Amapá are participating in this sample of municipalities, in some way, may have contributed to this scenario. However, this does not preclude the results found, which showed some coherence with the reality in question. This observation serves so that future studies can analyze this aspect in order to corroborate or not with the results achieved here.

Graph 5: Average of social and economic indices of municipalities with and without SUFRAMA: 2010 and 2018.
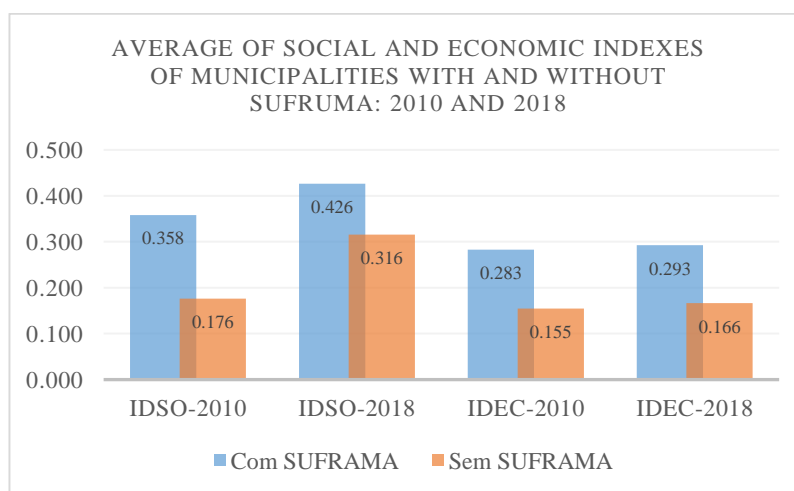
Source: Search result.

This analysis is important because it demonstrates that the economic issue is reflected in the social issue and vice versa. This analysis is in line with the thought of North[24], where social culture, built on the basis of a historical perspective, has a strong relationship with the development process of a region. Putnam[25] demonstrated this aspect when studying the reality of Italy for 20 years and found the power of social capital and its reflection on citizenship and the degree of development of Italian regions that occurred differently due to differences in traditions and culture. This aspect in the Amazon was worked on by Cavalcante[12] where he found that in Rondônia there are two historical scenarios that produced two very different societies in Rondônia, with different cultures and that this has influenced the dynamics of regional development to the point of demonstrating that social capital it is a factor that has interfered with intensity for the status quo of these regions in a differentiated way, each one in its dynamics and in its rhythm.

Thus, the starting point for a better understanding of this dynamic is the historical-economic formation of these regions, in order to allow a better critical analysis of the culture and its respective processes

of endogenous development. Corroborating with the thought of North[24] where the social is the basis for understanding the dynamics or stagnation of an economy, that is, the economic is not the cause but a consequence of a certain institutional arrangement built by the social force of the place, it allows to trace new future perspectives of studies in the field of social capital as a means to understand, from the historical trajectory, the present scenario and, from it, the future of the region. In view of this, studies in this direction prove to be quite fertile to understand the Amazon scenario and its peculiarities materialized in its multiple variables that normally escape the context of the everyday national scenario of large urban-industrial centers. Understanding such dynamics involves expertise and requires methodological instruments capable of dealing with a complex reality such as, in general, the regions inserted in the Brazilian Amazon context.

IV. FINAL CONSIDERATIONS

The research brought as a challenge to analyze the reality of Amazonian municipalities based on economic

and social indicators in order to determine the regional development index and, from there, analyze the degree of performance achieved by the municipalities assisted with the regional development policy linked to the context of the SUFRAMA policy in comparison with municipalities that were not contemplated with the aforementioned public policy in order to analyze its effect from the perspective of economic and social development.

The use of the quantitative method with the use of factor analysis allowed the impartial character of the research, since all the procedures performed in this work strictly followed the methodological procedures, thus avoiding any possibility of imposing or influencing a trend in the behavior of the data. Only after the construction of the indices and procedures that led to their systematization that make it possible to have the necessary conditions to analyze the results found.

In general, a low level of economic and social development of the surveyed municipalities was evidenced, indicating a reality that goes through challenges that need to be overcome and focused on the local reality in an integrated way to the national context such as logistics, infrastructure, health, education and aspects economic and socio-environmental issues as the main axis of strategic vision to overcome such a regional challenge. Such results can, in the first place, serve as a counterpoint to the main reason for maintaining the SUFRAMA policy in the region. However, the fact that this scenario of weak or very weak regional development observed in the municipalities that participated in this study, including the municipalities that are not assisted by the SUFRAMA policy, allows us to conclude, therefore, that this is a reality faced in the Amazon region as a whole, and that, therefore, should be the object of future research, in order to determine which factors contribute to this scenario, which may require other statistical methods used in the multivariate analysis of data, such as multiple regression, among other available models and applicable to specific cross-sectional data sets or time series or a combination of both.

On the other hand, based on the *ceteris paribus* concept, an analysis can be made from the endogenous point of view of SUFRAMA's regional development policy based on the indices and results found in this study. In this way, it was evident that even with performances, in general, depressing in terms of the performance of IDEC and IDSO, especially in the municipalities assisted by the aforementioned policy, even so it is still necessary for the development of the region, in view of many of these municipalities, characterized by being significantly limited by nature conservation units and indigenous lands that end

up, in some way, limiting productive areas, which strengthens the maintenance of the SUFRAMA policy as an alternative strategic action in search of sustainable development of these regions, in particular, and the Western Amazon more generally. In addition, it was shown that even with low levels of economic and social development in this study, the municipalities covered by the SUFRAMA policy presented a slightly better scenario compared to those not covered by this federal government policy, showing some type of influence of this policy in the local reality.

From the point of view of the growth pole theory and the economic development pole brought by Perroux, it is clear that it was not possible to observe the effects of this reality in the municipalities covered by the SUFRAMA policy and which participated in this study. Even so, it is clear that the scenario could be more serious if such a policy did not exist in the respective regions. Perhaps therein lies the biggest problem of this policy in not having yet managed to produce a prosperous and autonomous environment of endogenous development, which seems to impact the way of seeing the aforementioned policy not as an element of change in the local and regional reality, but as a welfare policy. generating behavior dependent on government actions that ends up contributing in some way to low social capital, human capital and, consequently, the impact of this behavior on the culture of the place. Although it is an aspect perceived in this study in an abstract way, there is a need for further studies within this perspective. Within a view of contributing to greater effectiveness of SUFRAMA's policy, the issue of distribution of resources collected from taxes generated by the economic activities of the place can be mentioned. This is because the current model indicates that all resources from taxes paid by companies installed and collected by the government basically present a one-way path, with a one-way path to the national treasury coffers and not in a two-way context, with a sense also back to the municipal coffers. In this sense, an observation is made on this aspect that, in our view, could positively impact the development of these regions covered by the aforementioned policy.

REFERENCES

[1] VEIGA, J.E.da. **Do global ao local**. Campinas, SP: Armazém Ipê (autores associados), 2005.
[2] SEN, Amartya. **Desenvolvimento como Liberdade**. Tradução de Laura Teixeira Motta. São Paulo: Companhia das Letras, 2000.
[3] SANTOS, N.B.; FARIA, A.M.M.; DALLEMOLE, D.; MANSO, J.R.P. Desenvolvimento econômico das macrorregiões de Mato Grosso nos anos de 2005 a 2013.

Interações, Campo Grande, MS, v.18, n.3, p.169-182, jul./set.2017.

[4] IBGE. Municípios da faixa de fronteira. Disponível em: https://www.ibge.gov.br/geociencias/organizacao-do-territorio/estrutura-territorial/24073-municipios-da-faixa-de-fronteira.html?=&t=acesso-ao-produto. Acesso em: 28/05/2021.

[5] REIS, E. **Estatística multivariada aplicada**.2. ed. Lisboa: Silabo, 2001.

[6] HAIR, J. F. et al. **Análise multivariada de dados**. 5. ed. Porto Alegre: Bookman, 2005. 730 p.

[7] SANTANA, A.C. de. **Métodos quantitativos em economia**: elementos e aplicações. Belém: UFRA, 2005a.

[8] SANTANA, A.C. de. **Elementos de economia, agronegócio e desenvolvimento local**. Belém: GTZ; TUD; UFRA, 2005b.

[9] GAMA, Z. J. C. ; SANTANA, A. C. de. ; MENDES, F. A. T. ; KHAN, A. S. Índice de desempenho competitivo das empresas de móveis da região metropolitana de Belém. **Revista de economia e agronegócio**, v. 5, p. 127-159, 2007.

[10] SANTANA, A.C. de. Análise do desempenho competitivo das agroindústrias de polpas de frutas do Estado do Pará. **Revista de economia e sociologia rural**, v. 45, n. 3, Brasília, jul/set. 2007a.

[11] FÁVERO, L.P; BELFIORE, P. **Manual de análise de dados**. 1ª ed. Rio de Janeiro: Elsevier, 2017.

[12] CAVALCANTE, F.R.C. **Análise da desigualdade regional no Estado de Rondônia á luz da teoria institucionalista de Douglass North**. Tese (Doutorado) - Universidade Federal do Pará, Núcleo de Altos Estudos Amazônicos, Programa de Pós-Graduação em Desenvolvimento Sustentável do Tropico Úmido. Belém-PA, 2011, 464 p.

[13] PARAGUASSU-CHAVES, C.A.; CAVALCANTE, F.R.C.; CLARO, P.C. G.; FISCHER, M.D.; OLIVEIRA, P. DE T. C. DE ; SILVA, I. R.R.P. E ; NETO, Z. DE O.; CALDERARO, I.F.N.; ALMEIDA, F.M. DE . Environmental Education Perception Index (IPEA) headed for sustainable development: A study in Elementary Schools in the city of Guajará-Mirim, Rondônia (Brazil). **INTERNATIONAL JOURNAL OF ADVANCED ENGINEERING RESEARCH AND SCIENCE**, v. 5, p. 38-50, 2018a.

[14] PARAGUASSU-CHAVES, C.A.; CAVALCANTE, F.R.C.; ALMEIDA, F.M. DE; NETO, L.S. DA L.; SOUZA, L.V. DE; UCHOA, M. R.; CALDERARO, I.F.N.; OLIVEIRA, P. DE T.C. DE; CLARO, P. C. G.; DANTAS, L. R.M.. Factor Analysis and the Social Capital Index: A Study at the Brazil / Bolivia Border. **INTERNATIONAL JOURNAL OF ADVANCED ENGINEERING RESEARCH AND SCIENCE**, v. 5, p. 41-51, 2018b.

[15] PARAGUASSU-CHAVES, C.A.; CAVALCANTE, F.R.C.; DANTAS, L.R.M.; ALMEIDA, F.M. DE; CAVALCANTE, A.M.M. DA F.; SOUZA, J. S. Índice de desempenho da condição de saúde (IDCS) nos municípios de fronteira do Arco Norte e Central do Brasil. **InterScience Place**, v. 14, p. 170-219, 2019.

[16] PARAGUASSU-CHAVES, C.A.; CAVALCANTE, F.R.C.; BARROS FILHO, A. K.D.; CAVALCANTE, A.M.M. DA F.; DUARTE, J.C.; ALMEIDA, F.M. DE; MOREIRA DANTAS, L.R.; CARVALHO, C.D.; FONSECA NETO, J.V. Quantitative methods and study of the parth dependence effect of Douglass North from the cocoa production index (CPI) in RondÃ´nia, Brazil. **INTERNATIONAL JOURNAL FOR INNOVATION EDUCATION AND RESEARCH,** v. 8, p. 469-493, 2020a.

[17] PARAGUASSU-CHAVES, C.A.; CAVALCANTE, F.R.C.; BARROS FILHO, A.K.D.; ALMEIDA, F. M. DE; DANTAS, L.R.M.; MACIEIRA, C. DE A.; NETO, J.V.F.; BARATA, C. DA S.; SIQUEIRA, S.M.M.; CAVALCANTE, A.M.M. DA F.; NETTO, E.M. Factor Analysis Applied in the Construction of the Socio-Environmental Performance Index (IDRSA) in the Guajará-Mirim Free Trade Area, Brazil / Bolivia Border. **INTERNATIONAL JOURNAL OF ADVANCED ENGINEERING RESEARCH AND SCIENCE**, v. 7, p. 312-324, 2020b.

[18] PARAGUASSU-CHAVES, C.A.; CAVALCANTE, F.R.C.; BARROS FILHO, A.K.D.; ALMEIDA, F. M. DE; DANTAS, L.R.M.; GOES, S.B. DE ; NETO, J.V.F.; CAVALCANTE, A.M.M. DA F.; BARATA, C. DA S.; NETTO, E.M.; ANJOS, O. DOS . Factor analysis as a tool for building the sustainable development index of river basins in Rondônia, Western Amazon. **INTERNATIONAL JOURNAL OF ADVANCED ENGINEERING RESEARCH AND SCIENCE**, v. 7, p. 220-237, 2020c.

[19] DILLON, W. R.; GOLDSTEIN, M. **Multivariate analisys**: methods and applications. New York: Wiley, 1984.

[20] JOHNSON, Richard A.; WICHERN, Dean W.**Applied Multivariate Statistical Analysis**. 2nd Edition. **ISBN 10: 0130411469 / ISBN 13: 9780130411464**

[21] SANTANA, A.C. de. Análise do desempenho competitivo das agroindústrias de frutas do Estado do Pará. In: CONGRESSO BRASILEIRO DE ECONOMIA E SOCIOLOGIA RURAL, 44., 2006, Fortaleza,CE. **Anais...** Brasília, DF: Sober, 2006. p. 1-20

[22] SANTANA, A.C. de. Índice de desempenho competitivo das empresas de polpas de frutas do Estado do Pará. **RER**, Rio de Janeiro, v.45, n.03, p.749-775, jul./set. 2007b.

[23] MATOS, D.A.S. e RODRIGUES, E.C. **Análise Fatorial**. Brasília, DF: ENAP, 2019.

[24] NORTH, D. **Institutions, Institutional Change and Economic performance.** Cambridge University Press, Cambridge, 1990.

[25] PUTNAM, R.D. **Comunidade e democracia: a experiência da Itália moderna**/ Robert D. Putnam, com Robert Leonardi e Raffaela Y. Nanetti; tradução Luiz Alberto Monjardim – 5ª ed – Rio de Janeiro: Editora FGV, 2006.

A 1-year follow-up case report of a biomimetic no post/no crown fiber-reinforced restoration of a structurally compromised tooth

José Antonio Castro Klenner[1,2], Priscilla Cardoso Lazari-Carvalho[3], Tomás Felipe Labarca Galecio[4], Marco Aurélio de Carvalho[3]

[1]Faculty, Department of Oral Rehabilitation and Implantology, School of Dentistry, Universidad Autonoma, Santiago, Chile.

[2]Master Student, School of Dentistry, Evangelic University of Goiás, Anápolis, Brazil.

[3]Faculty, Department of Oral Rehabilitation, School of Dentistry, Evangelic University of Goiás, Anápolis, Brazil.

[4]Master Student, School of Dentistry, Universidad de los Andes, Santiago, Chile.

Abstract— Treatment of structurally compromised endodontically treated teeth (ETT) is still a controversial topic faced daily in clinical practice. A correct diagnosis and treatment planning is mandatory to accomplish success and survival of the restoration, but most importantly, to stop the cycle of death of the tooth. This 1-year follow-up case report presents a no post/no crown fiber-reinforced restoration of a structurally compromised endodontically treated tooth. A 65-year-old female sought treatment for her upper left first premolar that had had endodontic treatment and an old MOD amalgam filling from a long time ago before it broke down. The buccal cusp was fractured, leaving less than 50% of the coronal tooth structure. While a conventional approach would require a cast metal or fiber post and a full-coverage crown, a biomimetic approach was chosen for this case. Therefore, a biobase was used for dentin replacement, and a ceramic restoration replaced the enamel. The biobase was reinforced with polyethylene fiber at its base to reduce the stress generated in the hybrid layer. Reconstruction of the dentin core was carried out with a short fiber-reinforced composite resin, which has mechanical properties similar to dentin. The palatal cusp was maintained, and a vonlay preparation was made, covering the remaining cusp. For enamel replacement, a lithium disilicate ceramic was used. The follow-up of this clinical report presents success and survival for 1 year.

I. INTRODUCTION

Structurally compromised endodontically treated teeth (ETT) comprise one of the most significant challenges clinicians face in private practice since the long-lasting restoration of these teeth is not as predictable as vital teeth.(Dietschi et al., 2007) Prosthetic failures are the most common reason for ETT extraction (Olcay et al., 2018); therefore, correct diagnosis and treatment planning when restoring these teeth should play an essential role in

the success and survival. When root canal treatment is performed, the biomechanical behavior of the tooth is changed, and it differs considerably from a vital tooth.(Dietschi et al., 2007) The main reasons for the difference are, in the first place, the loss of tooth structure, followed by caries lesion, fracture, or cavity preparation, including the access cavity before endodontic treatment.(Dietschi et al., 2008; Dietschi et al., 2007)From a biomimetic perspective, preserving and conserving tooth

structure is paramount in maintaining the balance between biological, mechanical, adhesive, functional, and esthetic parameters.(Carvalho et al., 2018) Thus, a ferrule is crucial for the optimal biomechanical behavior of ETT.(Juloski et al., 2012) However, it is not always present, and thus the macro-mechanical retention of coronal structure is compromised.(Lazari et al., 2018)

The options to restore ETT have changed in recent decades due to improvements in adhesive dentistry, with the rise of adhesive materials and techniques. The traditional method for restoring an ETT with a cast metal post and core was challenged by luted fiber posts and build-up, and now, there are new approaches without using a post. These so-called "biomimetic approaches" aim to maintain the highest amount of tooth structure, using new optimized adhesive techniques to restore the biomechanical behavior of compromised teeth.(Magne et al., 2016)

The biobase concept consists of reconstructing the base of a tooth, specifically the dentin, through materials with mechanical properties similar to it, and optimized adhesive protocols that attempt to reduce the stress generated by the polymerization of resinous materials.(Deliperi et al., 2017) One of these protocols utilizes polyethylene fibers, which have been studied for use in vital and non-vital teeth, especially in in vitro studies.(S. Belli et al., 2006; Sema Belli et al., 2006; Erkut et al., 2008; Belli et al., 2007; Hasija et al., 2020; Sadr et al., 2020; Deliperi et al., 2017) Among the advantages attributed to the use of fibers is a decrease in the stress generated by the polymerization shrinkage on the hybrid layer, thus increasing bond strength (Sema Belli et al., 2006), a reduction of the microleakage in class II MOD restorations and in overflared root canals(Erkut et al., 2008; Belli et al., 2007), and an increase in fracture strength of ETT(S. Belli et al., 2006).

In vitro studies have shown that postless approaches might be beneficial for preventing catastrophic failures without losing mechanical performance on fatigue survival(Carvalho et al., 2018; Lazari et al., 2018; Magne et al., 2017).Nonetheless, this topic needs to be further investigated, with different kinds of tests, clinical reports, and clinical studies. Therefore, this clinical report presents a minimally invasive technique without a post and without a crown, maintaining the highest possible amount of sound tooth structure, reinforcing the dentin core with a short fiber-reinforced composite, and replacing the enamel with a ¾ lithium disilicate partial restoration (vonlay).

II.　　CASE DESCRIPTION

A 65-year-old female sought treatment in a private practice complaining about a broken tooth. She sought to restore her tooth, recovering both function and esthetics. The patient's past dental history revealed that her upper left first premolar had endodontic treatment and an old MOD amalgam filling from a long time ago before failure. Her medical, social, and personal history were found to be inconsequential. No relevant conditions were discovered during the extra-oral examination. The patient had general bone loss due to periodontal disease, and she was informed about this condition. On the other hand, good plaque control was observed as well as that the broken tooth was not affected by significant bone loss.

During the intraoral examination, it was observed that tooth 2.4 with the root canal obturation had been exposed to the buccal environment for at least two weeks. Additionally, the old amalgam filling and the buccal cusp were gone because of the failure. The radiographic examination showed previous root canal treatment with poor obturation in length (1 mm) and a big loose of coronal structure (Figure 1).

Root canal retreatment followed by dentin reconstruction(build-up) and enamel replacement with a ceramic partial crown was planned. The treatment plan was discussed with the patient, and informed consent was taken. For better access and moisture control, rubber dam isolation of the tooth was performed (Rubber dam; Nictone) (Figure 2). Carious tooth structure was then removed with diamond bur under water spray. The gutta-percha was removed 2 mm into the pulp chamber and then sealed with 1 mm of a light-curing glass ionomer liner (Ionoseal; Voco). Air abrasion with 27 μm aluminum oxide (Danville) was used for 10 seconds at 10 mm and 2 bar with a sandblaster (Microetcher II, Danville) (Figure 3). Dentin hybridization was performed with a two-step self-conditioning adhesive system (Clearfil SE Bond; Kuraray). The acidic primer was actively applied for 20 seconds and gently air-dried for 20 seconds for solvent evaporation. The bond was actively applied for 20 seconds, and the excess was removed with a dry microbrush. Light polymerization was performed for 40 seconds at 1000 mW/cm^2 of irradiance (Valo Grand, standard mode, Ultradent). A resin coating was made with a flowable composite resin (Clearfil AP-X flow, Kuraray)(Figure 4). Light polymerization was then performed again for another 40 seconds. A 2-mm-wide polyethylene fiber was used on top of the resin coating layer (Ribbond-THM, Ribbond), applied between the inner side of the palatal cusp and the floor of the remaining structure (Figure 5). The polyethylene fiber was moistened with a light-cured low

viscosity resin (Fortify, Bisco) and then applied over a thin layer of non-polymerized universal composite resin (Clearfil AP-X, Kuraray). Light-polymerization was performed for 20 seconds. The dentin core was created using 2-mm increments of a short fiber-reinforced composite resin (everX Posterior, GC) (figure 6). Light-polymerization was then performed for 10 seconds after each increment. This composite was covered with a universal composite resin (Clearfil AP-X, Kuraray) and light-cured for 20 seconds (Figure 7). The tooth was covered with glycerin gel, and a final light polymerization was carried out for 60 seconds. Preparation was performed for a ¾ partial crown (vonlay) with a chamfer-type finishing line on the buccal and proximal margins of the tooth and a cusp reduction of 1.5 mm on the palatal cusp with a bevel of 1.5 mm width. The impression for the laboratory procedures was made with polyvinyl siloxane (President, Coltene). The ¾ partial crown (vonlay) was made of lithium disilicate according to manufacturer instruction (IPS e.max Press, Ivoclar) (Figure 8 and 9).

The bonding of the partial crown was carried out after restoration and preparation surface conditioning as follows: Partial crown surface conditioning: intaglio of the crown was etched with 9% hydrofluoric acid (Porcelain etch, Ultradent) for 20 seconds; rinsed with water for 60 seconds; cleaned with 35% phosphoric acid (Scotchbond, 3M ESPE) for 60 seconds; rinsed with water for 60 seconds; Silane (RelyX ceramic primer, 3M ESPE) was applied with a microbrush and heat dried with an air dryer for 60 seconds; low viscosity resin (Fortify, Bisco) application without light-polymerization. Preparation surface conditioning: rubber dam isolation; conditioning and cleaning of the preparation surface with 27 μm aluminum oxide (Figure 10); coating with a thin layer of a low viscosity resin (Fortify, Bisco) without light-polymerization. A light-curing veneer cement (RelyX Veneer, 3M ESPE) was applied to the intaglio surface of the partial crown and seated on the tooth preparation. Cement excess was removed and followed by 60 seconds of light polymerization for each side of the tooth (Figure 11). Air-blocking barrier and additional polymerization was carried out for 20 seconds.

Follow-up was done after 1 year. Both clinical and radiographic examinations were performed (Figure 12 and 13). Additionally, no problems were reported by the patient.

III. DISCUSSION

The biomechanical behavior recovery of ETT through restorative procedures is still a complex issue in modern adhesive restorative dentistry. Different approaches and techniques have emerged, and lately, the no-post/no-crown technique is gaining popularity among clinicians. The tooth death spiral(Simonsen, 1991; Elderton, 1988) explains the progression of tooth structure lost through multiple restorative procedures and reintervention that ends in tooth extraction. For this reason, minimal intervention dentistry has been gaining notoriety recently, both for vital and non-vital teeth.(Carvalho et al., 2018; Lazari et al., 2018; Magne et al., 2016) Improvements in endodontic treatment, restorative materials, and techniques have led to a better prognosis for ETT. One of the aspects to be discussed is the interruption or delay of the tooth death spiral by preserving and conserving sound tooth structure with modern adhesive partial restorations (extension preservation) instead of tooth reduction for full crowns (extension for prevention).(Carvalho et al., 2018)In this case, there was a loss of coronal structure of over 50%. If the conventional approach were chosen, a post would have been placed for core retention, and a full crown would have been retained. The no-post/no-crown approach has been studied in vitro over the years; however, there is still a lack of suitable studies.(Fedorowicz et al., 2012) Therefore, there is no consensus in the literature to support crown placement over direct restoration in severely broken-down ETT. Most sound dental tissue can now be preserved, and conserved and partial restorations can be adhesively bonded to the remaining coronal structure, particularly to the enamel substrate, directly or indirectly. (Carvalho et al., 2018) In this particular case, the palatal cusp was conserved and covered with an indirect restoration, preserving tooth structure and changing the biomechanical behavior from tensile to compressive forces.

Biomimetic adhesive restorative dentistry bases its principles on the adhesion of materials with similar properties to dentin and enamel to protect the tooth structure through bonded partial restorations. This type of approach has been studied in recent years with good results(Carvalho et al., 2018; Lazari et al., 2018; Magne et al., 2016; Magne et al., 2017; Murphy et al., 2009; Rocca and Krejci, 2013), but, it is still a field of investigation that needs more clinical studies. In adhesive restorative dentistry, and especially regarding ETT, the main objective is that the remaining tooth structure should last as long as possible. In case of a failure, it should be reparable in order to preserve the tooth.

Cast metal posts have a much higher elastic modulus than dentin. When the tooth is in function, the stress is concentrated on the root; therefore, it is more likely that the fracture mode is catastrophic, causing tooth extraction, the most problematic complication of ETT.(Olcay et al., 2018; Figueiredo et al., 2015) Fiber

posts have an elastic modulus similar to dentin. Thus, the stress is distributed more favorably along the root, decreasing the risk of catastrophic failures.(Figueiredo et al., 2015; Akkayan and Gülmez, 2002) Nonetheless, it has been shown that the incidence of catastrophic failures between cast posts and core and fiber posts do not significantly differ.(Figueiredo et al., 2015) In the present case report, no post approach was taken. A biobase on the tooth was created with a polyethylene fiber on the base in a palatal-buccal direction. The use of polyethylene fibers in dentistry has been studied over the past two decades, with confronting results. The benefits of using them have been described in some studies. (S. Belli et al., 2006; Sema Belli et al., 2006; Erkut et al., 2008; Belli et al., 2007) In this case, the polyethylene fiber was used on the bottom of the biobase, connecting the palatal cusp to the pulpal chamber floor to decrease the stress generated by the polymerization shrinkage on the hybrid layer thus increasing bond strength, as related in some in vitro studies.(Sema Belli et al., 2006) In addition, it has been demonstrated in in vitro studies that the polyethylene fiber reduces the microleakage in class II MOD restorations and in overflared root canals.(Erkut et al., 2008; Belli et al., 2007) Another property attributed to the polyethylene fibers in in vitro studies is the increase in fracture strength of ETT.(S.

Belli et al., 2006) This finding contrasts with another in vitro study, where the use of polyethylene fiber did not enhance the biomechanical behavior of teeth with no endodontic treatment.(Magne et al., 2012) The build-up was made using a short fiber-reinforced composite (SFRC) on a layering technique to replace dentin. SFRC is a dental restorative composite resin intended to be used in high stress-bearing areas as a stress-breaker restorative material. Mechanical testing has shown significant improvements in the load-bearing capacity, flexural strength, and fracture resistance of SFRC compared to conventional particulate filler composite resin.(Fráter et al., 2014) In the SFRC material, E-glass fibers are randomly oriented and possess isotropic features, leading to possible reinforcement in multiple directions.(Bialy et al., 2021) A review found that combining the SFRC as a bulk base with conventional composite improved the loadbearing capacity and failure mode of the material combination compared to plain conventional composite restoration. Furthermore, the biomimetic restoration technique of using SFRC showed promising characteristics, and therefore, might be recommended as an alternative treatment option for large cavities.(Garoushi et al., 2018) Despite this, more clinical studies are needed to support using polyethylene fibers and SFRC in different clinical situations.

IV.   FINAL CONSIDERATIONS

Adhesive restorative dentistry has changed in recent years. Improvements in materials and techniques are paving the way to restore teeth in a less invasive way, respecting the remaining tooth structure, and attempting to restore the tooth to its original biomechanical behavior. The main objective of the intervention is to postpone the tooth death spiral. Considering new materials and techniques, clinicians must be cautious when applying new protocols lacking high-level evidence. Therefore, clinical studies are still needed to support these new techniques and the biomimetic approach to restoring teeth. Nevertheless, the follow-up of this clinical report presents success and survival for 1 year with the mentioned approach.

V.   FIGURE LEGENDS

Fig.1. X-ray of tooth 2.4 before endodontic re-treatment.

Fig.2. Rubber dam isolation of tooth 2.4. A: Buccal aspect. B: Occlusal aspect.
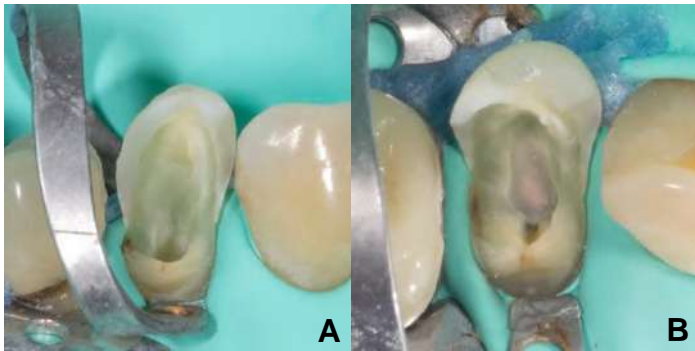
Fig.3. Endodontic treatment was sealed, and air abrasion was done. A: Buccal aspect. B: Occlusal aspect.
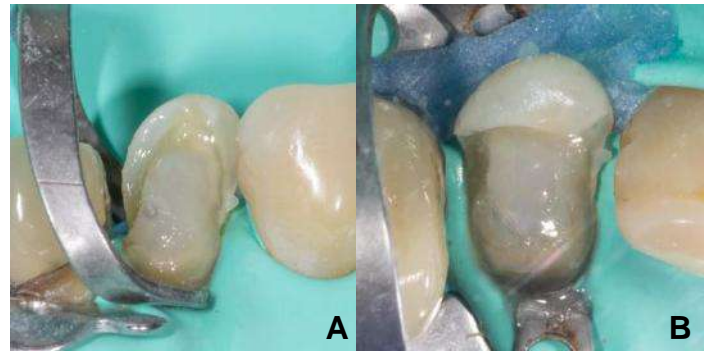
Fig.6. Build-up with short fiber-reinforced composite (Ever X, GC). A: Buccal aspect. B: Occlusal aspect.

Fig.4. Polymerized self-etch adhesive and resin coated. A: Buccal aspect. B: Occlusal aspect.
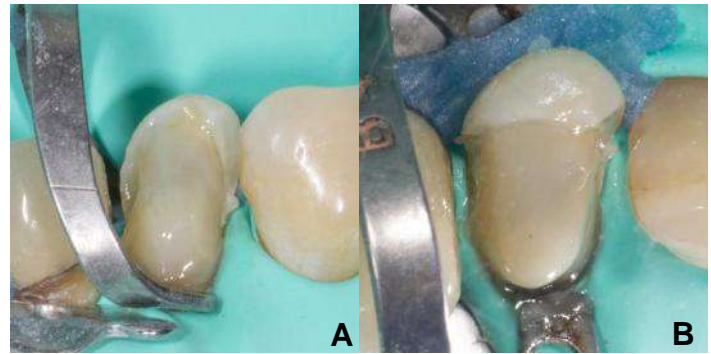
Fig.7. Short fiber-reinforced composite covered with a universal composite resin (Clearfil AP-X, Kuraray). A: Buccal aspect. B: Occlusal aspect.
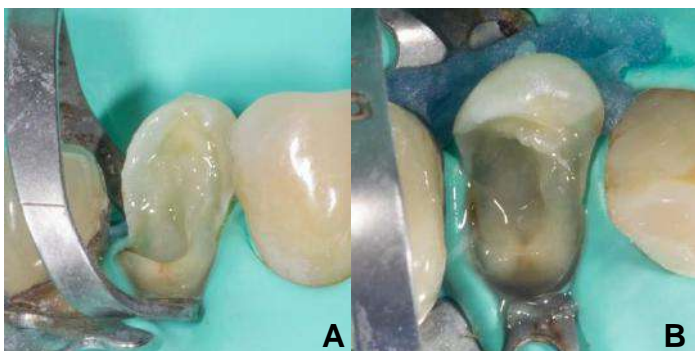
Fig.5. Polymerized polyethylene fiber (Ribbond THM, Ribbond) between the inner side of the palatal cusp and the floor of the remaining structure. A: Buccal aspect. B: Occlusal aspect.

Fig.8. Impression with a polyvinyl siloxane (President, Coltene).

Fig.9. The ¾ lithium disilicate crown (IPS e.max Press, Ivoclar).

Fig.10. Final preparation of the biobase and absolute isolation for bonding.

Fig.11. The ¾ ceramic crown bonded to the biobase.
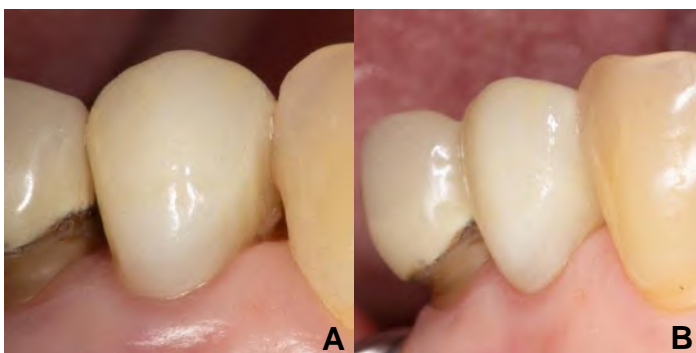
Fig.12. One-year follow-up of indirect restoration. A and B: Buccal aspect.

Fig.13. X-ray of 1-year follow-up of indirect restoration.

REFERENCES

[1] Akkayan B, Gülmez T (2002). Resistance to fracture of endodontically treated teeth restored with different post systems. *J. Prosthet. Dent.* 87:431–7.

[2] Belli Sema, Dönmez N, Eskitaşcioğlu G (2006). The effect of c-factor and flowable resin or fiber use at the interface on microtensile bond strength to dentin. *J. Adhes. Dent.* 8:247–253.

[3] Belli S., Erdemir A, Yildirim C (2006). Reinforcement effect of polyethylene fibre in root-filled teeth: Comparison of two restoration techniques. *Int. Endod. J.* 39:136–142.

[4] Belli S, Orucoglu H, Yildirim C, Eskitascioglu G (2007). The effect of fiber placement or flowable resin lining on microleakage in Class II adhesive restorations. *J. Adhes. Dent.* 9:175–81.

[5] Bialy M, Targonska S, Szust A, Wiglusz RJ, Dobrzynski M (2021). In Vitro Fracture

[6] Resistance of Endodontically Treated Premolar Teeth Restored with Prefabricated and Custom-Made Fibre-Reinforced Composite Posts. *Mater. (Basel, Switzerland)* 14.

[7] Carvalho MA de, Lazari PC, Gresnigt M, Del Bel Cury AA, Magne P (2018). Current options concerning the endodontically-treated teeth restoration with the adhesive approach. *Braz. Oral Res.* 32:e74.

[8] Deliperi S, Alleman D, Rudo D (2017). Stress-reduced direct composites for the restoration of structurally compromised teeth: Fiber design according to the "wallpapering" technique. *Oper. Dent.* 42:233–243.

[9] Dietschi D, Duc O, Krejci I, Sadan A (2007). Biomechanical considerations for the restoration of endodontically treated teeth: a systematic review of the literature--Part 1. Composition and micro- and macrostructure alterations. *Quintessence Int.* 38:733–43.

[10] Dietschi D, Duc O, Krejci I, Sadan A (2008). Biomechanical considerations for the restoration of endodontically treated teeth: a systematic review of the literature, Part II (Evaluation of fatigue behavior, interfaces, and in vivo studies). *Quintessence Int.* 39:117–29.

[11] Elderton RJ (1988). Restorations without conventional cavity preparations. *Int. Dent. J.* 38:112–8.

[12] Erkut S, Gulsahi K, Caglar A, Imirzalioglu P, Karbhari VM, Ozmen I (2008).

[13] Microleakage in Overflared Root Canals Restored with Different Fiber Reinforced Dowels. *Oper. Dent.* 33:96–105.

[14] Fedorowicz Z, Carter B, de Souza RF, de Andrade Lima Chaves C, Nasser M, SequeiraByron P (2012). Single crowns versus conventional fillings for the restoration of root filled teeth. *Cochrane Database Syst. Rev.*

[15] Figueiredo FED, Martins-Filho PRS, Faria-E-Silva AL (2015). Do metal post-retained restorations result in more root fractures than fiber post-retained restorations? A systematic review and meta-analysis. *J. Endod.* 41:309–316.

[16] Fráter M, Forster A, Keresztúri M, Braunitzer G, Nagy K (2014). In vitro fracture resistance of molar teeth restored with a short fibre-reinforced composite material. *J. Dent.* 42:1143–1150.

[17] Garoushi S, Gargoum A, Vallittu PK, Lassila L (2018). Short fiber-reinforced composite restorations: A review of the current literature. *J. Investig. Clin. Dent.* 9:e12330.

[18] Hasija MK, Meena B, Wadhwa D, Aggarwal V (2020). Effect of adding ribbond fibres on marginal adaptation in class II composite restorations in teeth with affected dentine. *J. oral Biol. craniofacial Res.* 10:203–205.

[19] Juloski J, Radovic I, Goracci C, Vulicevic ZR, Ferrari M (2012). Ferrule effect: a literature review. *J. Endod.* 38:11–9.

[20] Lazari PC, de Carvalho MA, Del Bel Cury AA, Magne P (2018). Survival of extensively damaged endodontically treated incisors restored with different types of posts-and-core foundation restoration material. *J. Prosthet. Dent.* 119:769–776.

[21] Magne P, Boff LL, Oderich E, Cardoso AC (2012). Computer-aided-design/computerassisted-manufactured adhesive restoration of molars with a compromised cusp: Effect of fiber-reinforced immediate dentin sealing and cusp overlap on fatigue strength. *J. Esthet. Restor. Dent.* 24:135–146.

[22] Magne P, Goldberg J, Edelhoff D, Güth J-F (2016). Composite Resin Core Buildups With and Without Post for the Restoration of Endodontically Treated Molars Without Ferrule. *Oper. Dent.* 41:64–75.

[23] Magne P, Lazari PC, Carvalho MA, Johnson T, Del Bel Cury AA (2017). Ferrule-Effect Dominates Over Use of a Fiber Post When Restoring Endodontically Treated Incisors: An In Vitro Study. *Oper. Dent.* 42:396–406.

[24] Murphy F, McDonald A, Petrie A, Palmer G, Setchell D (2009). Coronal tooth structure in root-treated teeth prepared for complete and partial coverage restorations. *J. Oral Rehabil.* 36:451–61.

[25] Olcay K, Ataoglu H, Belli S (2018). Evaluation of Related Factors in the Failure of Endodontically Treated Teeth: A Cross-sectional Study. *J. Endod.* 44:38–45.

[26] Rocca GT, Krejci I (2013). Crown and post-free adhesive restorations for endodontically treated posterior teeth: from direct composite to endocrowns. *Eur. J. Esthet. Dent.* 8:156–79.

[27] Sadr A, Bakhtiari B, Hayashi J, Luong MN, Chen YW, Chyz G, et al. (2020). Effects of fiber reinforcement on adaptation and bond strength of a bulk-fill composite in deep preparations. *Dent. Mater.* 36:527–534.

[28] Simonsen RJ (1991). New materials on the horizon. *J. Am. Dent. Assoc.* 122:24–31.

Productivity Optimization by Optimal Allocation of Human Resources with Application in Real Case at the Wagons Maintenance of Iron Ore Rail Transport

Clóvis Bôsco Mendonça Oliveira[1], Jonas Fontes de Carvalho[2], Antônio José Silva Oliveira[3]

[1]Electrical Engineering Department - Federal University of Maranhão, Brazil
Email: clovis.oliveira@ufma.br
[2]Master's Program in Energy and Environment - Federal University of Maranhão, Brazil
Email: jonasfontes@gmail.com
[3]Physics Department - Federal University of Maranhão, Brazil
Email: antonio.oliveira@ufma.br

Abstract—In the current industry the search for process optimization has been more and more constant, however many times this practice proves to be quite complex given the number of variables involved, an example of this is the case where from a heterogeneous group of workers want to define the best set of work pairs so that the collective productivity is as high as possible. In situations like this, the use of the metaheuristic genetic algorithm becomes quite attractive, since in the literature there are many examples of its use in the optimization of non-linear problems, with continuous and discrete characteristics of the control variables and with an exponential increase in the number possible solutions, in addition to the flexibility to incorporate the real problem constraints into the solution. In this context, this study codified a problem of real case for the definition of work teams in a mining wagon maintenance workshop. In the theoretical simulation stage, using historical team performance data, the genetic algorithm indicated a 22 percent better solution when compared to the random choice of work teams. Finally, the solution suggested by the genetic algorithm was implemented in the field, resulting in a performance increase of 7.9percent.

I. INTRODUCTION

The constant need to increase competitiveness makes companies look for each once again optimize its processes and resources, among these, the rational use of labor can be highlighted, that is, properly distribute the people available to perform tasks on service fronts, so that the overall productivity of the process is maximized.

Human being by nature is a social being who by affinity criteria tends to form groups, thus the interpersonal relationship in the work environment is quite complex, involves many variables and among others can affect the indicator of productivity of an organization. That said, it is a current challenge for organizations to define the optimal allocation of personnel and guarantee the ideal working conditions, so that the highest possible profitability is obtained.

However, due to the high number of variables involved in the optimization 15 of the allocation of labor, the use of

metaheuristic optimization techniques represents a very attractive alternative due to its robustness combined with results very close to the global optimum at a low computational cost. One of the most representative metaheuristic methods are genetic algorithms (GA), since they are based on the theory of natural evolution and genetics, have practical 20 application in the most different areas and stand out for their robustness and efficiency such as [1] and [2].

This work has as general objective to observe the dynamics of optimum allocation of human resources obtained by a traditional and recognized robust metaheuristic algorithm for problems with discrete characteristics, applied in a real scenario of a train wheel maintenance workshop that serves the mining market. This type of problem involves aspects of uncertainties in the algorithm's input data that attribute errors between the computational results and the field tests. This approach provides a perception of validation of the problem coding and attributes a potential of traditional optimization to the potential of less commonly used applications.

In a scenario of continuous search for process optimization and waste reduction in industries, it is extremely important, above all, to allocate resources available to perform tasks in the most appropriate way ([3]).

First of all, it is worth mentioning that in the routine of a railway maintenance area, decision making is a constant, some of them, due to the required agility added to the large number of variables involved, are not always taken in the best way, which can generate costs and inefficiencies in the production process ([4]).

On any freight railroad, one of the assets that most deserve attention by the maintenance team is its wagons, which show wear and tear mainly on its wheels due to wheel-rail contact. As a result, in addition to the wheels, the wagons also have a high maintenance demand on their bearings, these are positioned at the ends of the axles where the wheels are fixed and serve as a support point for the box of the wagon where the cargo is packed for transportation.

The set formed by an axle, two wheels and two bearings is called a wheeler, with each wagon having four of these in its structure. The workshop where this work was applied is responsible for maintaining the wheels of the iron ore wagons of a global mining company, whose fleet allocated to the railroad in question is close to 20 thousand wagons, thus totaling 80 thousand wheels.

Indeed, on the railroad to which this work refers, for operational reasons, when a car is identified with the need to change one or more wheels, it is not maneuvered alone for the maintenance shed, but within a fixed lot of 110 wagons called a homogeneous lot.

Thus, if you want to replace a single wheel of a wagon and considering that this activity takes 12 minutes, in fact it will not be just a wagon that will be stopped for maintenance for this time, but 110 wagons will be stopped for 12 minutes, waiting for a single asset to be maintained, that is, instead of 12 minutes of loss, there will be 1,320 minutes of available wagon time reduction.

In the case study approached monthly, the goal is to replace 4,500 defective wheels, knowing that each of these will require stopping a complete batch of 110 wagons, therefore, any reduction in the wheel change time has a potentialized gain due to the high quantity of impacted wagons, namely, for this monthly goal of changing wheelers, a reduction of 1 minute in the unit time of this activity would imply a gain of 495,000 minutes of available wagon time.

In this context, the present work is motivated to provide, through the use of the metaheuristic genetic algorithm, an optimized solution for the definition of workers pairs in a wagon maintenance workshop, more specifically maintenance of wheelsets, a problem that due to the many variables involved ends up making it is impossible to be optimized through simple human analysis.

II.   INTELLIGENT SCHEDULING AND HUMAN RESOURCE MANAGEMENT OPTIMIZATION

The human factor has become an important competitive strategy in the nowadays industry, beside this, the fast change in workplace has demand new approaches to human resource management in order to optimize the workforce productivity and efficiency ([5]).

The article [6] describe in their work that most of companies has realized that with the increase of market competition only reduce its operation cost is not an advisable long-term strategy, so optimize process becomes more important than only reduce cost.

Workforce planning is a complex problem and its optimization is a NP-hard problem, so depending on its size, it could be impossible to be solved with exact or traditional numerical methods ([7]).

Manage the organization´s manpower and resources allow effective outcomes to be achieved, and nowadays with the use of technological devices it is possible to improve the virtual human resource management in order to keep track of staff performance and have the maximum outcome from the team using them minimum resources of the company ([8]).

Some industries have the human resource allocation management more important and complex than to others, for example the software industry, where usually multiskilled teams work in multiple projects, in this case optimization methods 90 play an important role to minimize the total time needed in order to deliver a software, in the minimal cost and obeying the problem constraints ([9]).

The work of [9] presents an example of human resource optimization in software industry, where the focus was to combine Human Resource Allocation (HRA) and Staffing and Scheduling Software Project (SSSP) optimization.

SSSP problems are more complex to optimize than HRA problems, for the first one there is a general knowledge that meta-heuristic optimization is the best approach to adopt and the is very usual to use genetic algorithm ([10]).

The article [10] work divides workforce optimization in qualitative and quantitative models, the first one assumes a binary logic, where a worker has or not some skill, different from quantitative way, where for each worker each skill is quantified in a numeric range, so this allows that the workforce attributes be analyzed in a mathematical way.

The work [11] present in their work about different techniques of intelligent scheduling, one of the most efficient is the artificial intelligence approach, like 105 as genetic algorithm, ant colony, fuzzy logic, etc.

It is possible to see some researches focused in improve human resource management using some methods based on fuzzy logic theories or heuristic optimization algorithms, as example of the work [5] that present an approach to provide a method to help managers to make decision in daily human resources management tasks.

III. METAHEURISTIC OPTIMIZATION

There is a lot of nature inspired metaheuristic methods to solve optimization problems, like as genetic algorithm and ant colony optimization, both proved to be very effective to this kind of use ([7]).

As [12] describe in their work, metaheuristic methods are very effective for complex optimization and can be used in general-purpose optimization problems from the real world.

The metaheuristic optimization methods offer good solutions in reasonable computational time, that is extremely important mainly for real-world problems which usually involve several variables and constraints that become the solution more complex ([13]).

One way to improve the performance of an optimization problem solution is to combine different metaheuristics techniques, what is called hybrid metaheuristic solution. This combination can be described as different metaheuristics methods 125 applied sequentially at the same problem and at the end of process a better solution is obtained than in the case where only one method is applied ([14]). There are a lot of metaheuristic algorithms, for example Ant Colony Optimization, Genetic Algorithms, Particle Swarm Optimization, Simulated Annealing, Tabu Search, etc. These methods can be combined in the same problem in order to generate a hybrid algorithm that exploits the advantages and avoid the disadvantages of the multiple strategies combined ([14]).

The performance of mutation and crossover operator's effects directly the genetic algorithm ([15]), The exploration ability in GA is one of the biggest advantages over traditional optimization methods, it allows GA to decrease the chances of trapping in local optima. ([16]).

The article [16] classify metaheuristic methods in three categories: evolutionary based, physics-based and swarm-based techniques, all of then inspired in animal behavior or physical phenomena.

The propose [17] show that meta-heuristic algorithms when compared with traditional methods, such as random optimization, perform much better in terms of the computational effort and the quality of the solution provided.

IV. APPLICATIONS OF GENETIC ALGORITHMS

The use of genetic algorithms in the optimization of processes is quite common and diverse, it is possible, for example, to use the technique in the optimization 145 of the maintenance strategy of industrial equipment, obtaining the optimal periodicity for carrying out maintenance plans so that the equipment reliability is as high as possible with the minimum cost.

The article [18] presents a literature review about Flexible Job Shop Scheduling Problem (FJSSP) by approaches involving Genetic Algorithm (GA).

Another very common application of optimization through genetic algorithms is in the definition of work scales, which can be applied in the most diverse segments.

In addition to the use of genetic algorithms to define scales of team work, it is possible to find applications of GA for the formation of groups, as mentioned by the work

of [19] where an GA was used to, from a heterogeneous group of students, suggest a combination of study groups for a distance learning platform, considering that the students allocated in each group had the least possible diversity in terms age, discipline, daily study time and study time.

The work of [20] used genetic algorithm in their work to optimize task scheduling in cloud computing environment and compared the results with several other methods in terms of total completion time, average response time, and quality of service parameters.

The work of [21] presents a metaheuristic optimization using genetic algorithm designed to provide an optimal cut-off grade in order to maximize the net present value in an operating mine process.

The work of [22] presents different metaheuristic methods being used to identify parameters of photovoltaic module, in this case were applied four methods: differential evolution, artificial bee swarm optimization, modified particle swarm optimization and artificial bee colony.

A genetic algorithm was used in the work of [23] to optimize the shape of a wind turbine. [24] presented in their job an optimization of generators' efficiency in a thermoelectrical process using genetic algorithm, where was seen that the output power and efficiency of these increased 51.9% and 5.4% when compared to case without optimization.

In some cases, a problem presents a multi-objective optimization and metaheuristic methods are also appropriate in situations like this, for example in the work of [15] where a multi-objective optimization was done using a hybrid metaheuristic algorithm to minimize operational and environmental costs in a waste collection operation.

V. WAGON MAINTENANCE

The maintenance scope of railway wagons is quite wide, due to the varied range of components that require maintenance, such as wheels, bearings, brake system, couplings and even the wagon's own superstructure.

However, neglecting one or more of the aspects mentioned puts the railway's operational safety at risk, which can lead to major accidents with effects on the company's assets, the environment and even people.

5.1 Basic structure of a wagon

Among the various components of a railway operation, we highlight the rolling materials, which can be divided into the group of those that are pulled and those that are towed. However, among the tractors it is worth mentioning mainly the locomotives, responsible for tractioning the entire composition by the railroad, while in the group of towed vehicles, the wagons deserve special mention, which allow the packaging and adequate transport of the most varied loads by rail ([25] and [26]).

In Figure 1, a gondola wagon is shown, which is the most common type used for transporting iron ore and other minerals.
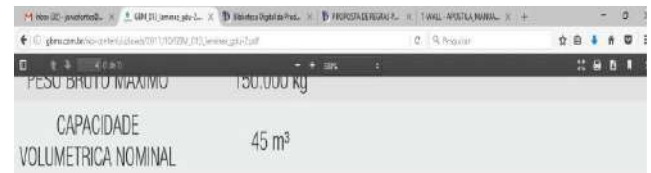
Fig. 1: Wagons. Source: [27]

Generally speaking, a wagon can be divided into four main elements, each of which has a defined function for the asset and can be subdivided into subcomponents, as shown in Figure 2.
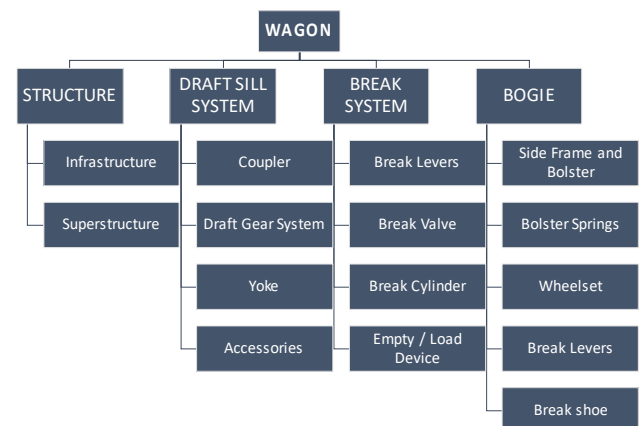
Fig. 2: Typical structure of a railway wagon.

The wagon's structure itself is divided into superstructure and infrastructure, since the first one corresponds to the box or platform of the wagon, responsible for the conditioning and security of the cargo to be transported, while the infrastructure is the support base of the superstructure.

The shock and traction set is responsible for ensuring the connection between the wagons, each of which has a hitch at its rear and another at the front in order to enable the series connection of several wagons.This set also plays an important role in absorbing the impacts of traction and compression between vehicles arising from the acceleration and braking dynamics of a train.

The brake system, on the other hand, performs the relevant function of controlling the speed of the train, this

is done through a pneumatic system that, once combined with the brake gear and a set of shoes, allows the application of brake on the wheels of railway vehicles. Finally, the trick is responsible for distributing the weight of the wagon structure and the load to the rails through the wheels, in addition to inscribing the wagon in the curves and cushioning the impacts from the track and the rail wheel contact.

Each wagon has two tricks in its assembly, these can present different configurations as to some elements of their constitution, however the principle of operation is essentially the same. Figure 3 shows a very common trick used in railway cars.
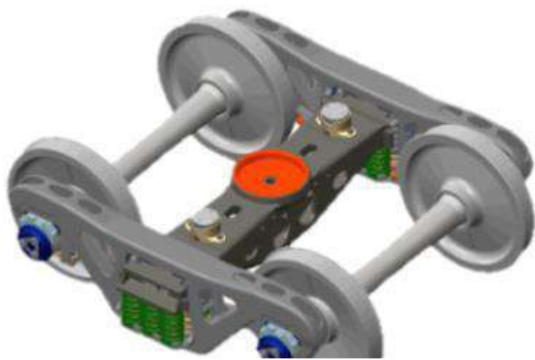
Fig. 3: Trick of a wagon. Source: [27]
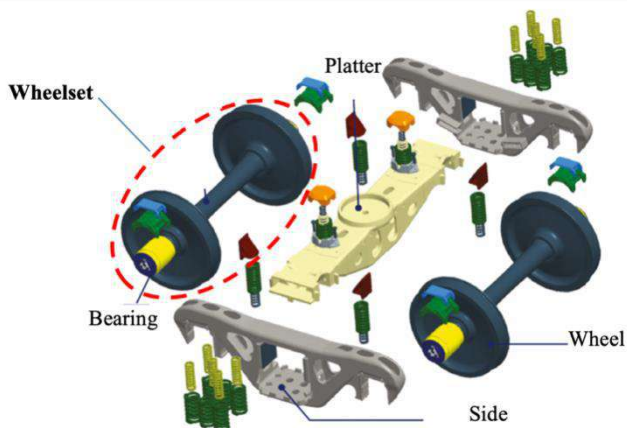
Fig. 4: Exploded view of a wagon trick. Source: [27]

As shown in Figure 4, the wagon wheels are in the trick, each pair of them is connected by an axle with two bearings at its ends, on which the right and left of the trick. This set formed by a shaft, two wheels and two bearings is called a wheel.

5.2 Aspects of wheelchair maintenance

Among the different components to be maintained in a wagon, one of the most important are its wheels, each of which, as previously mentioned, is formed by a set of two

wheels connected by an axle with a bearing at each end. In this way, there are four wheelers per wagon, responsible for supporting the total load of the railway vehicle in addition to keeping it on the tracks.

As the wagon moves along the railroad, each wheel of the railroad wears out, 230 both in the wheel, due to the wheel-rail contact, and in the bearings, due to the friction that occurs in its internal parts, being in any railroad. Management of the maintenance of its fleet of wheelers is fundamental.

In this context of continuous deterioration of the wheels, as the wagons move along the railroad, the number of wheels to be maintained constantly changes, 235 thus, new wheels are added daily to the list of those in need of maintenance, in addition to replacing defective wheels. By others good in the maintenance shed.

Once the wheel is removed to maintain it is not discarded, but recovered, for this it is necessary to machine the wheels so that they acquire the proper profile again and have any defects in their bearing surface removed, and for cases of bearing defects, it is necessary to remove the old bearings and install new or maintained bearings.

The workshop where this work was developed is located in S̃ao Luís in Maranh̃ao and is responsible for replacing defective wheels with others in good condition.

As for the structure, the workshop in question has 5 railway lines for simultaneous change of wheels, operating 24 hours a day, every day of the year, which has provided about 4,500 wheels changed per month.

5.3 The wheel change process

To replace a wheel in the workshop where this work was developed, equipment called a false table is used, for this the wagon where the wheel to be replaced is located on this table, more specifically the wheel in question must be aligned with the center of the table base, then once this position is reached, two mechanics make a first intervention in order to release the wheel that will descend along with the base of the false table towards an underground gallery.

After the descent of the wheel to be maintained, the new wheel takes exactly the opposite path from the removed wheel, that is, the new wheel is raised through the false table from the underground gallery to the wagon trick, after that the two mechanics again intervene in the wagon and complete the wheel replacement.

The sequence of the steps for replacing a wheel is illustrated in Figure 5 where the steps for positioning the wagon, removing the wheel to be maintained and installing the new wheel are shown.

Each wheel change is made simultaneously by two mechanics, one acting on the right side and the other on the left side of the wagon, each of whom is responsible for a set of tasks until the new wheel is placed on the maintenance wagon.
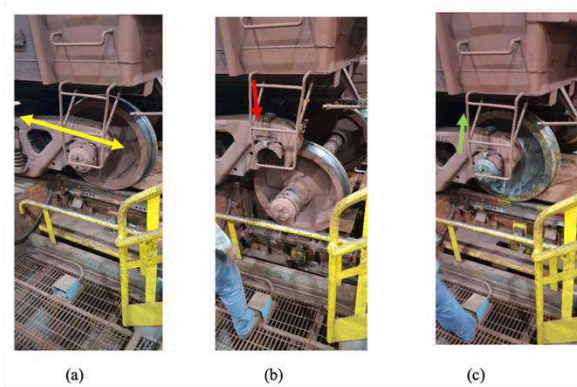
Fig. 5:Sequence of steps when changing wheels: positioning the wagon wheel on the table (a), removing the defective wheel (b) and installing the new wheel (c).

The estimated time for a pair of mechanics to change a wheel is 12 minutes, which is budgeted based on the ability to perform the task associated with the operational need to meet the ore transportation budget.

Each time this change is made, one of the mechanics of the pair registers the data of the maintenance they have just performed in a computerized system, using afor this purpose, with tablet the following information highlighted:

- Maintained car code

- Reason for changing the wheel

- Start time of the wheel change

- End time of changing the wheel

- Mechanics who changed the wheel

- Justification for carrying out maintenance above the expected time (if it exceeds 12 minutes)

5.4 Aspects of the problem complexity

Among the total of 120 possibilities of pairs, it is highlighted that in the formation of the set of 8 pairs, the same mechanic can only be present in a single pair, thus, the total possible scenarios of groups of 8 doubles formed from 16 mechanics can be calculated by the sequence below of products of combinations taken two by two:

$$Number\ of\ possible\ solutions =$$
$$C_2^{16}.C_2^{14}.C_2^{12}.C_2^{10}.C_2^{8}.C_2^{6}.C_2^{4}.C_2^{2} \qquad (1)$$

Looking at Equation 1, we can see a sequence of products of combinations taken two by two, which makes

it possible to arrive at Equation 2, which generalizes the calculation of the total number of possible solutions for a problem of this type to an even number any M of mechanics.

$$Number\ of\ possible\ solutions = \prod_{i=0}^{i=(M-2)/2} C_2^{M-2i} \quad (2)$$

Once the expression of the combination contained in Equation 2 has been unfolded, Equation 3 is obtained, in which, due to the number of solutions possible for the problem to vary with the factorial of the number of mechanics M.

$$Number\ of\ possible\ solutions =$$
$$\prod_{i=0}^{i=(M-2)/2} \frac{(M-2i)!}{2.(M-2i-2)!} \qquad (3)$$

Knowing that the workshop where this work was developed has 16 mechanics in the morning shift, the number of options for groups of 8 pairs that can be formed with this team can be calculated using Equation 3, as shown below:

$$Num\ Options = \prod_{i=0}^{i=(M-2)/2} \frac{(M-2i)!}{2.(M-2i-2)!} =$$
$$\prod_{i=0}^{i=(16-2)/2} \frac{(16-2i)!}{2.(16-2i-2)!} = \prod_{i=0}^{i=7} \frac{(16-2i)!}{2.(14-2i-2)!} =$$
$$81,729,648,000 \qquad (4)$$

From the previous result it can be seen that the problem in question has 81,729,648,000 solution scenarios, that is, given a group of 16 mechanics, there are more than 80 billion possibilities of forming clusters of 8 double with them.

VI. CODING OF THE PROBLEM OF OPTIMAL PERSONNEL ALLOCATION IN THE MAINTENANCE OF WAGONS

Since this work used real field data, an extensive phase of field data collection and processing was initially necessary in order to provide the input information for the GA.

Considering the complexity of the database, in the initial stage of this work some assumptions and restrictions to the problem were assumed, such considerations will be addressed in the first part of this section and in the sequence the aspects of the coding and optimization of the problem will be detailed.

6.1 Preparation of the database

Given that each wheel change is registered in a maintenance system, it was possible through historical data to evaluate the performance of each mechanic by teaming up with different co-workers, that is, assuming a team of N mechanics, each of these being able to form N-1 doubles and each of these with their own average wheel change time.

Regarding the data of wheel changes used in this study, those that met the following specifications were considered:

- Made between January 1, 2018 and January 31, 2019

- Made between 7:00 am and 4:00 pm

- Made by exactly two mechanics

- Made by mechanics who after January 2019 were still on the shift from 7am to 4pm

Considering these criteria, 3,126 samples of wheel changes were part of the study, made by a total of 16 mechanics.

For the sample space of 16 mechanics, each possible solution of the problem will be formed by a grouping of 8 pairs, with a total of 120 different pairs possibilities (combination of 16 elements taken two by two).

From the historical data of the 3,126 wheel changes considered, of the 120 possibilities of workers pairs it was possible to obtain 96 average times of change, that is, so far there were 24 pairs whose mechanics had not worked together before to have their time sampled. For this group of pairs without a previous sample, the joint time of the pair was obtained from an approximation based on the individual times of each member of the pair.

Assuming A and B two mechanics who have never worked together and who are in the group of 24 pairs without sampling time, a weighted average between the average time of changing A's wheelset was considered as an estimate of the average wheel change time for double AB with other mechanics (excluding B), and the average time of changing B's wheel with other mechanics (excluding A), adding to this weighted average a constant of adjustment.

The weighting coefficients were obtained from the data of the 96 pairs that had their times already sampled, these were interpolated through the SOLVER tool in Excel in order to obtain an equation that allowed to calculate the time of a pair from the individual times of two mechanics, seeking to present a minimum error.

The following is a summary of the steps described in this session in Figure 6, which were followed to collect and prepare the database.

Once all the average wheel change times were obtained for the 120 possible workers pairs, the problem was modeled so that the genetic algorithm proposed an optimized combination of 8 mechanical pairs, so that the average change time of the wheels of this set was minimized.

6.2 Sequence of work adopted for optimization in the field

During the implementation of the AG, theratewere fixed crossover and the stopping criterion, but different parameters of population and mutation rate were considered in order to evaluate the performance of the GA in different configurations.

Each GA configuration was simulated 50 times and its results were compared with each other and also with respect to random choice and optimization, with the configuration that presented the best performance considered to be taken forward to the practical field-testing phase.

After the GA and its respective parameters were validated, it was moved to the field-testing phase, for which a smaller scope of mechanics was considered, since the 16 initially evaluated worked in two different provinces which would imply greater difficulty. to conduct the study simultaneously in two groups. Thus, we opted for the inspectorate that had more mechanics and that presented more sampled data from wheel changes, which would guarantee a greater consistency of the database to be considered.
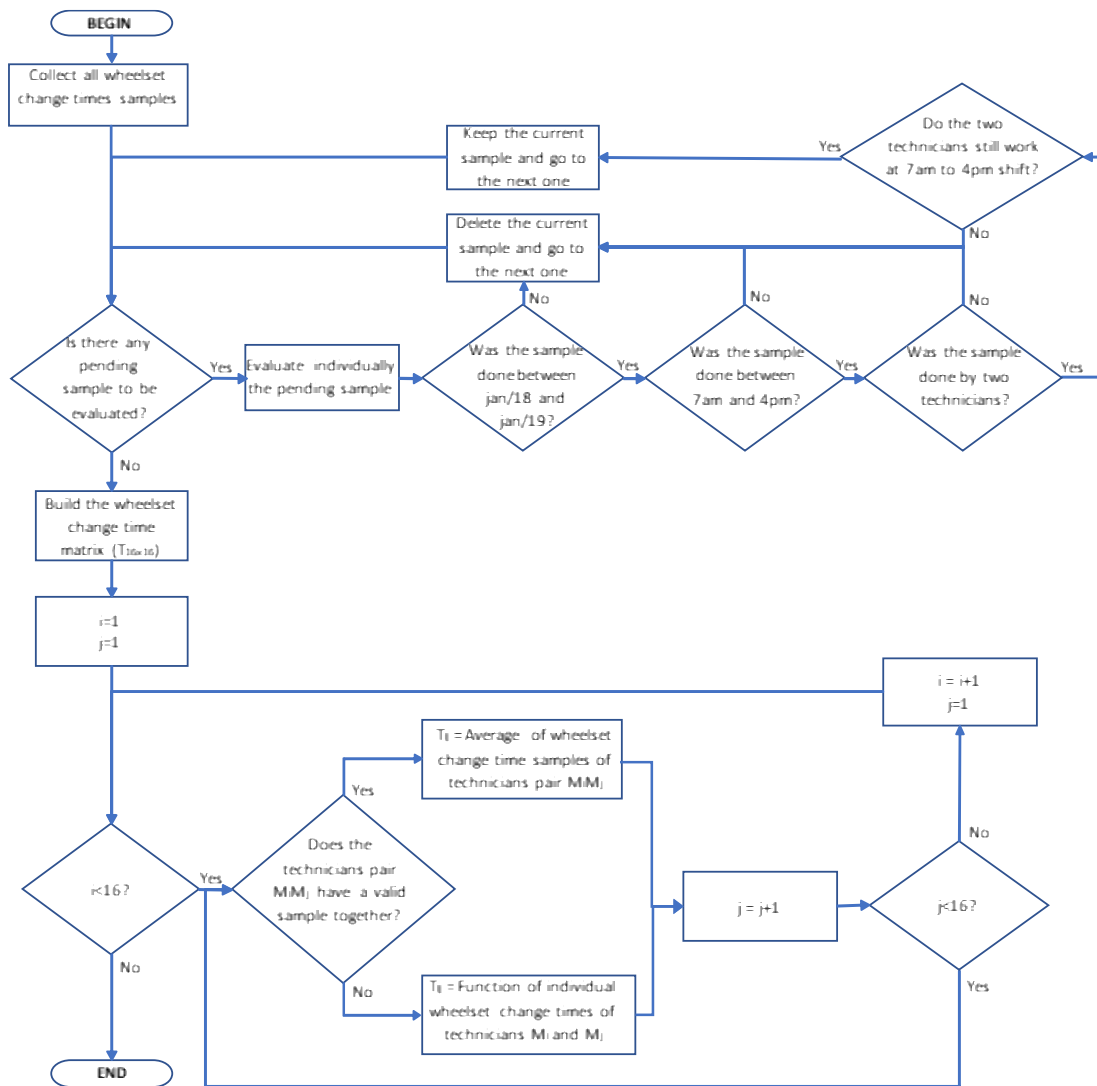
Fig. 6:Flow followed for collection and treatment of the database.

Thus, for the field testing phase the GA was run again considering now only the combination of mutation rate and population size that showed the best performance among the simulations made for the group of 16 mechanics. In this sense, considering from now on only the mechanics of the prioritized inspectorate, 10 mechanics were evaluated and, at the end of the optimization, were grouped into 5 workers pairs.

These 5 workers pairs proposed by the GA were implemented in practice,which caused a change in the scale of some employees and change in workers pairs 375 until then practiced, this new configuration being practiced for three months, between April and June 2019.

After three months of tests, it was then evaluated whether there was a reduction in the average time for

changing wheels for this group of 10 mechanics, in addition to also comparing the average time for exchanges made by the called optimized pairs with those made by randomly formed pairs.

Figure 7 shows the flow of simulations and field tests, it can be seen that GA was tested with 6 different combinations of mutation rate and population size, with the best result being tested in the field within a control group.

To process the GA, a computer with a 2.10 GHz AMD processor, with 8 GB RAM and a Windows 10 64-bit operating system was used, being used in implementation of the Visual Basic programming language within the Excel environment.
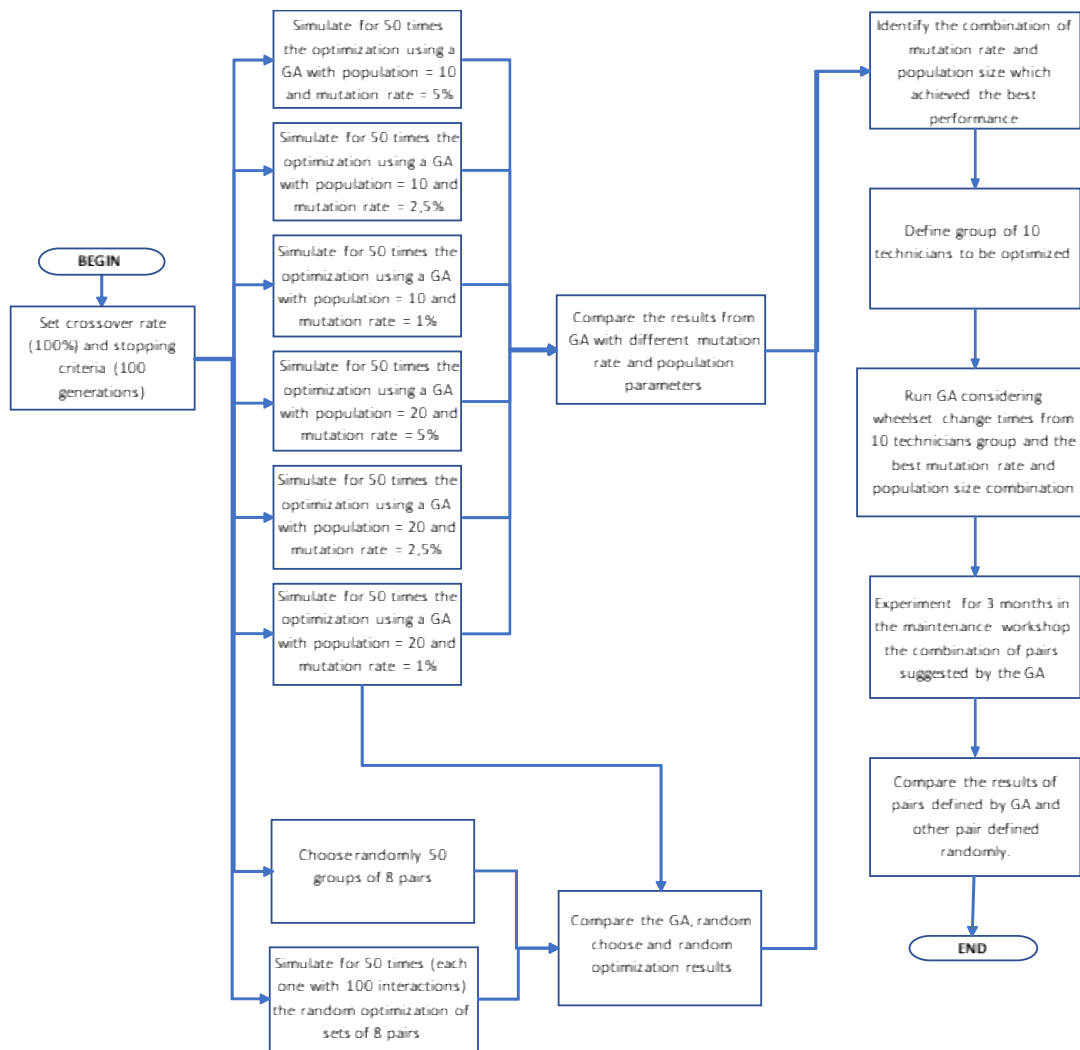
Fig. 7:Flow followed for simulations and field tests.

VII. TABULATION OF THE AVERAGE TIME OF CHANGE OF WHEELSET BY WORKER PAIR

The data of average time of change of wheelset by worker pair were structured in a matrix form, where the element T_{ij} represents the average time of change of wheelset formed by the pair mechanic i with mechanic j.

In this sense, it should be noted that in this time matrix the main diagonal of the same should not be considered valid, since a mechanic cannot pair with himself.

Another characteristic of the time matrix is that it is symmetrical, this is due to the fact that the average changeover time for the wheels of the mechanics pair AB is exactly equal to the time of the double BA, that is, the element T_{ij} of the matrix is exactly equal to the element T_{ji} , for any and i and j less than or equal to the total number of mechanics.

In the case of the problem in question, since there are 16 mechanics, the wheel change times table consists of a 16 x 16 matrix, where each element corresponds to the historical average of wheel changes made by two mechanics. A representative letter was assigned to each of the 16 mechanics, so the time 405 matrix looks as shown in Table 1.

To complete of Table 1, 240 data of average times of change of wheelsets were needed, which can be reduced by half given the symmetry of the table. However as seen previously, of the 120 required times 24 had never been sampled, that is, the mechanics of the pairs associated with the empty cells, in Table 1, until the time of data collection had never worked together before and therefore it was not possible to obtain their time. Despite the 24 missing times, another 96 were successfully obtained from historical data, so 80% of the data needed to

use as an entry to the AG was available, which were then used to estimate the 20% that had no previous samples.

Table 1: Actual data on average wheel change times for 16 mechanics (min).

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
A	-	23.4	19.0	10.6	11.9	13.5	12.6	18.0	14.5	11.4	14.3	12,7	11.9	13.0	16.1	12.6
B	23.4	-				11.7	21.7		20.6	15.0		15.0		19.5	17.2	12.6
C	19.0		-		14.9	14.8	18.0	11.7	17.3			10.4	12.8		13.2	11.0
D	10.6			-	12.0		11.5	12.4	11.2	13.0	23.5	10.8	12.8	11.8	17.2	12.3
E	11.9		14.9	12.0	-	12.5		16.3	15.9	21.7	21.5	15.5	15.8	11.8	14.3	12.3
F	13.5	11.7	14.8		12.5	-		33.0	13.6	11.3	15.3		13.0	10.4	12.4	10.8
G	12.6	21.7	18.0	11.5			-		12.0	10.7	16.3	11.3	12.9	10.9	25.6	12.9
H	18,0		11.7	12.4	16.3			-				33.0 to 12.3	11.4			14.7
I	14.5	20.6	17.3	11.2	15.9	13.6			-		12.0 to 17.3	13,6		23.5		
J	11.4	15.0		13.0	21.7	11.3	10.7			-	12.9	12.1	11.5	14.0	26.0	14.0
K	14.3			23.5	21.5	15.3	16.3		17.3	12.9	-	13.0	12.2	14.0	14,8	12.8
L	12.7	15.0	10.4	10.8	15.5		11.3		13.6	12.1	13.0	-	14.0	13.6	15.3	12.7
M	11.9	12,8		12.8	15.8	13.0	12.9	12.3		11.5	12.2	14.0	-	13.1	13.6	12.8
N	13.0	19.5		11.8	11.8	10,4	10.9	11.4	23.5	14.0	14.0	13.6	13.1	-	10.3	8.2
O	16.1	17.2	13.2	17.2	14.2	12.4	25,6			26.0	14.8	15.3	13.6	10.3	-	8.2
P	12.6	12.6	11.0	12.3	12.3	10.8	12.9	14.7		14.0	12,8	12,7	12,8	8,2	8,2	-

Among the 96 pairs with times already sampled in the evaluated history, 42 of these had at least 25 samples considered in determining their average wheel change time, so given their greater representativeness of data, these 42 pairs were considered to interpolate an equation that would allow estimate the average time for changing the wheel of a pair that had never worked together before, using the individual times of each mechanic when working with other partners.From the 42 times of the pairs whose values were obtained from more than 25 real samples each, an equation was simulated that considered the time of the 425 pair as being a weighted average between the time of the fastest mechanic in the pair and the slowest, adjusted by a correction constant, as shown in Equation 7.

$$Changeovertime = \alpha.SlowMechalnicalTime + \beta.FastMechalnicalTime + \gamma \qquad (7)$$

After SOLVER processing, tool from Excel Microsoft Software, Equation 8 was reached, which when used as a comparison with the actual measured results 430 of the exchange times of the 42 pairs with more than 25 samples each, presented an average error of 7.8%. Thus, the 24 pairs that did not have previous samples had their average wheel change times estimated from Equation 8.

$$Changeovertime = -0.69.SlowMechalnicalTime + 1.64.FastMechalnicalTime - 0.07 \qquad (8)$$

With the equation 8, it was possible to complete the remaining times in the matrix of average wheel change times, and then Table 2 was used as the input base for the genetic algorithm to be implemented. To provide the average wheel change times presented in Table 2 was used a huge electronic database with historical data of this task done by different mechanics, totalizing 21.856 samples, but considering that the main objective of this work was to implement in the real life the optimization suggested by GA, was necessary to discard 8.298 wheel change time samples that had the participation of workers who do not work anymore at the maintenance workshop.

Considering that there are some outliers in the 13.558 left samples after remove those done by past workers, a statistic treatment was necessary to remove these outliers, so in the end was used 12.037 samples statistically valid,8.

Table 2: Actual and estimated data for average wheel change times for 16 mechanics (min).

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
A	-	23,4	19,0	10,6	11,9	13,5	12,6	18,0	14,5	11,4	14,3	12,7	11,9	13,0	16,1	12,6
B	23,4	-	12,5	10,6	12,0	11,7	21,7	15,1	20,6	15,0	14,0	15,0	13,0	19,5	17,2	12,6
C	19,0	12,5	-	11,8	14,9	14,8	18,0	11,7	17,3	13,5	13,1	10,4	12,8	13,6	13,2	11,0
D	10,6	10,6	11,8	-	12,0	12,1	11,5	12,4	11,2	13,0	23,5	10,8	12,8	11,8	17,2	12,3
E	11,9	12,0	14,9	12,0	-	12,5	13,3	16,3	15,9	21,7	21,5	15,5	15,8	11,8	14,3	12,3
F	13,5	11,7	14,8	12,1	12,5	-	12,9	33,0	13,6	11,3	15,3	12,7	13,0	10,4	12,4	10,8
G	12,6	21,7	18,0	11,5	13,3	12,9	-	12,1	12,0	10,7	16,3	11,3	12,9	10,9	25,6	12,9
H	18,0	15,1	11,7	12,4	16,3	33,0	12,1	-	15,8	12,0	13,7	12,5	12,3	11,4	13,4	14,7
I	14,5	20,6	17,3	11,2	15,9	13,6	12,0	15,8	-	12,0	17,3	13,6	12,7	23,5	13,4	11,5
J	11,4	15,0	13,5	13,0	21,7	11,3	10,7	12,0	12,0	-	12,9	12,1	11,5	14,0	26,0	14,0
K	14,3	14,0	13,1	23,5	21,5	15,3	16,3	13,7	17,3	12,9	-	13,0	12,2	14,0	14,8	12,8
L	12,7	15,0	10,4	10,8	15,5	12,7	11,3	12,5	13,6	12,1	13,0	-	14,0	13,6	15,3	12,7
M	11,9	13,0	12,8	12,8	15,8	13,0	12,9	12,3	12,7	11,5	12,2	14,0	-	13,1	13,6	12,8
N	13,0	19,5	13,6	11,8	11,8	10,4	10,9	11,4	23,5	14,0	14,0	13,6	13,1	-	10,3	8,2
O	16,1	17,2	13,2	17,2	14,3	12,4	25,6	13,4	13,4	26,0	14,8	15,3	13,6	10,3	-	8,2
P	12,6	12,6	11,0	12,3	12,3	10,8	12,9	14,7	11,5	14,0	12,8	12,7	12,8	8,2	8,2	-
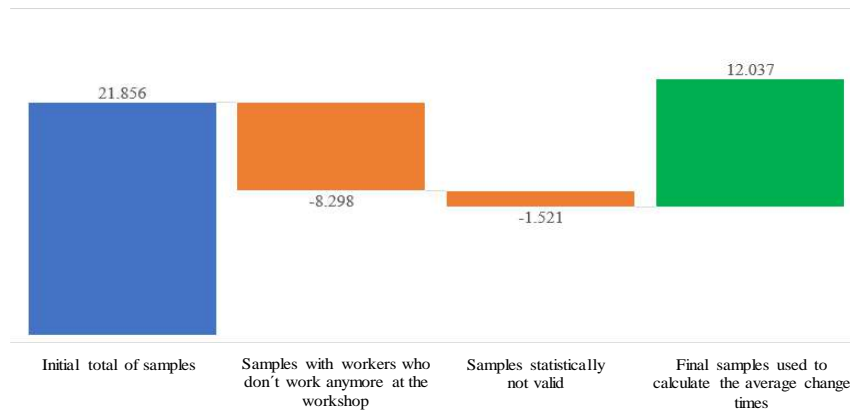
Fig. 8:Quantitative sample data of workers used.

VIII. COMPUTATIONAL CALCULATIONS AND ANALYSIS OF RESULTS

The GA modeling was conceived through order-based representation, thus each chromosome was composed by a sequence of 16 letters, so that each letter represented a different mechanic, with each two sequential letters representing a worker pair. In summary, a chromosome of the problem in question corresponds to a grouping of 8 pairs and its objective function is the result of the average changeover times for these 8 pairs, whose times are shown in Table 2. An example is given in Table 3 viable chromosome for the problem at hand.

Table 3: Example of a viable chromosome for the problem.

	Par 1		Par 2		Par 3		Par 4		Par 5		Par 6		Par 7		Par 8		Average Time Chromosome (min)
	C	K	G	L	F	D	J	B	H	O	E	M	I	N	A	P	14,6
Double Time (min)	13,1		11,3		12,1		15,0		13,4		15,8		23,5		12,6		

To test the performance of GA against different input parameters, it was evaluated by varying the population size (10 and 20 individuals) and the mutation rate (1%, 2.5% and 5%), thus totaling 6 different combinations, defining for all the same stopping criterion that was the limitation in 100 generations.

The crossover rate was 100% and the method of choosing individuals to cross was linear standardization, a method very similar to the roulette wheel, with the only difference that the probabilities of each chromosome draw depend not only on the original aptitude of the individuals, but rather of the relative position of each one of them before the list of all the chromosomes of the population when ordered in descending order by criterion of aptitude. The performance evaluation of each chromosome was done through the fitness function shown in Equation 9, where N is the number of individuals in the population, and i is the chromosome index in the population in decreasing order of the objective function. It is usual to adopt $1 \leq Max \leq 2$ and Max+Min = 2, so in this work was set Min = 0.5 and Max = 1.5.

The Max and Min parameters defines the selection pression, the bigger the difference between Max and Min the bigger the selection pressure will be, this way the GA search will strongly favor the best individuals found so far, in opposite, low selection pressures favor a little bit more chromosomes with low fitness, but at the same time allow the GA to explore unknow search areas.

$$Fitness = Min + (Max - Min).\frac{Ni}{N-1} \qquad (9)$$

From the fitness presented in Equation 6 it was possible to potentiate the 475 performance differences between chromosomes, since if they were evaluated directly by the original objective function, which is the average of the wheel change times of the 8 pairs of the chromosome, there would be a greater risk of individuals with good and bad performances presenting very close chances of being drawn for crossover.

With this change in fitness, a more effective criterion was obtained in prioritizing the best chromosomes, which reduced the chance of GA losing efficiency due to ineffective draws. Table 4 shows an example of this for a hypothetical population.

Table 4: Example of assessment in fitness chromosome a hypothetical population.

Individuals composed by pairs of workers													Function Objective	% of draw	i	Fitness	% of draw
K	H	N	C	E	F	B	I	A	O	L	G	P	D	J	M	13.94	9.9%	7	0, 8	8.3%
E	B	L	O	H	C	A	K	M	D	I	G	P	N	F	J	12.20	11.3%	1	1.5	15.0%
K	J	D	P	N	B	C	I	G	L	M	A	E	F	H	O	13.87	10.0%	5	1.1	10.6%
H	N	E	I	B	M	L	O	A	P	D	C	F	J	G	K	13.45	10.3%	4	1.2	11.7%
O	L	J	H	M	K	C	I	P	A	N	E	G	D	B	F	13.05	10.6%	3	1.3	12.8%
F	O	J	I	C	G	D	M	H	N	A	B	L	P	K	E	15.53	8.9%	9	0.6	6.1%
C	N	B	L	H	A	D	G	P	M	F	I	O	J	E	K	16.51	8.4%	10	0.5	5.0%
H	C	M	P	E	I	B	J	G	L	O	D	N	K	F	A	13.92	9.9%	6	0.9	9.4%
L	M	H	J	D	O	A	E	N	K	B	G	P	C	I	F	14.42	9.6%	8	0.7	7.2%
N	A	C	D	H	L	M	F	G	E	J	I	K	B	P	O	12.22	11.1%	2	1.4	13.9%

The precision gain that can be achieved with the adjustment fitness, this finding is clear from the comparison between the worst and the best individual in the population, with average wheel change times of 16.51 and 12.20 minutes respectively. If your objective function values were considered for selection for crossover, the worst individual would have an 8.4% chance of being drawn and the best would have 11.3%, whereas considering the use of fitness these percentages change to 5.0 % and 15.0%.

From the above observation, it can be seen that the use of Equation 6 as fitness allows to better evidence the extremes between the best and worst chromosomes, which for the genetic algorithm is of great value since the tendency of the best individuals to be drawn will be greater, there will soon be a greater chance that the best genes will perpetuate over the generations.

After the stage of linear standardization, the drawing of individuals took place using the roulette method, where each chromosome of the population was represented by a slice of an imaginary roulette, the size of this slice being proportional to the fitness of each chromosome. After all the slices of theroulette were delimited, a random number was generated simulating a spin of the roulette, which in turn had a fixed hand indicating the slice drawn, thus the greater the fitness, the greater the slice of this chromosome and the greater your chance to be drawn.

As it is a problem of combinatorial and non-numerical optimization, the operator crossover to be chosen for this AG cannot just copy part of the genetic material of two parents and join in a child, given that there is a risk of some genes repeating.

For cases like this, the operator crossover must take into account the relative position of each gene within the chromosome and not just the absolute position, that is, just saying that a particular gene is located in position 4 of the chromosome would not make much sense, this information would only have value coming together with the specification of the genes present in adjacent positions 3 and 5.

Therefore, once two chromosomes of the population were drawn, the crossover operator used was the OX crossover (order crossover), its basic operation can be summarized following the steps below:

- Step 1: Randomly draw two cut points on the chromosome.

- Step 2: With two chromosomes (C_1 and C_2) copyto the child chromosome (C_3 the genes of C_1) that are between the two cut points previously drawn.

- Step 3: From the position after the second cut point, copy to C3 the C2genes that are not yet present between the two cut points of the child chromosome.

- Step 4: If you reach the end of the child chromosome without having all the positions filled, continue filling it from the beginning of it following the same logic as the previous step.

Table 5 e 6 illustrates the steps described above, through which it is possible to see that the crossover OX is very suitable for this type of problem, since it does not allow having two identical genes within the same chromosome after crossing.

As for the mutation, it occurred so that it did not generate inconsistent individuals, as for example when there are two identical letters on the same chromosome, which would mean that the same mechanic would be allocated to two workers pairs at the same time. Thus, the mutation was based on a random draw of two positions on the chromosome, after which the genes in these positions inverted and gave rise to a new chromosome, as shown in Table 7.

In addition, in order not to lose the best individual of each generation, elitism was adopted, thus the algorithm was designed to always take the best individual of the current generation to the next generation.

For the purpose of validating the algorithm, each of the 6 combinations of population size (10 and 20 individuals) and mutation rate (1%, 2.5% and 5%) was simulated 50 times and the distribution of these 50 times average change of wheels obtained after optimization via GA was compared with 50 average times generated from the random choice of a group of 8 pairs of mechanics.

The performance of the proposed genetic algorithm was also compared with a random optimization, having been verified generation by generation the evolution of the optimization for both methods.

After the simulations, a comparative performance analysis was performed between each of the 6 combinations of population size and mutation rate scenarios, with the best performance being adopted for the field tests.

Table 5: sequence CrossoverOX.

STEPS	CHROMOSOME	OBSERVATION
1	C_1 K H N C E F B I A O L G P D J M	Parent chromosome C_1: the cutoff points between genes 2 and 3 and 13 and 14 were drawn.
1	C_2 E B L O H C A K M D I G P N F J	Parent chromosome C_2: the genes marked in red are already contained between the Ccutoff points₁.
-	C_3	Child chromosome₃ still empty.
2	C_3 _ _ N C E F B I A O L G P	The genes between positions 3 and 13 of C_1 are copied to the same positions in C_3.
3	C_3 _ _ N C E F B I A O L G P J	As N and F of C_2 already appear in C_3 between the cut points, take the Jgene from C_{22} and copy it to the position after the second cut point in C_3.
3	C_3 _ _ N C E F B I A O L G P J H	As J is the last gene in C_2, one must search from the beginning of C_2 which gene it does not yet appear in C_3, in this case it is the H gene, which must then be copied to the next empty position of C_3.
3	C_3 _ _ N C E F B I A O L G P J H K	After H in C_2 the next gene that does not yet appear in C_3 is K, so it must be placed in the position after H in C_3.

Table 6: sequence CrossoverOX - Continued.

Step	Chromosome	Observation
4	C_3 M _ N C E F B I A O L G P J H K	As we reached the end of C_3 but there are still empty positions at the beginning of the chromosome, we must follow the logic of copying the Cgenes that have not yet appeared in C_3 only considering from the first position of C_3.
4	C_3 M D N C E F B I A O L G P J H K	Finally, the *crossover* is completed by copying the D of C_2 to the last position of C_3 that was empty.

Table 7: Chromosome mutation for optimization based in order.

Chromosome	Observation
E B L O H C A K M D I G P N F J	Original chromosome before mutation.
E B L O H C A K M D I G P N F J	Positions 5 and 12 drawn for mutation.
E B L O G C A K M D I H P N F J	Chromosome after mutation.

IX. DESCRIPTION AND ANALYSIS OF THE RESULTS IN A REAL CASE

After compiling the 3,126 real samples of wheel changes made in the field, it was possible to elaborate the average wheel change times matrix for the 120 pairs possible to be formed with a team of 16 mechanics, as

presented previously in Table 2, this being the reference used as a basis for assessing the skills of chromosomes.

Using the proposed modeling, where each chromosome was formed by a sequence of 16 letters in which each represented a mechanic, the optimization code was written using a genetic algorithm that initially adopted rate crossover of 100%, mutation rate 1%, population of 20 chromosomes and stopping criteria for reaching the hundredth generation.

The optimization code was simulated 50 times with the average computational processing time for each simulation being 12 minutes and 58 seconds. In each of the 50 simulations, the average solution optimized by the genetic algorithm was calculated for each generation, resulting in Figure 9.

Calculating the average of the optimized value upon reaching the hundredth generation of each of the 50 simulations, an optimized average time was obtained for the set of 8 pairs of 11.1 minutes, with the lowest value found in the simulations being 11 minutes, which illustrates the effectiveness of the convergence of the implemented GA.
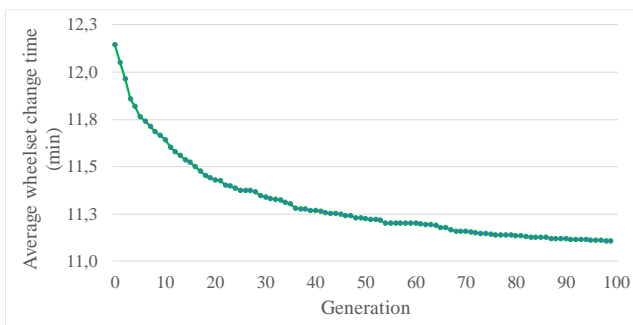
Fig. 9:Evolution of GA in 100 generations (Population = 20 and Mutation rate = 1%).

9.1 Comparison of optimization via AG versus random choice

In order to compare the quality of the choice of working pairs through optimization via genetic algorithm versus the choice of pairs at random, the results obtained by the 50 simulations of the GA were compared with 50 random choices of clusters of 8 workers pairs, resulting in the data distributions shown in Figure 10.
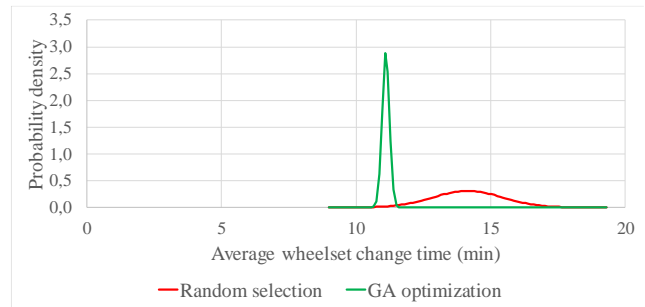
Fig. 10:Distribution of 50 average times for changing wheels obtained via GA versus random choice.

For the 50 results obtained through the genetic algorithm, an average time was found of 11.1 minutes with a standard deviation of 0.14 minutes, while for the 50 results obtained by random choice the average was 14.2 minutes and the standard deviation 1.29 minutes, both with normal distribution characteristics.

Through this simulation, it can be seen that the optimization via genetic algorithm is able to enhance the performance of the work team, since compared to the random choice of workers pairs, which is the method commonly adopted in practice, the GA presented a reduction 22% of the average wheel change time and a 89% reduction in standard deviation.

9.2 Comparison of optimization via GA versus random optimization

In addition to comparing the set of 50 samples of average exchange times obtained through the genetic algorithm with another 50 samples obtained from the random choice of workers pairs, it was also considered to simulate 50 random optimization cycles to compare with GA's performance over generations.

The random optimization consisted of choosing randomly and sequentially 100 samples from groups of 8 pairs, being then calculated for each set of 8 pairs the average time of change of associated wheel. The average optimized time for each iteration is given by the lowest average time found so far, so in the hundredth iteration the optimized time will be the shortest average time found over the 100 samples generated at random.

50 random simulations were run and the average time optimized for each iteration was compared with the 50 simulations of the genetic algorithm, with the result of the comparison shown in Figure 11.
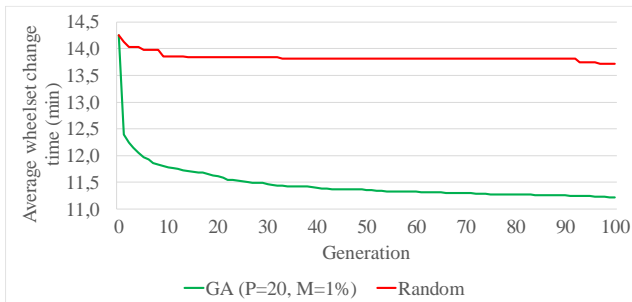
Fig. 11:Comparison of performance between random optimization and optimization via GA (P = population and M = mutation rate).

Fig. 12:Comparison of AG for different population parameters (P) and mutation rate (M).

The average of the 50 simulations of random optimization was 13.7 minutes, while through the GA an average of 11.1 minutes was obtained, that is, the optimization via GA was 19% more efficient than random optimization.

In addition to the superiority in the final value that the optimization found,it is clearly seen in Figure 11 how much the genetic algorithm proved to be faster than the random optimization, it showed stagnation in a good part over the 100 iterations, given that between the generations 10 and 90 practically the average time optimized randomly did not vary, while the GA value was consistently reduced.

9.3 Analysis of sensitivity of the parameters of the GA

In order to test the sensitivity of the parameters adopted in the genetic algorithm and also to confirm that the parameters used until then with a mutation rate of 1% and a population of 20 individuals were in fact assertive choices, simulations of optimization through the same GA changing only these parameters in order to compare their performance.

Two population size options (10 and 20 individuals) and 3 mutation rate options (1%, 2.5% and 5%) were considered, thus totaling 6 possible combinations on Tables 8 and 9.

For each combination of parameters, 50 optimization simulations were performedand in each simulation the same stopping criterion was used, which was reaching the hundredth generation of individuals.

The averages of the values optimized for each generation for each of the possible parameter combinations are shown in Figure 12, from which it is observed that the 3 simulations that considered a population of 10 individuals had a worse performance than the 3 simulations with population of 20 individuals, with the average 11.3 minutes and 11.1 minutes, respectively.
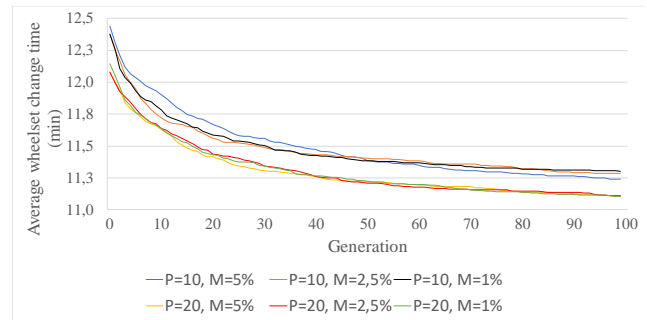
It is important to say that each curve in the figure 12 was obtained from an average of 50 simulations of GA optimization, that totalized 3.760 min of simulation time, with the following main statistics results.

Observing the simulations with a population size equal to 20, it was seen that even changing the mutation rate between 1%, 2.5% and 5% there was no significant difference between them over the generations, however considering the same mutation rates for the case of the population being 10 individuals, there was a greater variation in GA performance, especially in the first 50 generations.

From the results obtained, it was seen that the definition of the mutation rate at 1% with a population of 20 individuals, which were the parameters used until then, constitute an acceptable configuration to run the constructed genetic algorithm, and these are the parameters to be used. considered for field implementation.

Table 8: Summary of simulations with variation in population size and mutation rate with stop criteria in 100 generations.

	Total number of simulations	Total simulation time (min)		Optimized Wheel Change Time (min)	Simulation Time (min)
S1 - P=10, M=5%	50	596.7	Average	**11.2**	11.9
			Standard Deviation	0.19	1.0
			Maximum	11.8	12.5
			Minimum	11.0	8.9
S2 - P=10, M=2,5%	50	634.7	Average	**11.3**	12.7
			Standard Deviation	0.20	0.7
			Maximum	11.7	13.1
			Minimum	11.0	10.0
S3 - P=10, M=1%	50	561.4	Average	**11.3**	11.2
			Standard Deviation	0.24	1.2
			Maximum	11.9	14.2
			Minimum	11.0	8.0

Table 9: Continue - Summary of simulations with variation in population size and mutation rate with stop criteria in 100 generations.

	Total number of simulations	Total simulation time (min)		Optimized Wheel Change Time (min)	Simulation Time (min)
S4 - P=20, M=5%	50	623.8	Average	11.1	12.5
			Standard Deviation	0.10	0.7
			Maximum	11.4	13.4
			Minimum	11,0	9.5
S5 - P=20, M=2,5%	50	725.4	Average	11.1	14.5
			Standard Deviation	0.12	2.2
			Maximum	11.4	17.9
			Minimum	11.0	9.6
S6 - P=20, M=1%	50	648.1	Average	11.1	13.0
			Standard Deviation	0.14	1.1
			Maximum	11.4	15.7
			Minimum	11.0	9.7
TOTAL	300	3790.0			

9.4 Verification in the field

The entire optimization process was based on real data on the time of change of wheelsets, provided that they met some criteria as previously discussed, so at the end of the optimization, the algorithm indicated a combination of workers pairs that based on the data historical, supposedly together they would be able 645 to present an average time of change of wheels optimized for the workshop in point.

At this point, with the indication of the optimized group of workers pairs, the strategy to assess the real gain arising from the optimization was based on the indication of the genetic algorithm to maintain fixed workers pairs, in order to make the greatest number of wheel changes using the pairs indicated by the algorithm. After this redefinition of the pairs, the average time for changing the workshop was followed by three months, then the average time for changing the wheels before and after implementing the optimization of the pairs was compared.

From 16 mechanics considered in the problem, 10 of them belonged to the same province and 6 belonged to another, thus, in practice, the algorithm could indicate a pair formed by two mechanics from two different provinces, which is to be avoided because this way - there were two inspectors for the same work team.

The inspectorate with 6 people, in addition to making wheel changes, was also responsible for other maintenance services, while the one with 10 mechanics was exclusively responsible for changing wheels, for this reason the latter team had the highest percentage of wheels changed in the workshop.

As shown in Table 2, considering 16 mechanics, there are 120 possible pairs to be formed, however in the problem in question 24 of these pairs had not worked together in the last 13 months so that they could have their time sampled, in which case the Equation 1 as a way to estimate the time of the pair and thus enable the necessary data to run the optimization code.

In practice, each province formed its work teams using its own mechanics, that is, although it was not forbidden, it was not common to mix the mechanics of one province with those of the other, except when necessary due to some operational issue, such as the lack of a mechanic, which usually occurs due to vacation, training, illness, legal leave, lunch break, etc.

It is noteworthy that the more pairs without real samples of their wheel change time, the more times it will be necessary to use Equation 1 to estimate this value and the greater the chance of error in this interpolation, consequently the greater the chance of inaccuracy in the result of the optimization algorithm.

Considering only the inspectorate formed by 10 mechanics, there is the possibility of forming 45 pairs, and for the problem in question, only 3 of these pairs had no past samples of wheel changes and only in these cases would it be necessary to use Equation 1, which would reduce exposure to error due to this approximation.

It is known that the genetic algorithm originally considered 16 mechanics, based on these data, several simulations were made that showed a potential gain in the average time for changing the wheels if the combination of workers pairs pointed out by him was adopted, but for practical proof it was seen that working simultaneously with 16 mechanics would make the field test more complex due to the issues previously exposed, so it was decided to do the field tests considering the inspectorate composed of 10 mechanics as a control group.

Once only the group of 10 mechanics was adopted, Table 10 of times was obtained to be considered by the genetic algorithm as input data for the evaluation of the optimized combination of workers pairs.

Table 10: Matrix of average wheel change times for the inspection of 10 mechanics (min).

	A	B	D	G	J	K	L	M	N	O
A	-	23.4	10.6	12.6	11.4	14.3	12.7	11,9	13.0	16.1
B	23.4	-	10.6	21.7	15.0	14.0	15.0	13.0	19.5	17.2
D	10.6	10.6	-	11.5	13,0	23.5	10.8	12.8	11.8	17.2
G	12.6	21.7	11.5	-	10.7	16.3	11.3	12.9	10.9	25.6
J	11.4	15,0	13.0	10.7	-	12.9	12.1	11.5	14.0	26.0
K	14.3	14.0	23.5	16.3	12.9	-	13.0	12.2	14.0	14.8
L	12.7	15.0	10.8	11.3	12.1	13.0	-	14.0	13.6	15.3
M	11.9	13.0	12.8	12.9	11.5	12,2	14.0	-	13.1	13.6
N	13.0	19.5	11.8	10.9	14.0	14.0	13.6	13.1	-	10.3
O	16.1	17.2	17.2	25.6	26.0	14.8	15.3	13.6	10.3	-

From the times indicated in Table 6, the genetic algorithm was run again,considering the parameters of mutation rate of 1%,rate crossover of 100%, population of 20 individuals and stopping criteria reaching 100 generations. After running the optimization via GA considering the times in Table 10, an indication of 5 pairs of work was obtained, which became the desired combination of work team, since making the wheel changes through these pairs is expected to 700 have an average time for changing the wheel better than considering the random formation of the pairs.

It is worth mentioning that within the group of 10 mechanics considered for the field tests, there were people who worked at different scales, so even though all of them were working the morning shift, every day part of the 10 people were off duty while others were working.

The fact that the scale provides that two mechanics working on different scales there are days when when one is working the other will be off, has a direct impact on field tests since among the 5 pairs suggested by the AG there were pairs that currently worked on different scales, there would soon be days that it would be impossible for them to work together in the workshop.

The work schedule hitherto practiced in the workshop consisted of a cycle of four days of work followed by a day off, followed by another four days of work followed by two days off. Altogether there were six different scales, all running in this sequence, just differing by the lag between them, so every day there was one or two scales off, which meant that on specific days some mechanics were not simultaneously in the workshop, Table 11 shows the workshop scales, it shows for example that on days 5 and 6 a mechanic working on scale 1 and another on scale

2 will not be together in the workshop, because the first will be off on the first day while the second will be off on the second day.

Table 11: Practical work scales in the workshop (T = working day, F = day off).

Scale / Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Scale 1	T	T	T	T	F	T	T	T	T	F	F	T	T	T	T	F	T	T
Scale 2	F	T	T	T	T	F	T	T	T	T	F	F	T	T	T	T	F	T
Scale 3	F	F	T	T	T	T	F	T	T	T	T	F	F	T	T	T	T	F
Scale 4	T	F	F	T	T	T	T	F	T	T	T	T	F	F	T	T	T	T
Scale 5	T	T	F	F	T	T	T	T	F	T	T	T	T	F	F	T	T	T
Scale 6	T	T	T	F	F	T	T	T	T	F	T	T	T	T	F	F	T	T

However, after the indication of the optimized pairs, the two mechanics that made up each of the five pairs of work indicated by the genetic algorithm were placed on the same scale of work, so that for example, in the combination of pairs, mechanic A was the ideal pair for mechanic B, both working on the same scale, so that in most cases they could change wheels together.

Even defining fixed work pairs and adjusting the scales to facilitate the formation of these work groups in practice, it was not possible to guarantee that all wheel changes were always carried out by the optimized pairs, since during the working day there is a need to do rotation of the team for lunch in addition to medical absenteeism, holidays and other absences of personnel that may occur.

With the 5 pairs indicated by the GA as an optimized combination of work group, the suitability of the workers pairs was disclosed to the team and the inspector of the area was instructed to do his utmost to maintain this combination. In order to remember the new workers pairs, it was fixed in the workshop notice board which pairs should be adopted from that moment.

For comparison purposes before and after the implementation of the optimized workers pairs, we observed the history of the last 9 months before the optimization and another 3 months after the change, thus totaling a performance analysis in a window of 1 year.

In this 12-month period, 10,835 wheeler changes were accounted for, of which 7,228 exchanges were carried out by the inspectorate composed of 10 mechanics who were prioritized for field tests, that is, approximately 67% of the workshop's production in the approached shift was fulfilled. precisely by the chosen control group.

The standardization of working pairs based on the indication made by the genetic algorithm became effective as of April 1, 2019, and continued until June 30 of the same year, in this period the maximum effort was made to keep the mechanics of each working together one of the 5 workers pairs appointed by the AG, because if the

formation of the wheel change pairs remained essentially random, it would be impossible to associate any gain in productivity with the implementation of the pairs signaled by the GA.

Considering the inspectorate formed by the 10 mechanics, 7,228 wheel changes were carried out between 1 July 2018 and 30 June 2019, with the average wheel change times shown in Figure 13.

Fig. 13:History of the average wheel change time of the control group (min).

It can be observed that although the months of April and June 2019 have shown excellent results, with average wheel change times of 15.3 and 16.1 minutes, respectively, the month of May fell short expectations, presenting 17.5 minutes, a better value, but very close to the level that had been occurring before the optimization.

The disagreeable result in the month of May 2019 can be understood through operational factors that may have compromised the performance in that specific month, in this case, there were huge impacts due to the lack of new wheels to be installed, since several times in the month May after the mechanic removed a bad wheel from the wagon, instead of having the new wheel readily installed in place of the one just removed, given the lack of new wheels, the same wheel was removed for the process of recovery and after the whole cycle of maintenance of the wheel it returned to the wagon, which considerably affected the average time of changing wheels.

In addition to any operational impacts not directly associated with the performance of the work teams, as occurred in May 2019 with the impact due to the lack of wheels, there are other variables that can also affect the average changeover time, such as failure of industrial equipment and lack of manpower, however, historically the problem of lack of wheels has been the most representative of all.

In order to reduce the seasonality of possible operational problems that may compromise the average

time for changing wheels, the same period of 12 months was analyzed, however in quarterly windows, the result being shown in Figure 14.
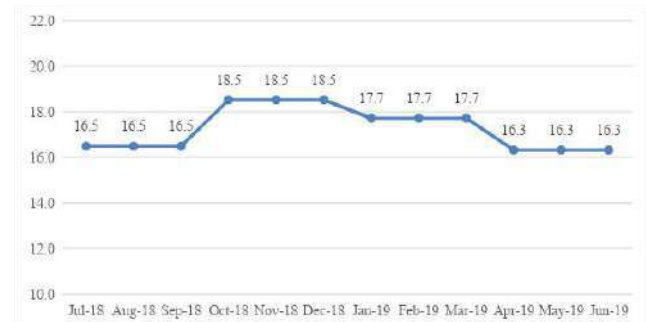
Fig. 14:Average time of wheel change grouped by quarter (min).

In the quarter between April and June 2019, the period in which optimization was tested in practice, the best average wheel change time in the last 4 quarters was obtained, and compared with the quarter between January and March 2019, there was a reduction of 17.7 to an average of 16.3 minutes, which represents an improvement of 7.9% between the first and second quarter of 2019.

Since there is a practical understanding that the impact due to lack of wheelhas been the biggest problem in the workshop and that this directly affects the average time of changing the wheel, even though it has no direct relationship with the performance of the work team, it was decided to take ning the month- to-month impact of this lack of wheelset and purging this effect from the average switching times, so that it would be possible to have a more adjusted and more consistent result with the performance aspects of the work teams. Raising the impact due to the lack of wheels, we arrived at Table 12 through which it is possible to see that in May 2019 there was the greatest impact on the changeover time due to the lack of a new wheel to replace the one removed from the wagon, being that in this month the average time of the control group was 17.5 minutes, of which 4.4 minutes were of impact due to the duo having to wait for the arrival of the new wheel, thus, purging this effect, the average change time of adjusted itinerary for the month of May 2019 would be 13.1 minutes.

Table 12: History of impacts on wheel change time due to lack of available wheel between July 2018 and June 2019.

	jul	ago	sep	oct	nov	dez	jan	fev	mar	abr	may	jun
Total wheelsets changes made by control group	453	857	498	437	385	665	500	690	504	800	733	706
Exchanges made by nonoptimized dual control group	431	817	493	429	371	633	462	676	465	224	187	268
Exchanges made the optimized dual control group	22	40	5	8	14	32	38	14	39	576	546	438
Average time of purging NO optimized double impact by wheelset (min)	14,9	14,1	15,0	14,4	15,4	16,8	17,0	16,9	14,8	14,8	13,1	12,7
Average time of the optimized pairs purging impact per wheel (min)	10,7	11,6	11,6	12,5	19,3	12,2	13,7	17,9	14,2	14,4	13,1	12,3

Figure 15 shows the history of the average wheel change time for the control group purging the impacts due to lack of wheel, in which the effect of optimization is more clearly perceived in the months of April, May and June 2019, where we see a reduction in average time, with 14.7 minutes in the month before the optimization and at the end of the third month running with the optimized fixed pairs, we reached the time of 12.4 minutes. minutes, which represents a reduction of 2.3 minutes per wheel change or 15.6%.

Fig. 15:History of the average wheel change time excluding the impact of unavailability of new wheels (min).

It is known that as of April 2019 there was a greater search for the maintenance of fixed workers pairs, the definition of these pairs being obtained from the indication of the genetic algorithm, whereas before this month the definition of workers pairs was done in an essentially random way.

Although there has been a greater repetition of the so-called optimized pairs since April 2019, it is worth clarifying that it was not possible to guarantee that all

exchanges in this period were carried out exclusively by these pairs, however when compared with the period before April, the percentage of exchanges made by the pairs considered to be optimized was much higher, as can be seen in Table 13.

Table 13: History of the rate of exchange of wheelsets made by optimized pairs between July 2018 and June 2019.

	jul	ago	sep	oct	nov	dec	jan	fev	mar	abr	may	jun
Wheels changed	453	857	498	437	385	665	500	690	504	800	733	706
Wheels changed for non-optimized pairs	431	817	493	429	371	633	462	676	465	224	187	268
Routes exchanged for optimized pairs	22	40	5	8	14	32	38	14	39	576	546	438
% of exchanges made for optimized pairs	5%	5%	1%	2%	4%	5%	8%	2%	8%	72%	74%	62%

From Table 13 shows that in the three months before field tests, on average, only 6% of wheel changes months of the month were made by the so-called optimized pairs, while from April 2019, after running the optimization algorithm, readjusting the work schedules and disclosing to the team the optimized pairs that should be followed, was reached in the period of field assessment an average of 69% of the exchanges made by the control group being performed by the optimized pairs.

Through this evaluation, it is possible to make the connection between the percentage of exchanges made by the optimized pairs and the average time of change of wheels of the control group. For the first quarter of 2019, we had 16.1 minutes as an average time for changing wheels, purging the effect of lack of wheels, and in this same period only 6% of the exchanges sampled belonged to so-called optimized pairs, whereas in the test phase of field, which took place in the second quarter of 2019, obtained an average change time of 13.3 minutes, excluding impacts from lack of wheels and 69% of exchanges made with optimized pairs in the same period, that is, an increase of 63 percentage points in the rate of exchanges made by optimized pairs resulted in a reduction of 17.4% in the average wheel change time.

In order to evaluate the average changeover times of wheelsets month by month, analyzing in this case separately the exchanges made by the pairsappointed by the GA with those said to be not optimized whose formation took place at random, the data in Table 14 was obtained.

Excluding the losses associated with waiting per wheel, it is observed in Table 14 that in the 12-month period in

question in only 2 of them the average time of the optimized pairs was worse than the average time of the randomlyformed pairs (times highlighted in red), which represents an assertiveness rate regarding the greater efficiency of the pairs proposed by the GA of 83% of the months in this observation window.

Table 14: History of the average times for changing wheelsets made by optimized and non-optimized between July 2018 and June 2019.

	jul	ago	sep	oct	nov	dez	jan	fev	mar	abr	may	jun
Total wheelsets changes made by control group	453	857	498	437	385	665	500	690	504	800	733	706
Exchanges made by nonoptimized dual control group	431	817	493	429	371	633	462	676	465	224	187	268
Exchanges made the optimized dual control group	22	40	5	8	14	32	38	14	39	576	546	438
Average time of purging NO optimized double impact by wheelset (min)	14,9	14,1	15,0	14,4	15,4	16,8	17,0	16,9	14,8	14,8	13,1	12,7
Average time of the optimized pairs purging impact per wheel (min)	10,7	11,6	11,6	12,5	19,3	12,2	13,7	17,9	14,2	14,4	13,1	12,3

In order to give more representation to the sample, still continuing in Table 14, if only the months in which the optimized pairs made at least 20 exchangesin the month were considered, of the 12 months there would be 8 left, in which in all of them the average exchange time of optimized pairs races were better than when compared to the average time of non-optimized pairs, which reinforces the quality of the indication of the five pairs indicated by the genetic algorithm. Considering the first and second quarter of 2019, there was a reductionfrom 17.7 to 16.3 minutes in the average wheel change time, that is, the wheel change was 1.4 minutes faster after the implementation of the optimization, even considering the impacts due to lack of wheels. This value, despite appearing to be small, in addition to the large number of wheel changes made and the high cost of leaving a wagon stopped, is estimated to have a high potential for financial gain.

In the workshop in question to change a wheel it is necessary to stop a complete batch of 110 wagons and not just the wagon with the defective wheel to be replaced, thus, it is estimated that every 1 hour of a batch of 110 wagons stopped the company stops earning approximately R$ 13,000.00 and knowing that in the second quarter of 2019 there were 2,239 wheel changes made by the control

group, at an average time 1.4 minutes less than the first quarter of the same year, this means that there were a 52.2 h reduction in the unavailability of 110 wagon lots, which meant that the company stopped losing R$ 679,163.33 with wagons stopped in maintenance between April and June 2019.

As of July 2019 it was no longer it is possible to collect new performance data from the control group since from that date there has been a shift in the work shift on the part of the company, which caused a total redistribution of the work teams and the duplication references were lost the optimized ones, however according to the 3 months of practical tests of the optimization of the distribution of the workers pairs via genetic algorithm, the improvement in the average performance of the control group was noticeable.

X. CONCLUSION

A practical application of optimization was presented, where based on historical performance data from a maintenance team, combined with the use of the metaheuristic genetic algorithm, it was possible to arrive at an optimized solution for the distribution of work teams, so that the average performance of the team as a whole was maximized.

After 50 simulations of GA with 1% mutation rate, population of 20 individuals and 100-generation stop criterion, an optimized mean time of 11.1 minutes was obtained, which was 19% better than when compared to the mean time from 50 simulations of random optimization.

When observing the consistency of the GA, we noticed that after 50 simulations, the optimized average times produced by the GA showed an average of 11.1 minutes and a standard deviation of 0.14 minutes, which shows improvement when compared to the average of 14.2 minutes and standard deviation of 1.29 minutes produced from the random generation of 50 clusters of 8 pairs of work each, thus the average time for changing the wheels of the solution proposed by the AG was 22% better than when compared with the choice randomization of teams.

In fact, it was found that the problem modeling, GA coding and its population parameters, mutation rate and stopping criteria proved to be robust enough to deliver an optimized solution within an acceptable computational time for the complexity of the problem. addressed, whose number of possible solutions exceeded 81 billion alternatives.

In the field test stage, it was seen that comparing the average time of changing wheels in the quarter after the implementation of the optimization with the quarter before the field test phase, a reduction of 7.9% was noticed, reducing this time from 17.7 to 16.3 minutes, which represents an estimated financial gain of R$ 112,300.00 per month in the case study company.

In the individual evaluation month by month within the quarter in which the optimization was implemented, it was observed that in the second month (May / 19) there was a sharp increase in the average time for changing wheels, this peak being explained by the impact of the lack of wheels new ones in the wheelyard.

In order to compare the collective performance of the team before and after the proposed optimization, disregarding impacts caused by aspects outside the direct scope of the mechanics, the average wheel change times were recalculated, purging the impact of changes that took longer than anticipated by delay in waiting for the new wheelset to be installed in the wagon, in this case, in a more pronounced way, the gain achieved with the optimization was also observed, and after three months working with the teams in an optimized way, an average time of 12.4 minute wheel change, which represents a 15.6% reduction compared to the 14.7 minute time that was practiced in the month immediately prior to the optimization implementation.

The reduction in the average wheel change time between April and June 2019 could be associated with the implementation of the improvement proposed by the genetic algorithm, since it was seen that in the optimization evaluation quarter, an average of 69% of the changes were made by the five pairs suggested by the GA, an index that in the quarter prior to the improvement was only 6%.

From the evaluation of the average time for changing wheels, purging any impacts due to the lack of new wheels, seeing a quarter before and one after the implementation of the optimization, it was found that an increase of 63 percentage points in the proportion of wheel changes made by Optimized doubles caused a 17.4% reduction in the average time for changing wheels in the quarter, which was reduced from 16.1 to 13.3 minutes.

Also evaluating the average time of changing wheels, purging the effect of impacts due to lack of wheels, we observed that in a window of 12 months, in 10 of them the average time of exchanges made by so-called optimized pairs was less than the average time of the wheels. exchanges made by non-optimized pairs, which represents

an assertiveness rate of 83% for the indication made by the genetic algorithm.

Although the field tests were carried out for an inspectorate of 10 people in a single shift of the workshop in question, since the maintenance data are recorded in a computerized system by all the teams at all times, there is a glimpse of great opportunity for future work the development of software capable of interpreting field data as it is inserted in the computerized system and from this information, using the same programming logic developed in this work, it is possible to indicate an optimized combination of work teams for the current condition of the workshop, thus expanding the gain found in this experiment to all shifts and all processes of the workshop where this work was developed.

In addition, it will be possible to evaluate in subsequent works the performance of this problem from metaheuristic algorithms most recently presented in the literature and that have documentary satisfactory performance for problems of a discrete nature.

REFERENCES

[1] B. Biesinger, B. Hu, G. R. Raidl, A genetic algorithm in combination with a solution archive for solving the generalized vehicle routing problem with stochastic demands, Transportation Science 52 (2018) 497–737, DOI: 10.1287/trsc.2017.0778.

[2] D. M. Carpintero, D. Saez, C. E Cortes, A. Nunez, A methodology based on evolutionary algorithms to solve a dynamic pickup and delivery problem under a hybrid predictive control approach, Transportation Science 49 (2015) 163–431, DOI: 10.1287/trsc.2014.0569.

[3] G. S. Parnell, G. E. Bennett, J. A. Engelbrecht, R. Szafranski, Improvingresource allocation within the national reconnaissance office, INFORMS Journal on Applied Analytics 32 (2002) 1–97, DOI: 10.1287/inte.32.3.77.40.

[4] Y. K. Al-Douri, P. Tretten, R. Karim, Improvement of railway performance: a study of swedish railway infrastructure, Journal of Modern Transportation 24 (2016) 22–37, DOI: 10.1007/s40534-015-0092-0.

[5] M. MH, J. ZG, Decision making support in human resource management based on multi-objective optimization, TWMS Journal of Pure and Applied Mathematics 9 (2018) 52–72, DOI: 10.1287/trsc.2014.0569.

[6] H. L, L. W, S. Q, M. C, Discrete optimization model and algorithm for driver planning in periodic driver routing problem, Discrete Dynamics in Nature and SocietyID: 9476362.

[7] F. S, L. G, R. O, P. M, G. P, Hybrid ant colony optimization algorithm for workforce planning, Proceedings of the Federated Conference on Computer Science and Information Systems 15 (2018) 233–236, DOI: 10.15439/2018F47.

[8] M. TJ, I. RA, M. MF, Performance analytics and reviews on virtual human resources for cost optimization, International Journal of Interdisciplinary Environmental Studies 5.

[9] C. J, T. S, X. H, N. Y, Z. J, Model and algorithm for human resource- constrained r&d program scheduling optimization, Discrete Dynamics in Nature and Society (2019) 163–431ID: 2320632.

[10] K. SMAA, A Comparative Study of the Relative Performance and Real-World Suitability of Optimization Approaches for Human Resource Allocation, PhD Thesis, 2018.

[11] Z. MHF, A. AAS, S. S, C. O, A state of the art review of intelligent scheduling, ArtifIntell Rev 53 (2020) 501–593, DOI: 10.1007/s10462-018- 9667-6.

[12] E. AE, A. OJ, A. AA, V. S, A conceptual comparison of several metaheuristic algorithms on continuous optimisation problems, Neural Computing and Applications 32 (2020) 6207–6251, DOI: 10.1007/s00521- 019-04132-w.

[13] A. H, K. A, K. M, Optimal design of pitched roof rigid frames with non-prismatic members using quantum evolutionary algorithm, PeriodicaPolytechnica Civil Engineering 63 (2019) 593–607, DOI: 10.3311/PPci.14091.

[14] R. O, F. S, P. M, Intercriteria analysis of aco and ga hybrid algorithms. recent advances in computational optimization, Studies in Computational Intelligence 610 (2018) 107–126, DOI: 10.1007/978-3-319-21133-6 7.

[15] A. HF, M. A, J. A, B. F, Solving a multi-objective sustainable waste collection problem considering a new collection network, Reseach International JournalDOI: 10.1007/s12351-018-0415-0.

[16] K. S, K. S, An efficient hybrid algorithm based on water cycle and moth-flame optimization algorithms for solving numerical and constrained engineering optimization problems, Soft Comput 23 (2019) 1699–1722, DOI: 10.1007/s00500-017-2894-y.

[17] K. M, S. A, V. E, C. R, Performance analysis of six meta-heuristic algorithms over automated test suite generation for path coverage-based optimization, Soft Comput 24 (2020) 9143–9160, DOI: 10.1007/s00500-019- 04444-y.

[18] M. K. Amjad, S. I. Butt, R. Kousar, R. Ahmad, M. H. Agha, Z. Faping, N. Anjum, U. Asgher, Recent research trends in genetic algorithm based flexible job shop scheduling problems, Mathematical Problems in EngineeringDOI: 10.1155/2018/9270802.

[19] [A. Balieiro, I. Melo, D. Araujo, S. Neto, E. Galdino, A. Gomes, Uma abordagem baseada em algoritmo genético para formação de grupos de estudos em ambientes virtuais de aprendizagem - in portuguese. translation: An approach basedongeneticalgorithm for formationofstudygroups in virtual learningenvironments, Simposio Brasileiro de Informática na Educação - SBIE.

[20] Z. Z, L. F, Z. H, J. H, Abawajy, C. U, An improved genetic algorithm using greedy strategy toward task scheduling optimization in cloud environments, Neural Comput&Applic 32 (2020) 1531–1541, DOI: 10.1007/s00521-019- 04119-7.

[21] A. MR, S. RS, Cutoff grade optimization in open pit mines using genetic algorithm, Resources Policy 55 (2018) 184–191, DOI: 10.1016/j.resourpol.2017.11.016.

[22] H. O, H. KE, T. GM, V. C, Comparison of different metaheuristic algorithms for parameter identification of photovoltaic cell/module, Journal of Renewable and Sustainable EnergyDOI: 10.1063/1.4822054.

[23] C. CM, B. HL, H. DQ, Blade shape optimization of the savonius wind turbine using a genetic algorithm, Applied Energy 213 (2018) 148–157, DOI: 10.1016/j.apenergy.2018.01.029.

[24] C. WH, W. PH, L. YL, Performance optimization of thermoelectric generators designed by multi-objective genetic algorithm, Applied Energy 209 (2018) 211–223, DOI: 10.1016/j.apenergy.2017.10.094.

[25] C. A. Viktorovich, The economy and material management on a railway transport, INFRA-M Academic Publishing LLC, 2020, DOI: 10.12737/1085329.

[26] A. O. A. RAILROADS, AAR Section C Part II: Manual of Standards and Recommended Practices Design, Fabrication, and Construction of Freight Cars (2015).

[27] G. Maxion, Solução Completa e Integrada para Ferrovias da América do Sul - in portuguese. Translation: Complete and Integrated Solutions for South American Railways, Available in: http://gbmx.com.br/wp-content/uploads/2017/11/GBM 011 Folder.pdf - Accessed in: 01 Abr. 2020.

Implementation of Condition-Based Maintenance (CBM) in a central air conditioning unit by using microcontroller and open-source monitoring platforms

Danilo Augusto Santana de Souza[1], Matheus Damaceno Artur[2], Diogo de Souza Rabelo[2], Fernando Nunes Belchior[2]

[1]Clinical Hospital, EBSERH, Federal University of Goiás, Goiânia, Brazil
Email: danilo.eng.mec@hotmail.com
[2]School of Sciences and Technology, Federal University of Goiás, Aparecida de Goiânia, Brazil
Email :matheusartur@yahoo.com.br, diogo.rabelo@ufg.br✉, fnbelchior@ufg.br

Abstract—In this work, an online and real-time monitoring system was developed in order to perform Condition-Based Maintenance (CBM). The proposed system named HC 4.0 uses low-cost hardware components such as an Arduino microcontroller and the graphical user interface was designed with the Grafana software, an open-source platform, to measure temperature, relative humidity, compressors currents and motor fan currents in a central air conditioning unit installed at a Brazilian Clinical Hospital named "Hospital das Clínicas da UFG/EBSERH" (HC-UFG/EBSERH). The HC 4.0 solution presents as a result useful information for the maintenance team indicating how to act in a faster, more assertive and effective way regarding the inherent failure modes that are dealt with in a usual work routine.

A long-time experiment was conducted for 30 days while the Hospital was operating normally and prominent results were obtained. A designed dashboard through Grafana is used to evaluate the conditions required in order to make an early intervention in the equipment. Furthermore, the system is able to send alerts to the maintainer's cellphones by using a message app such as Telegram, when some parameter goes beyond the pre-defined limits. Additionally, a Failure Mode and Effect Analysis (FMEA) for the central air conditioning unit of the hospital is presented alongside the recommendations to each situation for the maintainer. The results encourage the use and further development of the HC 4.0 approach in order to implement low-cost CBM of Hospital equipment's such as the central air conditioning unit focused on this work.

I. INTRODUCTION

One of the great challenges for maintenance teams is to take assertive decisions before the functional failure of an equipment occurs. Acting on the right moment, when the equipment is in the incipient stage of its failure mode may represent the opportunity to reduce both direct and indirect maintenance costs that involve material purchases and maintenance time. At the same time, promptness of service is optimized. Teles (2019) says that a failure mode is the way how the failure is born in an equipment, getting worse

with time until it turns to a functional failure when the equipment loses its projected operational functions. This paper proposes the use of a low-cost online monitoring system that was developed, capable of identifying failures in real-time, aiming to detect failures at a certain stage as early as possible. Thus, a monitoring solution to a central air conditioning unit from a Brazilian Clinical Hospital (HC-UFG/EBSERH) with a microcontroller (Arduino) and a monitoring platform (Grafana) was developed.

In the concept of Industry 4.0, there are new technological ways to apply improvements in a hospital. For instance, to achieve certain goals such as performing near real-time online monitoring of the operation of a critical equipment. Industry 4.0 acts as the umbrella term made up of the tools which form its structure, namely, Cloud Computing, Cyber Physical Systems (CPS), Big Data and the Internet of Things (IoT) (CHESWORTH, 2018; KRISHNARAJ, 2021; CARVALHO, 2020). Monitoring variables of equipment, system or environment is not something difficult nowadays, since the production of low-cost sensors and microcontrollers is a reality worldwide that maintenance managers need to know and utilize. With relatively low investments it is possible to turn the maintenance strategy of critical equipment's from Corrective Maintenance or Preventive Maintenance to Condition-Based Maintenance (CBM). This strategy not only helps to reduce the inherent maintenance costs, but also helps to improve the safety of the monitored equipment's or structures (SILVA et al., 2020). Additionally, promptness of service can be optimized with the proper operation of such a system, reducing the chance of inactivity or waiting time for the patients.

In times of Industry 4.0, the term Predictive Maintenance might be confused with CBM. However, it is possible to differentiate between them. Dabrowski and Skrzypek (2018) compare both indicating that, on the one hand, CBM is characterized by being performed after some condition is observed in a certain equipment. It requires monitoring devices and qualified staff. As a result, CBM maximizes the productive time and the useful life of the equipment. Predictive Maintenance, on the other hand, is characterized by the need for high investment in monitoring, prognostic and diagnostic equipment; managing to maximize productivity and equipment life, giving a high possibility of planning. Schmidit and Wang (2016) indicate that Predictive Maintenance is an approach that uses condition monitoring data to predict future machine conditions and make decisions based on that prediction. Lai, Jiang and Jackson (2019) explain that CBM assumes there are indicators which can be used to detect and quantify possible equipment failure before it actually occurs. (Rabelo et al., 2017a) explain that CBM

have been evolving constantly and such strategies aim at detecting the presence and severity of damage on a statistical basis.

There are many possible ways to monitor equipment's available in the world market or by self-development. The failure prediction process can be achieved either by using machine learning techniques or without them, being the alternatives implemented according to the need, complexity, cost and severity. Yan et al (2020) have demonstrated an experiment to monitor rotating equipment without sensors, using only audiovisual resources to predict the failure mode, demonstrating the effectiveness and limitations for this type of solution. De Azevedo et al (2017) have used accelerometers to monitor the bearing vibration of real wind turbines, identifying a failure in one of the bearings and verifying that the vibration spectrum changed after the bearing was changed. Rabelo et al., (2017b) have used a low-cost impedance-based monitoring system in order to detect real-time growth of fatigue cracks in an aluminum beam using piezoelectric transducers. Raduenz et al (2018) have demonstrated the possibility of predicting directional valve failures based on the control signal, spool position and supply current, concluding that the online measurement of the data provides faster reaction in the solution. In the context of maintenance 4.0, online monitoring, in its various forms, has become a necessity for critical equipment's. The main limitation in this regard are the costs, which still characterize some advanced technological solutions, as well as the cost and difficulty of finding resources on the market with the necessary analytics and information technology (IT) skills (RODA; MACCHI; FUMAGALLI, 2018).

The main goal of this paper is to propose a low-cost solution to implement a CBM model to monitor failure modes regarding the central air unit of the hospital where it has been deployed. The solution presents results making the maintenance process more assertive, with online monitoring capability of a critical equipment of the hospital.

User monitoring interface with Grafana (Grafana, 2022) also added to HC-UFG/EBSERH the concept of Internet of Things (IoT) in the Physical Infrastructure Sector. Kumar et al (2019) states that the Internet of Things (IoT) is an emerging paradigm that enables communication between electronic devices and sensors through the internet to make our lives easier. Magrani (2018) conceptualizes Internet of Things as the interaction and connectivity between various types of everyday objects, with the possibility of connecting to the internet. In order to perform online monitoring, the developed system uses the Ethernet Shield which, connected to the HC-UFG/EBSERH intranet, transmits the data collected

by the sensors. Online monitoring has several advantages, since it is cheaper and easier, no human presence is required, usually the measurement is more accurate, the measurement is independent of the worker's skill, it enables the possibility of programmable alerts and triggers. Also, data storage is easy, allowing for further studies of forecasts and statistical models.

Throughout the development of this work, some papers were searched to verify if some of them would suggest the proposal of a low-cost monitoring solution focused in CBM to hospital equipment. However, even though some studies have reported the proposal of methodologies to implement CBM to hospital equipment, very few have focused on the development of a low-cost solution to perform online monitoring. The main contribution of this paper is to propose such methodology by using the central air conditioning unit of a clinical Hospital.

This kind of solution is very important to certify that a CT Scanner (Computed Tomography Scanner) environment is kept within the standard operational boundaries. This provides risk mitigation of corrosion in components of equipment of high responsibility in a hospital such as a CT Scanner (shown in Fig. 1), whose costs are significantly high.

Fig. 1: CT Scanner

II. APPLICATION OF ARDUINO FOR DATA COLLECTION WITH SENSORS

For the design of the DAQ (Data Acquisition) system, low-cost hardware components were chosen for the solution, which includes a microcontroller board (Arduino Mega 2560), nine electrical current sensors (SCT-013-000), one temperature and humidity sensor (DHT22), and an infrared sensor (E18). The microcontroller was programmed to collect data of temperature and relative humidity from an environment with a CT Scanner, which requires strict controls on these variables. The data were

collected in the return duct. All measurements of electrical currents were performed within the electrical panel at the contactors output, as highlighted in yellow in Fig. 2. The DAQ system was also set to collect the electric currents of two hermetic refrigerant compressors in order to sense the electric currents of an evaporator fan motor as well as the fan rotation.

Fig. 2: Electrical panel and current sensors

It should be noted that although the central air conditioning targeted by this work is used to control the climatization in a tomography room, it also climatizes two other rooms. Due to infrastructure limitations, the measurement could not be performed inside the room. To work around this issue, the return air measurement, which would be sufficient and a correct method if it were only one environment, had to be corrected to achieve the specific desired room setpoint and not the contribution of all three rooms.

Fig. 3: E18 infrared sensor

A calibrated datalogger (Icel HT-4000) was used to perform 439 measurements that were compared to the developed monitoring system measurements, as shown in Fig. 5 and Fig. 6. The points that are darker than others refer to higher frequency of the same correlation between room temperature and return duct temperature (Fig. 5) and it can be seen on bar graphs over the axes, where the bars are bigger when there are more data repeatability. The linear correlation value between temperature values is 0.8665, which shows a strong linearity. On the other hand, Fig. 6 is about the relative humidity values with the same measurement conception. The linear correlation value between relative humidity values is 0.5982, which shows a good linearity as well. Thus, since there is linearity between the data, it was possible to perform a linear regression to calibrate the data measured by the sensor in the microcontroller program.
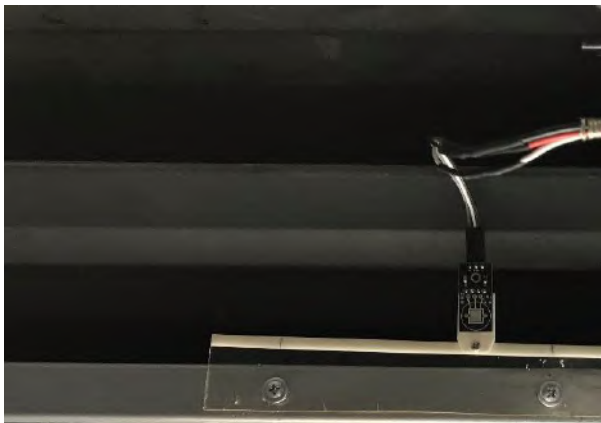
Fig. 4: Temperature and relative humidity sensor (DHT22)

In order to correct the measurement between temperature and relative humidity in the room and in the air return duct, a linear regression was applied. Fig. 5 and Table 2 illustrate an example with 14 measurements out of 439 performed to generate the linear equation that correlates the value measured inside the room and the value measured on the air return duct to temperature and relative humidity, respectively. In Fig. 5, T_Datalogger and T_DHT_0 represent the temperature measured in the room and air return duct, respectively. In Table 2, UR_Datalogger and UR_DHT_0 represent the relative humidity measured in the room and air return duct, respectively. At both tables a regression column is presented where the regression equation has been applied, generating temperatures values with average percentual difference of 0.744 % in regard to room temperature. Concerning the relative humidity values, an average percentual difference of 1.133% was observed in regard to room relative humidity.
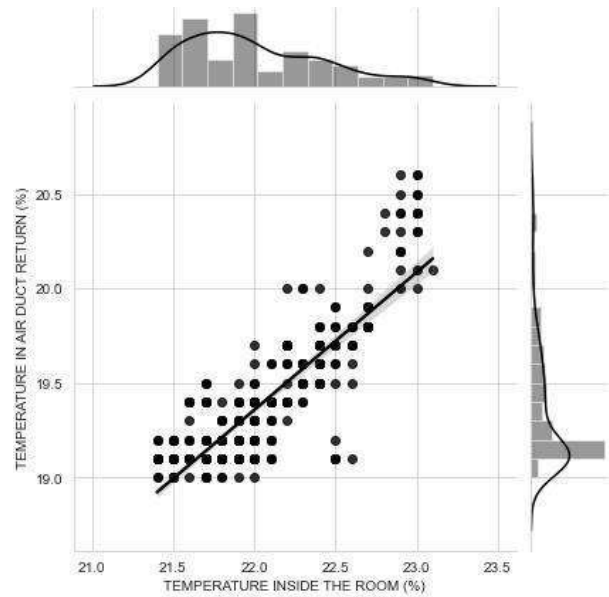
Fig. 5: Correlation between room temperature and Arduino temperature

Table.1: Correlation between room temperature and air return duct

ID	Date	Hour	T_Datalogger	T_DHT_0	Regression
1	10/23/2020	14:52:19	23.00	20.40	23.08
2	10/23/2020	15:02:19	23.00	20.60	23.28
3	10/23/2020	15:12:19	22.90	20.60	23.28
4	10/23/2020	15:22:19	23.00	20.60	23.28
5	10/23/2020	15:32:19	23.00	20.50	23.18
6	10/23/2020	15:42:19	23.00	20.50	23.18
7	10/23/2020	15:52:19	23.00	20.30	22.97
8	10/23/2020	16:02:19	23.00	20.40	23.08
9	10/23/2020	16:12:19	23.00	20.40	23.08
10	10/23/2020	16:22:19	23.00	20.40	23.08
11	10/23/2020	16:32:19	22.90	20.40	23.08
12	10/23/2020	16:42:19	22.90	20.30	22.97
13	10/23/2020	16:52:19	22.90	20.40	23.08
14	10/23/2020	17:02:19	22.90	20.50	23.18
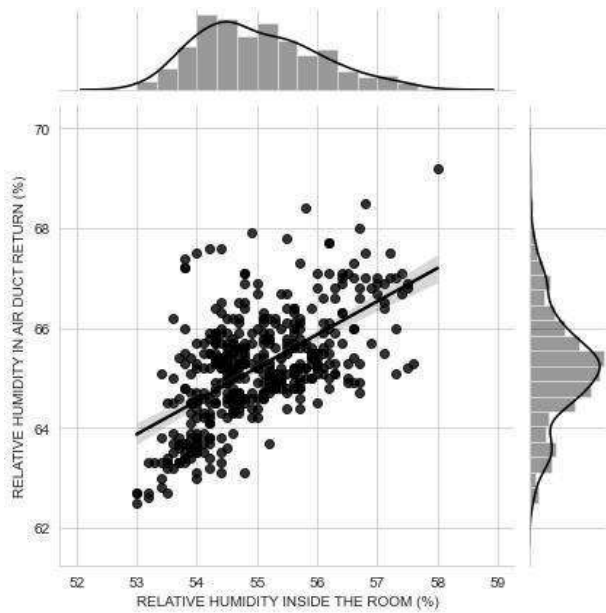
Fig. 6: Correlation between room humidity and Arduino relative humidity

Table.2: Correction analysis of relative humidity measurements

ID	Date	Hour	UR_Datalogger	UR_DHT_0	Regression
1	10/23/2020	15:02:19	58.00	69.20	57.19
2	10/23/2020	15:12:19	57.10	66.40	55.66
3	10/23/2020	15:22:19	56.60	66.00	55.44
4	10/23/2020	15:32:19	56.30	65.30	55.06
5	10/23/2020	15:42:19	55.10	65.10	54.95
6	10/23/2020	15:52:19	56.00	64.50	54.62
7	10/23/2020	16:02:19	56.20	65.50	55.17
8	10/23/2020	16:12:19	56.00	65.50	55.17
9	10/23/2020	16:22:19	56.20	66.00	55.44
10	10/23/2020	16:32:19	55.90	65.60	55.22
11	10/23/2020	16:42:19	55.50	65.50	55.17
12	10/23/2020	16:52:19	56.20	65.00	54.89
13	10/23/2020	17:02:19	55.30	65.60	55.22
14	10/23/2020	17:12:19	55.00	64.60	54.68

The variables measured by the monitoring system developed have been represented graphically in Grafana. Fig. 7 shows the complete dashboard that has been developed in this work.

A section with the instantaneous measurements of temperature, relative humidity and fan rotation speed is shown in Fig. 8. This type of graphical representation is called a Gauge, with visual warnings that indicate whether or not the variable is within acceptable limits. If the value displayed is in the green color, it is in the expected condition. If it is in the yellow color, it is out of range, but not in critical condition yet. The yellow temperature range was considered 19-20°C or 24-25°C, while the relative humidity yellow range was considered 35-40% or 60-65%. Lastly, if it is in the red color, it is in the unwanted critical

condition. The limits were established by using the CT Scanner manual and maintainers experience.

III. DEVELOPMENT OF AN INTERFACE WITH GRAFANA

In this work, a graphical interface has been made with Grafana dashboard. The software Grafana provides a highly customizable interface, and allows templated queries for the desired variables (BRATTSTROM; MORREALE, 2017).

Fig. 7: Work Dashboard using Grafana

Fig. 8: Represents temperature, relative humidity and rotation instantaneous reading

Fig. 9 shows a histogram of electric currents. Since all values are green, the dashboard displays a safe operation occurring. In case the upper limit is crossed, the bars start to show red colors.
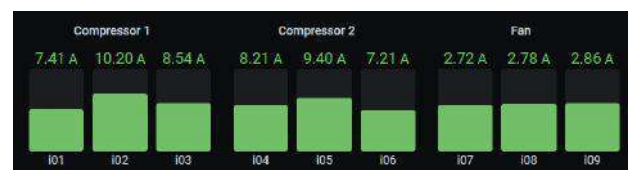
Fig. 9: Compressors and fan currents instantaneous reading

Fig.10-Fig. 15 present time domain plots of the temperature, relative humidity, fan rotation speed, compressors 1 and 2 electrical currents and fan currents, respectively. This is the dashboard part that is programmed to send alarms through a mobile message application when the variables values reach the region red for more than 10 minutes. For this experiment, the application Telegram was used.
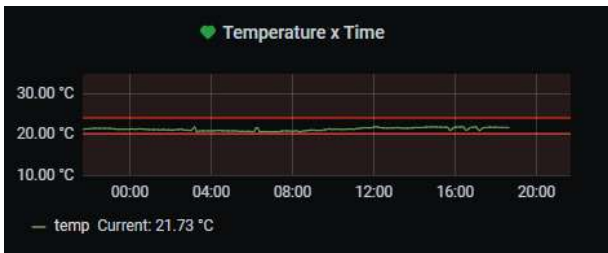
Fig. 10: Temperature along the time
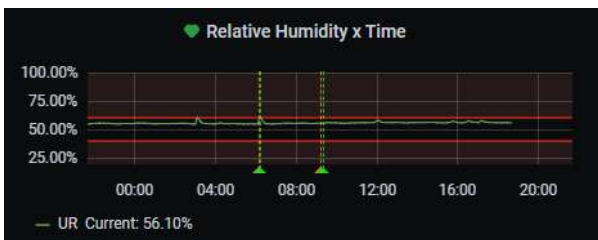
Fig. 11: Relative humidity along the time
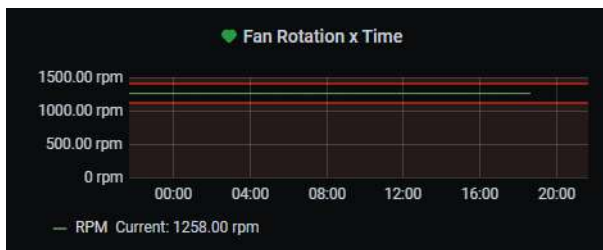
Fig. 12: Fan rotation along the time
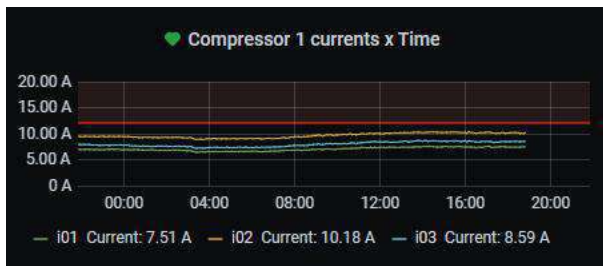
Fig. 13: Compressor 01 currents along the time
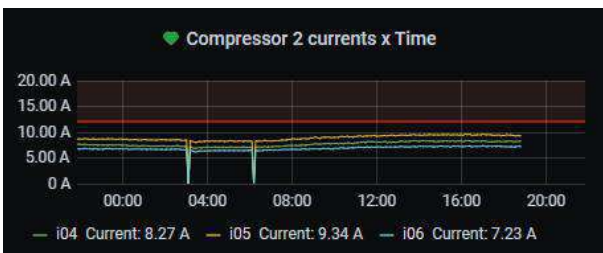
Fig. 14: Compressor 02 currents along the time
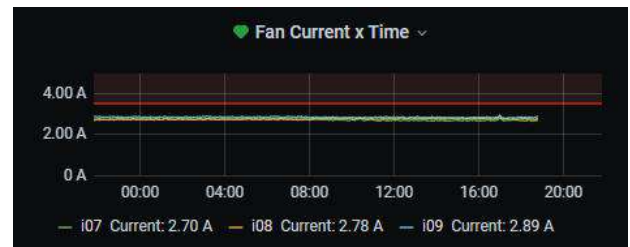
Fig. 15: Fan currents along the time

On the last dashboard line (Fig. 16) a line of time versus equipment total availability is presented. The line will be reduced in case the rotation speed value becomes zero. In addition, Fig. 16 presents a table showing which relays responsible for triggering components of the central air conditioning are switched either on, off or in last status. At the moment when Fig. 17 was captured, the fan relay (VT) was on and all others components were in last status.

Fig. 16: Machine availability along the time

Fig. 17: Type of operation

IV. SOLUTION PLANNING AND EXECUTION

This work has been developed in order to create a solution for the benefit of the Maintenance Team (SIF) from HC-UFG/EBSERH, a federal public hospital. The solution proposed is to deploy a pilot project of a critical equipment managed by a CBM strategy.

For the experiment design, a period of 30 days was established for continuous online monitoring and verification of the system. During this time, data was collected to analyses whether the measurements presented satisfactory results while the equipment's were in operation. Data has been carefully checked during the tests and were verified using appropriate instruments. Fig. 18 shows a fan rotation speed measurement where the data collected was satisfactory providing 0.89% of variation in relation to a calibrated instrument.

Fig. 18: Rotation measurement

For comparing the temperature inside de CT Scanner room and the temperature in the air conditioning duct outlet, it was utilized a datalogger to collect the data inside the room, as shown in Fig. 19. In this figure is possible to see 3 curves with three different colors:

- Yellow: Relative humidity (RH %);
- Red: Temperature (ºC);
- Green: Dew point.

Fig. 20 (Temperature) and Fig. 21 (Relative humidity) represent the same moment of measurement (from 10-30-2020 to 11-03-2020), however using the sensor DHT22. The results were satisfactory comparing with the measurement inside the room.
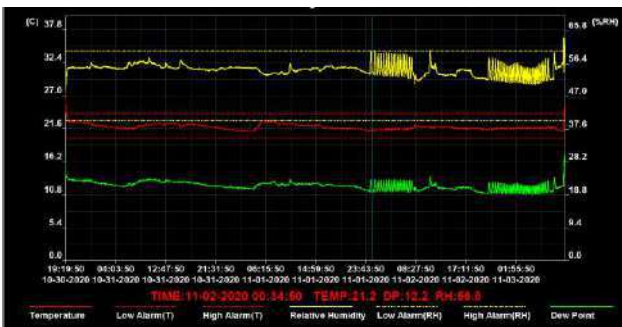
Fig. 19: Temperature and relative humidity from 10/30/2020 to 11/03/2020 using datalogger inside the room before of starting this work

The electrical currents were tested as well by comparing with a current measurement with a plier ammeter (basic precision of 2%) and it has been observed an average difference from 2.2% to 2.5% for all phase currents. For the scope of the proposed application, the measurements have been considered satisfactory.
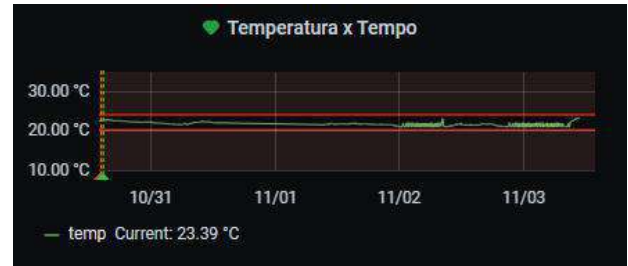
Fig. 20: Temperature from 10/30/2020 to 11/03/2020 in the air conditioning duct outlet

Fig. 21: Humidity from 10/30/2020 to 11/03/2020 in the air conditioning duct outlet

4.1. CBM applied to the fan

The possible failures in the fan electric motor can be resulted from the transmission belt failure mode, the bearing or the electric motor, and all these conditions can generate other more expensive failures if not corrected in an early stage.

On the one hand, in case of failure of the electric fan motor or failure of the fan bearing, the electric currents tend to increase as the failure becomes more severe. On the other hand, the fan rotation tends to decrease and vibration tends to increase as the problem gets worse.

This situation can be seen on Fig. 22, which shows the bearing problem during some days (from 06/02/2020 to 06/08/2020) until the electric motor breaks. This situation has occurred during the development and installation of the HC 4.0. At the time, the team did not know the behavior, and, on this period, it did not have yet the measurements of electric currents. This event shows that even with online monitoring, it is necessary to study and learn about the failures behavior in order to create the right alerts in the system. As can be seen in this failure, the alert trigger was lower than the necessary level to call the maintenance team to go to the site to act before the break. The setpoint was set to 800 RPM, however the failure could be alarmed at the 1100 RPM level. As shown in Fig. 12, the lower threshold for fan rotation has been adjusted to 1100 RPM and it is possible to see too that rotation speed is normally stable in 1258 RPM.
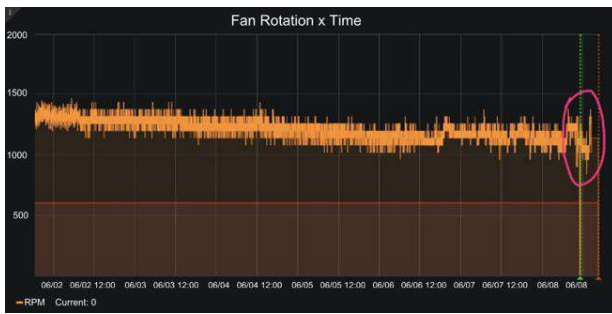
Fig. 22: The fan electric motor failure and break from 06/03/2020 to 06/08/2020

Another failure linked to the fan has been observed during the experiment time: the transmission belt breakage, which is shown on Fig. 23. This behaviour observed was very different from the bearing failure, since there is first a kind of vibration that increases the rotation speed measurement (moment "A"). Different from the bearing failure, in which the rotation speed decreases instantly from 1258 RPM to 1000 RPM (moment "B"). After some hours the transmission belt has broken at exactly 7 a.m. and the equipment automatically turned off (moment "C"). At this specific instance, unfortunately no maintenance maintainer was available before 7 a.m. Nevertheless, the transmission belt changing (moment "D") lasted only 18 minutes. Without an online monitoring strategy, this kind of activity would be dependent on the perception of the CT Scanner operation team about how hot the room temperature would be in that time, thus becoming susceptible to human error. Several problems could have happened if an early intervention had not occurred. For instance, the evaporator could freeze and generate a lot of consequences like gas refrigerant in liquid state inside the compressor, increasing the mechanical efforts, reducing the central air conditioning compressor useful life. Additionally, the CT Scanner could be shut down in case of high temperature.
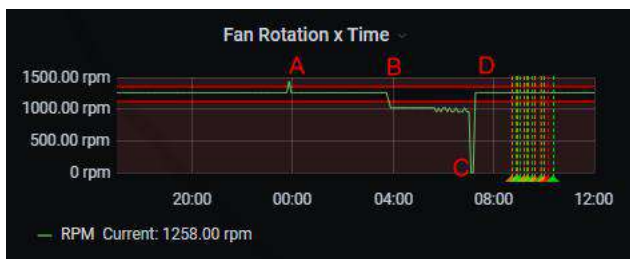
Fig. 23: Detection of transmission belt breakage

It is important to analyze that the machine vibration behavior, when the transmission belt breakage occurs (Fig. 23), is different of the bearing failure mode (Fig. 22), the vibration occurs only between moment "B" and "C" in the first one.

4.2. CBM of the compressors

Like the motor-fan, some conditions can be observed in the graph that cause the failure or the compressor's failure mode. Compressors in a refrigeration system tend to have their currents increased when their mechanical efforts increase. Some possible causes are listed below:

- A dirty condenser prevents the fluid heat exchange which increases its average temperature, expanding the fluid and increasing the system pressure. Consequently, this requires more mechanical effort from the compressor. In this way, the maintainer carrying out the equipment cleaning will be able to check if there is any other condition that is keeping the current high or if only the cleaning was sufficient for the correction;
- If the compressor is in failure mode due to any mechanical component, its electrical currents will also increase. However, because it is a hermetic compressor, the only way to work around this is to change the compressor, as the continuity with it until the break can cause greater damage such as fire risk;
- In the event of a lack of refrigerant in the system, the electric current will tend to reduce, as there will be less mechanical effort, with the visual consequence of freezing the evaporator and the environment temperature increasing. Therefore, with low electric current in the compressor and an increase in temperature in the room, the maintainer must evaluate the system pressure and replace refrigerant gas if necessary;
- If the operation table (Fig. 17) indicates that some compressor should be operating, but the electric currents are indicating value zero, the compressor is already broken. A case that can occur in moments that there is no maintenance team in the hospital to act before the breakage. Another possibility is that some electric protection might be disabled, or some cable might be disconnected;
- Another problem can be seen by analyzing the three electric currents of compressors or fan. If at least one electric current is different than zero and at least one other is equal to zero, there's a problem of phase loss. The maintainer needs to go to the equipment to verify if some electrical terminal is disconnected after the phase failure relay;
- The last problem that can be seen is unbalanced electric current, this is visual on the graphical interface (Grafana) and it will must be necessary to evaluate the equipment on site.

4.3. CBM of the electrical resistors

In case of electrical resistors, devices responsible of controlling the relative humidity that do not have sensors for performance monitoring, it may give rise to failure or failure mode if the system sends a relative humidity alert above the upper limit, for a long time.

4.4. FMEA

The Table 3 from Attachment A shows a part of the central air conditioning FMEA from CT Scanner I room, that shows the main equipment failures. Some actions should be instructed by the FMEA. This table has been developed by using the engineer and technician's maintenance interdisciplinary knowledge. One can see that there are some suggested actions for a specific kind of failure. These instructions help the technician to better understand the alerts that are emitted by the online monitoring system developed.

V.   RESULTS AND DISCUSSIONS

The online monitoring developed in this work is in action for more than 30 days, considering commissioning and tests. The HC 4.0 has been stable during this period to measure and has been adding knowledge about the equipment. It also has helped the team to act in a faster and more assertive course of action.

As already introduced from Fig. 19 to Fig. 21, the temperature and relative humidity, main variables to be monitored in this work for having direct impact in the CT Scanner useful life, were satisfactory and mirrored very well the datalogger data.

During the monitoring period, it was possible to verify the exactly moment when there was a leak in one of the compression systems due to the drop in electrical current from one of the compressors. The team went to the site with a manifold, a refrigeration tool to measure the pressure of refrigeration equipment, and the system pressure was checked and there was a leak in one of the copper tubes connection flanges. The team replenished the gas before the drop was significant, preventing loss of refrigerant gas R-410a.

It was also possible to verify that one of the central air conditioning covers had fallen down and the engine room door was open, as the fan motor electric current increased. And in order to check if there was a problem in the electric motor, the team discovered this new fan electric current behavior. After closing the lid and door, the electric current normalized.

The cell phone alerts by Telegram has worked very well. An example may be seen in Fig. 24 when the central air conditioning room door was open. It was a new behavior that occurs when some professional does not close the door and a lot of hot air enters through the evaporator. In this case it was human error, but when the problem is in the equipment, usually it is the case when some heat exchanger is dirty, that is the main purpose of the displayed alert message.

As already mentioned in this paper in Fig. 23, the transmission belt breakage event shows 3 failure mode moments:

- A false increase of rotation speed;
- The real decrease of rotation speed;
- The transmission belt breakage.

The broken belt is shown in Fig. 25 representing the mapped event.
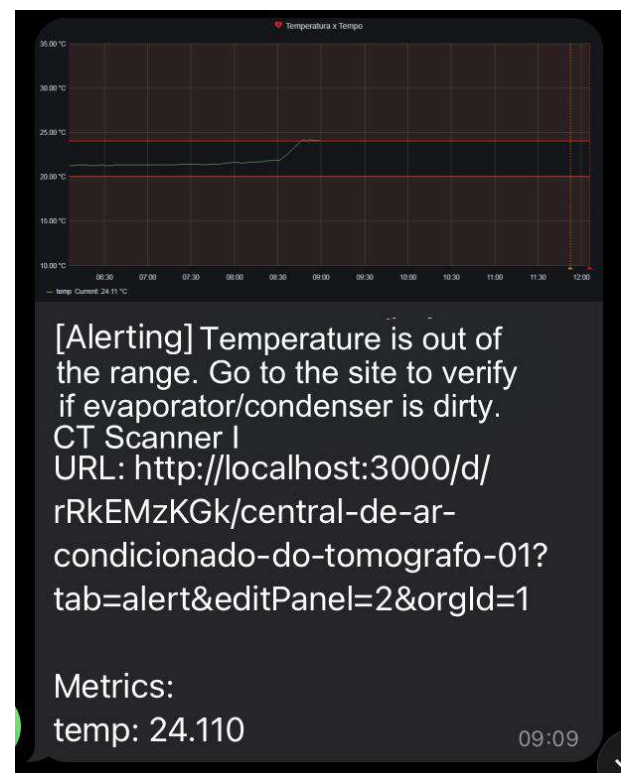
Fig. 24: Cell phone alert

Fig. 25: The broken belt
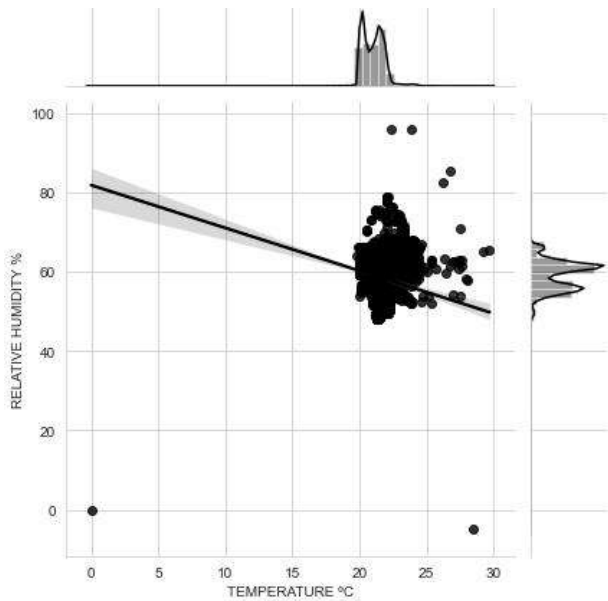
Fig. 26: Correlation between Temperature and Relative Humidity, showing that a system with electric resistances is non-linear

The online monitoring gave the opportunity to analysis the collected data, total of 21,063 rows in the data base. This data base has allowed to infer that the average CT Scanner room temperature is 21.039 ± 0.824 ºC and average relative humidity is 59.080 ± 3.941%. These pieces of information are too difficult to know without a kind of online monitoring. There is a weak negative linear correlation between temperature and relative humidity of -0.225, this correlation graph can be seen in Fig. 26. The linearity occurs only when there is no resistance working. If the system did not have electric resistances and humidificator, this linear correlation could tend to be stronger. The central air conditioning has 22 operations modes (Table 4 from Attachment B). Given the same temperature variation, different operations could be taking place, some of them could be doing the relative humidity to increase (humidification operation) and others could be doing the relative humidity to decrease (dehumidification operation). About these 22 operation modes, the Fig. 27 shows that the mode 7 was more usual during the experiment time (30 days). This operation occurs when the temperature approaches 20ºC and the relative humidity approaches 60%, keeping turned on two group of resistances and both compressors.
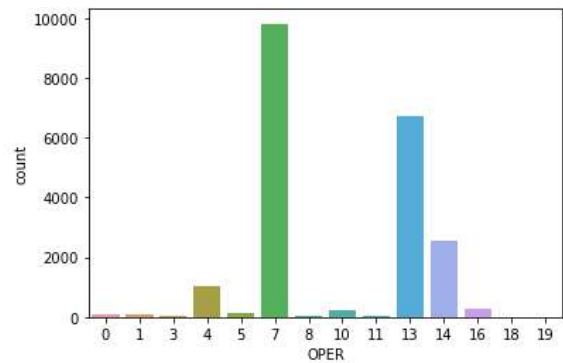
Fig. 27: Operation modes

The Fig. 28 shows the linear correlation between main HC 4.0 variables:

- TEMP: Temperature;
- UMID: Relative humidity;
- COR01: One current of the compressor 1;
- COR04: One current of the compressor 2;
- COR07: One current of the fan.
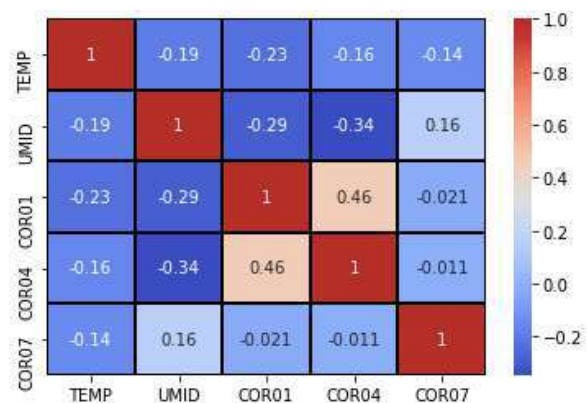
Fig. 28: Linear correlation between the main variables

It is observed that the value of the electric currents of the compressors have higher negative linear correlation with the relative humidity and temperature, but it is not strong as the others too.

VI. CONCLUSION

The solution proposed in this work to perform online monitoring of critical variables of a central air unit in the hospital has provided satisfactory results. It should be noted that the proposed system can be customized for different equipment's, with low cost and high efficiency. The union of Grafana with Arduino has shown results with a good quality of analysis, creating a condition for carrying out Condition-Based Maintenance of the central air conditioning.

The application of linear regression to correct the reading of temperature and relative humidity was efficient, generating satisfactory results when compared with the datalogger inside the controlled room.

The data collection has provided greater correlations knowledge between the variables of the system in studying, giving greater ability for the maintenance team from HC-UFG/EBSERH to make decisions when analyzing different central air conditioning modes of operation conditions.

This paper has also presented a detailed analysis of failure modes related to central air conditioning which is very useful in addition with the online monitoring that has been implemented.

In addition, this work has shown that it is possible to use Arduino and open-source platforms to develop professional, reliable, low-cost and user-friendly solutions.

ACKNOWLEDGEMENTS

REFERENCES

[1] Brattstrom, M.; Morreale, P. Scalable Agentless Cloud Network Monitoring. *In*: 2017 IEEE 4th interncational conference on cyber security and cloud computing (CSCLOUD) 2017, Anais [...]. [s.l: s.n.] p. 171–176. DOI: 10.1109/CSCloud.2017.11.

[2] Carvalho, C. P., Simões, B. R., Carvalho, E. A., Diniz, R. R., SENSING: An Approach to Establish the First Step to Prepare a CNC Machine for IoT Implementation .International Journal of Advanced Engineering Research and Science (IJAERS), Vol-7,Issue-11,November 2020, Available in:https://dx.doi.org/10.22161/ijaers.711.10.Access in: 28 mar. 2022.

[3] Chesworth, Daren. Industry 4.0 Techniques as a Maintenance Strategy (A Review Paper). 2018. Available in: https://www.researchgate.net/publication/322369285. Access in: 28 mar. 2022.

[4] Dabrowski, Karol; Skrzypek, Katarzyna. The predictive maintenance concept in the maintenance department of the ïndustrie 4.0" production enterprise. Foundations of Management, *[S. l.]*, v. 10, p. 283–292, 2018.

[5] De Azevedo, Henrique D. M.; De Arruda Filho, Pedro H. C.; Araújo, Alex M.; Bouchonneau, Nadège; Rohatgi, Janardan S.; De Souza, Ricardo M. C. Vibration monitoring, fault detection, and bearings replacement of a real wind turbine. Journal of the Brazilian Society of Mechanical Sciences and Engineering, *[S. l.]*, v. 39, n. 10, p. 3837–3848, 2017. DOI: 10.1007/s40430-017-0853-2. Available in: https://doi.org/10.1007/s40430-017-0853-2. Access in: 28 mar. 2022.

[6] Grafana, Distributed Systems and Scalability Feed. Available in: https://www.scaleyourapp.com/. Access in: 28 mar. 2022.

[7] Krishnaraj, N., Padmini, J., Akalya, A. P., Snekha, M., Real Time IOT-based Crop Protection and soil maintenance, International Journal of Advanced Engineering Research and Science (IJAERS),Vol-8,Issue-4,April 2021, Available in: https://dx.doi.org/10.22161/ijaers.84.38. Access in: 28 mar. 2022.

[8] Kumar, Sachin; Tiwari, Prayag; Mikhailzymbler. Internet of Things is a revolutionary approach for future technology enhancement: a review. Journal of Big Data, *[S. l.]*, v. 6, p. 1–21, 2019.

[9] Lai, Chia Tai Angus; Jiang, Wei; Jackson, Paul R. Internet of Things enabling condition-based maintenance in elevators service. Journal of Quality in Maintenance Engineering, *[S. l.]*, v. 25, p. 563–588, 2019.

[10] Magrani, Eduardo. A internet das coisas. 1. ed. Rio de Janeiro: FGV, 2018.

[11] Rabelo, D. S.; Tsuruta, K. M.; De Oliveira, D. D.; Cavalini, A. A.; Neto, R. M. Finzi; Steffen, V. Fault Detection of a Rotating Shaft by Using the Electromechanical Impedance Method and a Temperature Compensation Approach. Journal of Nondestructive Evaluation, *[S. l.]*, v. 36, n. 2, p. 25, 2017. a. DOI: 10.1007/s10921-017-0405-9. Available in: https://doi.org/10.1007/s10921-017-0405-9. Access in: 28 mar. 2022.

[12] Rabelo, D. S.; Hobeck, J.; Inman, D.; Finzi Neto, R.; Steffen V., Jr. Real-time structural health monitoring of fatigue crack on aluminum beam using an impedance-based portable device. Journal of Intelligent Material Systems and Structures, *[S. l.]*, v. 28, p. 1045389X1770521, 2017. b. DOI: 10.1177/1045389X17705213.Available in: https://doi.org/10.1177/1045389X17705213. Access in: 28 mar. 2022.

[13] Raduenz, H.; Mendoza, Y. E. A.; Ferronatto, D.; Souza, F. J.; Da Cunha Bastos, P. P.; Soares, J. M. Castro; De Negri, V. J. Online fault detection system for proportional hydraulic valves. Journal of the Brazilian Society of Mechanical Sciences and Engineering, *[S. l.]*, v. 40, n. 7, p. 331, 2018. DOI: 10.1007/s40430-018-1240-3. Available in: https://doi.org/10.1007/s40430-018-1240-3. Access in: 28 mar. 2022.

[14] Roda, Irene; Macchi, Marco; Fumagalli, Luca. The Future of Maintenance Within Industry 4.0: An Empirical Research in Manufacturing: IFIP WG 5.7 International Conference, APMS 2018, Seoul, Korea, August 26-30, 2018, Proceedings, Part II. *In*: [s.l: s.n.]. p. 39–46. DOI: 10.1007/978-3-319-99707-0_6.Available in: https://dx.doi.org/10.1007/978-3-319-99707-0_6. Access in: 28 mar. 2022.

[15] Schmidt, Bernard; Wang, Lihui. Cloud-enhanced predictive

maintenance. The International Journal of Advanced Manufacturing Technology, *[S. l.]*, v. 99, n. October 2018, p. 5–13, 2016. DOI: s00170-016-8983-8.https://link.springer.com/article/10.1007/s00170-016-8983-8. Access in: 28 mar. 2022.

[16] Silva, R. N. Fernandes; Tsuruta, K. M.; Rabelo, D. S.; Finzi Neto, R. M.; Cavalini, A. A.; Steffen, V. Impedance-based structural health monitoring applied to steel fiber-reinforced concrete structures. Journal of the Brazilian Society of Mechanical Sciences and Engineering, *[S. l.]*, v. 42, n. 7, p. 383, 2020. DOI: 10.1007/s40430-020-02458-4. Available in: https://doi.org/10.1007/s40430-020-02458-4. Access in: 28 mar. 2022.

[17] Dutra, J. T.Planejamento e controle da manutenção descomplicado: Uma metodologia passo a passo para implantação do PCM. 1° ed. 2019. Brasília, Editora Engeteles.

[18] Yan, H.; Zhao, Y.; Yang, R.; Li, T.. Monitoring operational status of electromechanical systems using audiovisual information fusion. Journal of the Brazilian Society of Mechanical Sciences and Engineering, *[S. l.]*, v. 42, n. 8, p. 445, 2020. DOI: 10.1007/s40430-020-02522-z. Available in: https://doi.org/10.1007/s40430-020-02522-z. Access in: 28 mar. 2022.

Attachment

A.   Attachment A

Table 3 - FMEA

Equipment	Equipment's function	Component	Failure Mode	Cause of failure	Recommended preventive actions
Fan	Vent the cooled air from the evaporator	Bearings	Elevation of electric current Excessive noise Rotation speed reduction	Excessive vibration; Damaged belt; Fan unbalance; Misalignment of the electric motor.	Check that the belt is intact; Perform Fan sirocco cleaning; Check that the pulley of the electric motor is aligned with the pulley of the Fan.
Fan	Vent the cooled air from the evaporator	electric motor	Low insulation resistance (according to measurement history / manufacturer's manual) Tripping of thermomagnetic electrical protections Variations in electric current and torque Engine heating	Internal engine contamination; Wire insulation enamel failure; Impregnation varnish failure; Rapid fluctuations in the supply voltage.	Check equipment voltage and current; Check insulation resistance; Rearm protections; Check equipment temperature
Fan	Vent the cooled air from the evaporator	electric motor	Low insulation resistance (according to measurement history / manufacturer's manual) Tripping of thermomagnetic electrical protections Variations in electric current and torque Engine heating	Internal engine contamination; Degradation of insulating material by drying, caused by excess temperature; Insulation material failure.	Check equipment voltage and current; Check insulation resistance; Rearm protections; Check equipment temperature
Fan	Vent the cooled air from the evaporator	electric motor	Low insulation resistance (according to measurement history / manufacturer's	Internal engine contamination; Insulating material failure; Connection overheating due to bad contact.	Check equipment voltage and current; Check insulation resistance; Rearm protections; Check equipment temperature

Equipment	Equipment's function	Component	Failure Mode	Cause of failure	Recommended preventive actions
			manual) Heating of electrical connections Tripping of thermomagnetic electrical protections		
Fan	Vent the cooled air from the evaporator	electric motor	Low insulation resistance (according to measurement history / manufacturer's manual) Variations in electric current and torque Engine heating Tripping of thermomagnetic electrical protections	Internal engine contamination; Degradation of insulating material by drying, caused by excess temperature. Wire insulation enamel failure; Impregnation varnish failure; Insulating material failure; Rapid fluctuations in the supply voltage	Check equipment voltage and current; Check insulation resistance; Rearm protections; Check equipment temperature
Fan	Vent the cooled air from the evaporator	electric motor	Disarming the protections	Violent fluctuation in the supply voltage, for example, lightning strikes;	Check the quality analyzer measurements
Fan	Vent the cooled air from the evaporator	electric motor	Electric current unbalance	Voltage and / or current imbalance between phases; Bad contacts in connections, switches, contactors, circuit breakers, etc .; Voltage fluctuations in the three phases.	Retighten the terminals; Check for loose terminal; Check the measurements of the quality analyzer; Check the quality analyzer measurements.
Fan	Vent the cooled air from the evaporator	electric motor	Elevation of electric current	Excessive difficulty in starting the engine, due to high voltage drop, very high inertia and load torque; Locking the load axis.	Check electrical currents; Change engine bearings.

Equipment	Equipment's function	Component	Failure Mode	Cause of failure	Recommended preventive actions
Fan	Vent the cooled air from the evaporator	electric motor	Wire and / or motor heating	Very long and / or very thin power cables; Incorrect connection of the motor connection cables; Excessive number of matches in short time; Excessive load on the shaft end (permanent or occasional / periodic); Overvoltage or undervoltage in the supply network (permanent or occasional / periodic); Poor ventilation (defective or damaged baffle cover, dirt on the housing, high ambient temperature, etc.).	Check cable connection; Check if the motor fan is working; Check the motor temperature with thermal imager.
Fan	Vent the cooled air from the evaporator	electric motor	voltage and current loss in at least one of the phases	Bad contact in switch, contactor or circuit breaker; Bad contact in connections; Blowing a fuse; Breaking a power cable	Check terminal connections and protection and control devices; Check the integrity of the fuses.
Fan	Vent the cooled air from the evaporator	electric motor	Does not start	Circuit breaker tripped; Burnt winding;	Reset circuit breakers; Rewind electric motor.
Fan	Vent the cooled air from the evaporator	Transmission belt	Excessive vibration and atypical noise / Rotation speed reduction	Belt wear; Wrong belt; Pulley damaging the belt.	Change belt; Align pulleys; Machining pulley.
Fan	Vent the cooled air from the evaporator	Fan Palettes	Excessive vibration and atypical noise	Unbalance of the palettes; Breaking of a palette; Detaching a palette.	Balance Fan.
Compressor	Compress refrigerant gas	Compression system	Elevation in electrical current / Hot pipes.	Contactor does not work; Broken mechanical components such as bearings; Loose wires from loose terminals.	Check if a signal is arriving at the contactor; Check electrical current; Retighten wires;

Equipment	Equipment's function	Component	Failure Mode	Cause of failure	Recommended preventive actions
Compressor	Compress refrigerant gas	Compression system	Low electric current; Frozen line.	Lack of refrigerant gas in the system; System leak.	Check for leakage; Repair leaks; Reset refrigerant gas.
Compressor	Compress refrigerant gas	Contactors	Contactor does not work	Burnt coil; The signal from the switchboard contactor is not being sent; Arduino relay problem.	Check if the Arduino relay is working; Check if the wires are connected correctly; Check if the signal is being sent to the contactor.
Exhaust fan	Make the air exchange heat with the condenser	Bearings	Elevation of electric current; Excessive noise; Increased system temperature.	Excessive vibration; Damaged belt; Fan unbalance; Misalignment of the electric motor.	Change bearing; Check electrical currents.
Exhaust fan	Make the air exchange heat with the condenser	electric motor	Fan does not work. Compressor current 2 low or equal to zero	Burned capacitor; Capacitor disconnected; Phase loss.	Check capacitor capacitance; Change capacitor; Check if there was a phase loss.
Exhaust fan	Make the air exchange heat with the condenser	Helix	Excessive vibration and atypical noise	Fan with broken propeller palette; Propeller unbalanced; Fan with clearance in the fixation.	Balance propeller palettes; Retighten screws.
Evaporator	Receive heat from the air	Serpentine	System pressure drop; Freezing evaporator.	Dirty evaporator; Punctured evaporator.	Clear Evaporator; Check for gas leakage and correct.
Condenser	Remove heat from the air	Serpentine	System pressure drop; Freezing evaporator.	Dirty condenser; Bored condenser.	Clean condenser; Check for leaks in the condenser and correct.
Resistance bench	Add heat to dehumidify relatively	Electrical resistance	Electrical resistance	Burnt electrical resistance; Phase loss; Wrong wire connection; Loose wire in electrical resistance	Check if the resistances are heating up; Check if voltage is coming; Check the connection of the wires.

Equipment	Equipment's function	Component	Failure Mode	Cause of failure	Recommended preventive actions
Switchboard	Control the equipment	Controller board	Temperature and relative humidity measurement with NAN value	Loose jumper wire; DHT22 sensor problem; Some loose suppressor filter; Electronic board problem.	Test if there is a contactor generating noise on the Arduino when it is released; Check for loose jumper wire; Check if there is a problem with DHT22.
Switchboard	Control the equipment	Controller board	Some frame contactor does not activate	Loose jumper wire; Problem in the relay module; Arduino problem.	Check that all contactor connections are correct; Check if there is a problem in the relay module; Check if there is a problem with the Arduino.
Switchboard	Control the equipment	Controller board	Does not send data to Grafana	Problem with ethernet shield; Blocking the Firewall system; Loose ethernet wire; Error reading DHT22.	Check for network infrastructure problems; Check if the ethernet cable is connected; Check if there is a problem with the ethernet shield; Check blocking in the Firewall; Check for loose jumper wire.

B. Attachment B

Table 4 – Table of truth

Legend: cell colors indicate values (G = green, R = red, B = blue, blank = unfilled).

OPERATION	ROTATION (INFRA.)	TEMPERATURE TOO HIGH	TEMPERATURE IN TOO HIGH OFFSET	TEMPERATURE IN HIGH OFFSET	TEMPERATURE OK	TEMPERATURE IN LOW OFFSET	TEMPERATURE IN TOO LOW OFFSET	TEMPERATURE TOO LOW	RELATIVE HUMIDITY HIGH	RELATIVE HUMIDITY OK	RELATIVE UMIDITY LOW	RELE_VENT	RELE_RES1	RELE_RES2	RELE_COMP1	RELE_COMP2	RELE_UMID
0	B	B	B	B	B	B	B	B	B	B	B	G	R	R	R	R	R
1	B	B	B	B	B	B	B	B	B	B	B	R	R	R	R	R	R
2	G	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	G	R	R	R	R	R
3	G	G							B	B	B	G	R	R	G	G	R
4	G			G					G			G	G	R	G	G	R
5	G			G						G		G			G	G	
6	G			G							G	G	R	R		G	G
7	G					G			G			G	R	R	G	G	R
8	G					G				G		G			G	R	
9	G					G					G	G	R	R		R	G
10	G		G						G			G	R	R	G	G	
11	G		G							G		G			G	G	
12	G		G								G	G	R	R	G	G	G
13	G					G			G			G					
14	G					G				G		G					
15	G			G							G	G	R	R			G
16	G						G		G			G				R	R
17	G						G			G		G			R	R	
18	G						G				G	G			R	R	G
19	G							G			G	G			R		R
20	G							G		G		G			R		
21	G							G			G	G			R	R	G

INPUT AND OUTPUT				
TYPE	**GREEN**	**RED**	**BLUE**	**UNFILLED**
INPUT	Reached condition	FAILURE	REGARDLESS OF CONDITION	DID NOT REACH THE RANGE
OUTPUT	ON	OFF	NOT APPLICABLE	MAINTAINS THE LAST STATUS

Pleurotus ostreatus mushroom productivity in different substrates of agro-industrial residues generated in the southern region of Tocantins, Brazil

Ana Luiza Santiago Pereira[1], Aloisio Freitas Chagas Junior[2], Marcos Giongo[3], Gessiel Newton Scheidt[4], Jader Nunes Cachoeira[5], Augustus Caeser Franke Portella[6].

[1] Student in the Forest Engineering course at the Federal University of Tocantins, Gurupi Campus-TO, Brazil
https://orcid.org/0000-0001-8540-9574
[2] PhD in Agronomy Engineering at the Federal University of Tocantins, Gurupi Campus-TO, Brazil
https://orcid.org/0000-0002-7489-8701
[3] PhD in Forest Engineering at the Federal University of Tocantins, Gurupi Campus-TO, Brazil;
https://orcid.org/0000-0003-1613-6167
[4] PhD in Biotechnological Engineering at the Federal University of Tocantins, Gurupi-TO, Brazil Campus
https://orcid.org/0000-0002-4729-3416
[5] PhD in Forest Engineering at the Federal University of Tocantins, Gurupi Campus-TO, Brazil
https://orcid.org/0000-0001-9150-5431
[6] PhD in Biotechnological Engineering at the Federal University of Tocantins, Gurupi Campus-TO, Brazil
https://orcid.org/0000-0001-5178-9257

Abstract — Some of the main agro-industrial residues available in the cerrado region in the south of the state of Tocantins were evaluated for the cultivation of the Pleurotus ostreatus mushroom. The following substrates, hay and andropogon grass, enriched with barley, organic compost, and corn cob, were tested. All substrates received 2% inoculant (Cal) and were incubated at 24°C. After colonization, the spawn were kept in an air-conditioned environment for 24 hours and humidity at 80%. The substrate andropogon grass increased with corn cob added with 2% lime showed the best result in mushroom production, with a biological efficiency of 39.08% and an average production of 381.07 g/Kg substrate in 25 days of follow-up.

I. INTRODUCTION

With the increase in areas destined for agriculture in the North region, mainly in the Brazilian Cerrado biome, lignocellulosic residues of agricultural and forestry nature are available (SALES-CAMPOS; ANDRADE, 2011). These generated residues can contain great added value because many are rich in nutrients, or, due to the simple fact that reuse already adds more value, they are called residual plant biomass, generated mostly as a result of agricultural activity (BARBOSA et al., 2020; POPPE, 2021).

Some of these materials were tested in our work for the production of the P. ostreatus mushroom, as an alternative production to generate income for family agriculture and small producers, such as brewery residues (barley grain), crushed corn cob, and composting (organic compost). The conversion of these wastes into new products takes place with few resources, reduces environmental damage, and improves the circular economy.

An alternative for the use of these residues is bioconversion. In the cultivation of edible mushrooms, the recycling of these materials can be retransformed into foods

with high food potential, with proven properties such as anticancer, anticoagulant, known in the foreign market and with potential for expansion in the domestic market, rich in proteins, B vitamins, fibers , carbohydrates with low levels of lipids in addition to high levels of glutamate and low levels of sodium (HELENO et al., 2009; CHEUNG et al., 2012; BELUHAN & RANOGAJEC, 2011; BENTO; CASARIL, 2000). The interest of the international scientific community in mushrooms has increased due to these medicinal properties (EIRA, 2003)

II.   THEORICAL REVIEW

In Brazil, the most produced and commercialized edible mushroom species are: Lentinula edodes (shiitake), Pleurotus spp. (shimeji, hiratake or houbitake) and Agaricus bisporus (Paris mushroom). The latter, the famous champignon, was the first to be cultivated in Brazil and is the most cultivated and consumed in the world (SANCHÉZ, 2009).

The basidiomycete Pleurotus ostreatus is a lignocellulosic fungus capable of degrading several materials, due to the production of extracellular enzymes, mainly lignolytic enzymes such as laccase (POPPE, 2005; SILVA et al., 2007, LECHNER; PAPINUTTI, 2006). This enzyme acts on lignocellulosic materials, allowing the use of agro-industry by-products, rich in lignin and cellulose, for mushroom cultivation. Thus, mushroom cultivation is a way of adding value to waste that would otherwise be discarded and producing biomass of therapeutic and nutritional interest (EIRA, 2003; ISHIKAWA et al., 2001; SHARMA; MADAN, 1993; SOUZA-PACCOLA et al., 2004).

The edible mushroom Pleurotus ostreatus belongs to the second largest group of mushrooms most produced and consumed worldwide, behind Agaricus bisporus (champignon) and followed by Lentinula edodes (shiitake). Its characteristics have very desirable biological properties, in addition to its delicious flavor and texture, it also has medicinal activities, such as: antitumor and antioxidant, prevents the increase in blood pressure in cases of hypertension and a hypocholesterolemic and immunomodulatory effect, in addition to antibacterial, antifungal and antibacterial activity. antiviral (ADEBAYO et al., 2012).

III.   MATERIALS AND METHODS

Microorganism, Culture Media and Inoculum

The experiments were carried out in a cultivation house at the Bioactive Compounds Laboratory of the Federal University of Tocantins on the Gurupi Campus. The

fungus Pleurotus ostreatus, (UFT PO Eguirra 2020), belonging to the mycoteca of UFT, Campus de Gurupi (TO) was maintained in the laboratory using PDA medium (potato, dextrose, agar) in Petri dishes, previously sterilized in an autoclave at 124°C for 1 hour.

Substrate preparation

For the tests, the fungi were inoculated in a substrate based on hay and andropogon grass, enriched with barley, organic compost, crushed corn cob 2% lime, with three replications each in two production flows until complete production/colonization with a space of 20 to 30 days between them, as specified in Table 1.

Table 1 - Substrate formulation

Base Substrate	Supplementation (added 2% lime)	Final substrate weight (g)
Hay	Barley (H+Bs)	102,0±3
Hay	Organic compound (H+Oc)	102,0±3
Hay	Corn cob (H+Cc)	102,0±3
Andropogon Grass	Barley (Ga+Bs)	102,0±3
Andropogon Grass	Organic compound (Ga+Oc)	102,0±3
Andropogon Grass	Corn cob (Ga+Cc)	102,0±3

Source: survey data.

To identify the experiments, we used the acronyms where H and Ga are the base substrates (Hay, Grass Andropogon) + the acronym for Barley supplementation (Bs), Crushed corn cob (Cc) and Organic compost (Oc).

Induction

Each residue was left to soak for at least two hours and then drained for 4 hours before packaging. The supplements were added after draining and the substrates obtained were packed in polypropylene bags with a capacity of 1 kg and autoclaved for 1 hour at 121°C. Each substrate bag received 20 g of inoculum, (2%), added to the top of the bag. Subsequently, the bags were partially closed, allowing the gas exchange necessary for mycelial growth.

The bags were incubated in a grow house with wooden shelves framed with fresh (untreated) bamboo under a black canvas cover to provide diffused light. The temperature and humidity were controlled with the help of a 5 liter air humidifier, maintaining a humidity around 90% and air conditioning at an average temperature of 23°C. The experiments were arranged in trays with two units each.

Determination of biological efficiency

All mushrooms harvested were subjected to a gravimetric evaluation to determine biological efficiency, using Equation 1.

$$EB = \frac{\text{Mushroom fresh weight}}{\text{Initial substrate weight}} x100 \qquad (1)$$

The experimental design was completely randomized with six replications, using the Tukey test at 5% of significance to compare the means after the Analysis of Variance.

IV.   RESULTS AND DISCUSSION

Despite the contaminations, there were important fructifications. Fruiting regularity was not taken into account, considering that each substrate fruited only once, with exceptions made to H+Oc and Ga+Cc substrates, with two and three fruiting moments, respectively. All fruiting mycelia were harvested at the end of the twenty-fifth day (Figure 1).
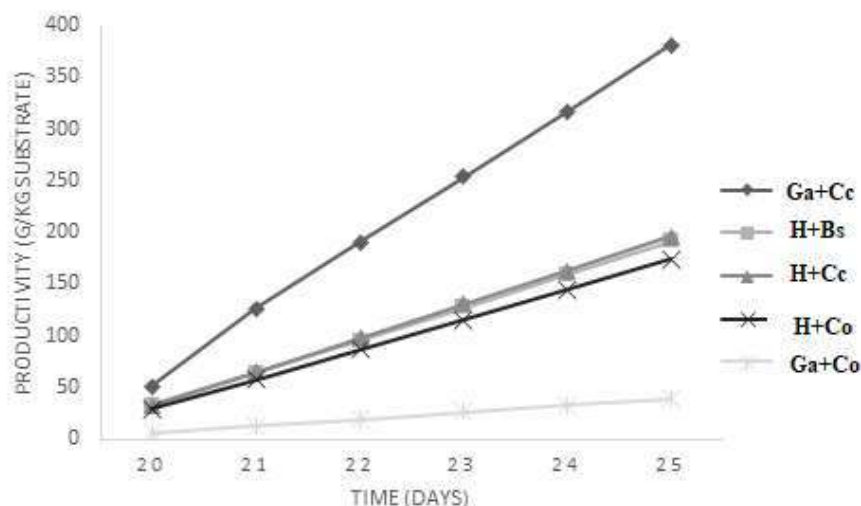
Fig.1. Mycelial growth of the Pleurotus ostreatus strain during 25 days in polyethylene plastic bags. Columns followed by the same letter did not differ significantly from each other by Tukey's test (p<0.05).

Source: survey data.

The kinetics show uniform growth between treatments over time, with similar growth rates (Figure 1), except for Andropogon Grass with corn cob (Ga+Cc) substrates. For Ga+M, the average productivity was 63.5 g/kg of substrate/day and for the Ga+Oc substrate it was only 6.53 g/kg of substrate/day, which showed the lowest productivity during the tests. Table 2 shows data on initial and final weight, fresh weight and dry weight of the mushrooms harvested, mycelial development and the number of days the substrate had to express its data.

Table 2 - Experimental cycle data

WEIGHT (g) +2% lime	H+Bs	H+Cc	H+Co	Ga+Bs	Ga+Cc	Ga+Co
initial substrate	102.00	102.00	102.00	102.00	102.00	102.00
final substrate	88.14	75.25	99.83	--	116.52	89.90
fresh mushroom	19.49	20.00	17.73	--	39.87	4.00
mushroom dry	1.50	2.20	3.13	--	4.35	0.40
Production days	23 days	24 days	13 days	--	20 days	23 days

Source: survey data.

The Ga+Bs formulation had substrate contamination not allowing Pleurotus colonization after inoculation, the experimental unit was excluded from the tests. Several attempts were made to reduce substrate moisture, but due to the hygroscopic characteristics of both, the expected results were not obtained. The hay

supplemented with Barley and corn cob had a good efficiency, around 20%, with an average production around

190 g/Kg of substrate (Table 3). In addition to presenting a fast mycelial growth with spontaneous fruiting.

Table 3 – P. ostreatus mushroom production results under different agricultural residues enriched as follows.

Basis	Suplementation	Time (days)	Average Production (g/Kg substrate fresch)	Biological Efficiency (%)
Hay	Barley	23	191.07±0.01[a]	19.06[a]
Hay	Organic compound	13	173.82±0.03[b]	17.38[b]
Hay	Corn cob	24	196.07±0.02[a]	19.60[a]
Andropogon Grass	Barley	-	-	-
Andropogon Grass	Organic compound	23	39.21±0.05[c]	3.92[c]
Andropogon Grass	Corn cob	20	381.07±0.03[d]	39.08[d]

Values are expressed as mean ± SD. Means inthe same row with diferente superscipts were significantly diferente ($p \leq 0.05$). Source: survey data.

The use of hay with organic compost had a lower biological efficiency (17.76%), with a yield of 173.82 g/Kg of substrate. However, its production period was only 13 days, the shortest of all experiments. A slower micellization was observed compared to the others despite having fructification when exposed to light, but with many primordia aborted in the course of mushroom development. After harvest, there was a high rate of contamination of the substrate, it was removed from the experiment after fruiting. The substrate appeared dry and possibly depleted of nutrients.

Andropogon Grass showed not to have a good biological efficiency. Substrate Andropogon Grass suplemented with Organic compost (Ga+Oc) had many pins, however, did not develop, not reaching large fructifications. There was no contamination in the substrate. The substrate was healthy, despite being dry, with little mycelial vigor and low biological efficiency. However, the grass had a good result when complemented with corn cob (34.21%) and a better yield in this work (381.07 g/Kg of substrate). It produced two large sized mushrooms, both weighing over 15g each. There were other pins, but they didn't develop.

This result leads to the understanding that substrates that contain a supplement with corn residues have a tendency to produce better yields. This result corroborates with Dias et al. (2003), who, when using pure corn husk in their studies, obtained a biological efficiency of 51.1% with an average production of 85 g of mushroom per kilogram of fresh substrate.

At the end of the experiment, all substrates showed a dry appearance, with superficial green mold contamination. In the mushroom induction and production

phase, physical factors such as temperature, luminosity, gas exchange, water availability in the compost, relative humidity and induction methods are aspects that influence mushroom production and quality (ZADRAZIL; GRABBE, 1983). The superficial contamination covered some points of the white mycelium, leaving it dry, and without future fruiting.

For the North region, one of the possibilities would be the use of agro-industrial residues based on corn in a greater proportion, combining with the others as a way of reducing the cost.

V. CONCLUSION

We seek to demonstrate the feasibility of the enterprise, for its cost-effectiveness, overcoming the difficulties of acclimatization of the Cerrado biome with the development of mushroom strains that are more adaptable to local climatic conditions, such as high temperature and low humidity, in addition to reducing the contamination factor that remains active in the experiments precisely because of these conditions.

REFERENCES

[1] ADEBAYO, E. A.; OLOKE, J. K.; AYANDELE, A. A.; ADEGUNLOLA, C. O. Phytochemical, antioxidant and antimicrobial assay of mushroom metabolite from Pleurotus pulmonarius–LAU 09 (JF736658). Journal of Microbiology and Biotechnology Research, Ogbomoso, Nigeria, junho.2012. Disponivel em:
https://www.researchgate.net/publication/235992283_Phytochemical_antioxidant_and_antimicrobial_assay_of_mushroom_metabolite_from_Pleurotus_pulmonarius_-LAU_09_JF736658. Acesso em: 6 set. 2021.

[2] BARBOSA, E. E. P; PIMENTA, L; BRITO, A, K, P; MARTIM, S, R; TEIXEIRA, M, F, S. Cultivo de cogumelo comestível em resíduos lignocelulosicos de floresta tropical para produção de proteases. Brazilian Jornal of Development, Curitiba 27 nov.2020. Disponivel em: https://www.brazilianjournals.com/index.php/BRJD/article/view/20567/16951 Acesso em: 6 set.2021.

[3] BELUHAN. S; RANOGAJEC. A. Chemical composition and non-volatile componentes of Croatian wild edible mushrooms. Food Chemistry. Croatia, 26 jul. 2010. Disponivel em: https://www.academia.edu/12984548/Chemical_composition_and_non-volatile_components_of_Croatian_wild_edible_mushrooms. Acesso em: 15 set. 2021.

[4] BENTO, C. B. P; CASARIL, K. B. P. B. Bioconversão de resíduos agroindustriais lignocelulósicos por fungos causadores da podridão branca: uma alternativa à produção de alimentos. Revista Faz Ciência. Francisco Beltrão, PR, 01 jan. 2000. Disponível

[5] em: http://e-revista.unioeste.br/index.php/fazciencia/article/view/8030 .Acesso em: 15 set. 2021.

[6] CHEUNG, Y; SIU, K; LIU, Y; WU, J; Molecular properties and antioxidante activities of polysaccharide–protein complexes from selected mushrooms by ultrasound-assisted extraction. Process Biochemistry 47, Hong Kong, 15 jan. 2012. Disponível em:https://www.sciencedirect.com/science/article/pii/S1359511312000682?casa_token=WPWQ0GL44L8AAAAA:oF_2dnHHOlgZI4eAIQtCmGR3_exK2DRab3AP74V-KzqbdrD7SgLXuM646JvRZd4kO4531BM1OTU . Acesso em: 15 set. 2021.

[7] EIRA, A. F. **Cultivo do cogumelo medicinal** *Agaricus blazei* **(Murrill) ss.**

[8] **Heinemann ou** *Agaricus brasiliensis* **(Wasser et al.).** Viçosa: Aprenda fácil, 2003.

[9] HELENO, S; BARROS, L; SOUSA, M; MARTINS, A; FERREIRA, I; Tocopherols composition of Portuguese wild mushrooms with antioxidant capacity. Food Chemistry, Bragança, Portugal, 8 set. 2009. Disponível em: https://www.sciencedirect.com/science/article/pii/S0308814609010693?casa_token=RG

[10] JOFD3iKSAAAAAA:3FZXy2jZQoOL9lL9o4dLyB7c1Lzo3c37TwCeXDDcmM133-F

[11] WUkcl7HzcH7aXAtYIL6tQBbIVV5Q Acesso em: 15 set. 2021.

[12] ISHIKAWA, N. K.; FUKUSHI, Y.; YAMAJI, K.; TAHARA, S.; TAKAHASHI, K. Antimicrobial cuparene-type sesquiterpenes, enokipodins C and D, from a mycelial culture of Flammulina velutipes. Journal of Natural Products, Washington, v.64, n.7, p.932-934, jul. 2001.

[13] LECHNER, B. E.; PAPINUTTI, V. L. Production of lignocellulosic enzymes during growth and fruiting of the edible fungus *Lentinus tigrinus* on wheat straw. **Process Biochemistry**, Amsterdam, v. 41, p. 594-598, 2006.

[14] POPPE, J. Substrate. In: **Shiitake cultivation**. Korea: Mushworld, 2005. p. 75-85.

[15] SALES-CAMPOS, C.; ANDRADE, M. C. N. Aproveitamento de resíduos madeireiros para o cultivo do cogumelo comestível Lentinus strigosus de ocorrência na Amazônia. Acta Amazonica, Manaus, AM, 3 mar. 2010. Disponível em: https://www.scielo.br/j/aa/a/8hvGtsmhjz3HGcnDYbb4KGk/abstract/?lang=pt Acesso em: 15 set. 2021.

[16] SANCHEZ, C. Cultivation of Pleurotus ostreatus and other edible mushrooms. Applied Microbiology and Biotechnology, Txacala, Mexico, 3 dez. 2009. Disponível em: https://www.researchgate.net/publication/40444029_Cultivation_of_Pleurotus_ostreatus

[17] _and_other_edible_mushrooms Acesso em: 15 set. 2021.

[18] Sharma, S. e Madan, M., Microbial protein from leguminosas e não leguminosas substratos. Acta Biotechnol., 13: 131-139. 1993.

[19] SILVA, E. G.; DIAS, E. S.; SIQUEIRA, F. G.; SCHWAN, R. F. Análise química de corpos de frutificação de *Pleurotus sajor-caju* cultivado em diferentes concentrações

[20] de nitrogênio. **Ciência e Tecnologia de Alimentos**, Campinas, v. 27, n. 1, p. 72-76, 2007.

[21] SOUZA-PACCOLA, E. A. et al. Antimutagenic action of Lentinula edodes and Agaricus blazei on Aspergillus nidulans conidia. Brazilian Journal of Microbiology [online]. 2004, v. 35, n. 4 [Accessed 1 April 2022], pp. 311-315. Available from: <https://doi.org/10.1590/S1517-83822004000300008>. Epub 23 May 2005. ISSN 1678-4405. https://doi.org/10.1590/S1517-83822004000300008.

[22] ZADRAZIL, F.; GRABBE, K. Edible mushromm. In: REHM, H. J.; REED, G. Eds. **Biotechnology**. Verlag Chemil. Wiinhein, v. 3, n. 1, p. 145-187. 1983.

Establishing the initial benchmark for the sustainability of Arabica coffee-growing householders in a highland region, Brazil

David Brunelli Viçosi[1], Cecília Uliana Zandonadi[1], Victor dos Santos Rossi[2], Wesley Zambom da Silva[2], Fabiano Tristão Alixandre[2], Cesar Abel Krohling[2], Cleber Cássio Ferreira[2], Evaldo de Paula[2], Marx Bussular Martinuzzo[2], Douglas Gonzaga de Souza[2], Maurício Lorenção Fornazier[3], Lúcio Herzog De Muner[4], Ricardo Dias Alixandre[5], HigorAlixandre Macette[5], David dos Santos Martins[1], Luiz Fernando Favarato[2], Maurício José Fornazier[2], Rogério Carvalho Guarçoni[6]

[1]Scientific initiation scholarship holder / Secretaria de Estado da Agricultura, Abastecimento, Aquicultura e Pesca (SEAG) / Fundação de Amparo à Pesquisa do Espírito Santo (FAPES), State of Espírito Santo, Brazil
E-mail: davidvicosi@hotmail.com; ceciliauli@hotmail.com; davidentomol@gmail.com
[2]Instituto Capixaba de Pesquisa, Assistência Técnica e Extensão Rural (NCAPER), State of Espírito Santo, Brazil
E-mail: dsrvictor@yahoo.com.br; wesleyzambom1@gmail.com; fabianotristaoalixandre@hotmail.com; cakrohling@gmail.com; clebinhoferreira@yahoo.com.br; evaldo.paula@incaper.es.gov.br; bussularmartinuzzo@gmail.com; douglas.sousa@incaper.es.gov.br; lffavarato@gmail.com; mauriciofornazier@gmail.com
[3]Scientific scholarshipholder / Fundação de Amparo à Pesquisa do Espírito Santo (FAPES), Instituto Federal do Espírito Santo (IFES)/Campus Alegre, State of Espírito Santo, Brazil
E-mail: mauzier_lf@hotmail.com
[4]Scientific initiation scholarship holder/Consórcio Café (CONCAFÉ); State of Espírito Santo, Brazil
[5]Centro de Ciências Agrárias e Engenharia da Universidade Federal do Espírito Santo, CCAE-UFES, Alegre, ES, Brazil
E-mail: ricardoalixandre@gmail.com; higoralimacette@gmail.com
[6]Instituto Capixaba de Pesquisa, Assistência Técnica e Extensão Rural (INCAPER), State of Espírito Santo, Brazil/Project Coordinator, SEAG/FAPES scholarshipholder, E-mail: rogerio.guarconi@gmail.com

Abstract — The production of specialty coffees is an important activity for farm incomes and should be encouraged. However, it is necessary that this process may respect the principles based on the economic, environmental, and social axes of sustainability. This research was carried out aiming to generate the initial benchmark of the sustainability of four farms in the municipality of Afonso Cláudio, State of Espírito Santo, Brazil. The System for Assessing Sustainability Standards for Coffee Growing in Espírito Santo, a tool in the format of an electronic spreadsheet, was used in order to quantify the scores of the different standards. The results showed a gap in the three axes with intervention needs mainly related to economical standards, followed by environmental, and social ones. The main interferences have been related to the quality of coffee beans management, costs and incomes of the farms, improvement in harvest and post-harvest processes, training in the use of manual machines, and the correct use of pesticides. Different intervention techniques will be offered to coffee-growers for

intervention in the farms aiming to improve the level of their adequacy regarding the sustainability standards. However, the owner's family values, as well as their cultural and economic restrictions, must be respected. Thus, the results of farm adjustments must be achieved in different ways and at different times.

I. INTRODUCTION

Brazil is worldwide the largest coffee exporter and has the second position among countries that consume coffee. The State of Espírito Santo is the second largest Brazilian coffee producing, cultivating Arabica and Robusta (Conilon) coffee species. The total coffee crop of these two coffee species reached a total production of 837,480 tons, being 285,900 tons of Arabica coffee (CONAB, 2020; SOUZA et al., 2021).

Arabica coffee is one of the main agricultural activities in the State of Espírito Santo, where it is cultivated in sloping areas with altitudes ranging from 500 to 1,200 m. Approximately 170,000 ha have been cultivated, and more than 26,000 farms and 53,000 householders are directly involved in the cultivation of this coffee species in this Brazilian State (INCAPER, 2020; SEAG, 2021). Most of these farms fit the definition of family-based agriculture (Law 11,326, of July 24, 2006), responsible for a large part of the Brazilian economy. Despite its great representation, familyfarming still needs technological investments to increase crop productivity and to provide more significant economic returns for producers (SULZBACHER; DAVID, 2009).

The main characteristic of the Arabica coffee cultivation system in the highland region of the geographical indication (GI) "Café Montanhas do Espírito Santo" is the manual labor. This happens mainly due to the conditions of sloping areas where the use of agricultural machinery becomes quite difficult. However, in this region, great unavailability of labor for work in agriculture has been related. So, different types of partnerships among owners have been adopted, such as agricultural partnership, sharecropping, and temporary hiring of employees. But all such partnerships need to be properly registered in accordance with Brazilian labor law. On the other hand, different technologies have been adopted by householders in order to maximize the use of available labor, as well as trying to replace it in crop management, harvesting, and post-harvesting of coffee berries (DIAS et al., 2021; KROHLING et al., 2021).

Soils of this sloping region are, for the most part, chemically poor, acidic, and with low levels of nutrients. Thus, many producers still practice the traditional cultivation system, which is highly dependent on external inputs, such as chemical fertilizers and pesticides. In addition, when these inputs are used inappropriately, they can cause environmental impacts, contamination of soils, water, and air, and may cause pest/disease resistance and increasing greenhouse gas emissions; besides it could increase coffee production costs (ROSSET et al 2014; KROHLING et al. al., 2021; DIAS et al., 2021).

During important events such as the United Nations Conference on Development and the Human Environment (1972), the World Commission on Environment and Development (1987), and the United Nations Conference on Environment and Development (ECO-92, 1992), the concept of sustainability was being adapted. It is currently defined as a set of actions or use of natural resources that must meet the needs of the present generation, without affecting the possibility of future generations to meet theirs. Sustainability, therefore, includes actions in several areas, known as axes, mainly in the Economic, Environmental, and Social. Thus, for an activity to be considered sustainable, it needs to guarantee a financial return without neglecting the importance of environmental preservation, and respect for human dignity (MARTINUZZO et al. 2021).

Agricultural technologies for coffee production are available and can allow high levels of productivity. Despite this, these technologies have been used inappropriately aiming to obtain overproductions, making this process unsustainable (DEPONTI, 2001; VERDIN FILHO et al., 2019).Although there are appropriate and adapted technologies for householders to produce specialty coffees, these technologies have not been widespread for them (GREENBERG, 1997; DE MUNER et al., 2019).

Sustainability assessment and monitoring standards have been important tools for identifying problems, as well as defining strategies that promote necessary changes to improve the sustainability performance of farms (DE MUNER et al. 2019).

Despite its extreme importance, the assessment of sustainability in coffee farming is still a major challenge due to the complexity of environmental, socioeconomic, and cultural aspects.It is a dynamic and complex process that cannot be measured by parameters or universal criteria that cover all this complexity. In this way, the assessment of sustainability standards is considered as a system under construction, which evolves and stabilizes at increasing levels and adapted to each regional socioeconomic and cultural reality. One of the advantages of carrying out a sustainability assessment is that it is able to provide an

analytical framework for studying and comparing different systems and farms. In addition, it also allows prioritizing and selecting a set of standards for monitoring, guiding planning, and decision-making processes (ASTIER et al. 2008; DE MUNER et al., 2019).

The System for Assessing Sustainability Standards for Coffee Growing in Espírito Santo is a methodology instrument developed by Incaper to assist in measuring the levels of socioeconomic and environmental adequacy. It uses standards selected based on the sustainability protocols followed by the main international certification organizations.This evaluation criteria have the format of a spreadsheet, is an accessible and cost-free way, and is designed to assist the user in assessing the level of adequacy of the farms to the standards used in the economic, environmental, and social axes. Its use facilitates the identification of the standards that need more attention, often representing a bottleneck in the axes; on the other hand, its use facilitates the planning intervention needs to adapt farms to the pre-established standards. (MARTINUZZO et al. 2021).

This research was carried out due to characterize the economic, environmental, and social reality of different farms in the municipality of Afonso Cláudio, State ofEspírito Santo, Brazil, aiming to generate the initial benchmark for sustainability of Arabica coffee farms. Based on the data of this research, technical assistance interventions will be offered to the farmers aiming at improving the level of adequacy of the farms in terms of the sustainability standards.

II. MATERIAL AND METHODS

2.1 Location of the sampled farms

Data collection was carried out on four sampled farms in the municipality of Afonso Cláudio, State of Espírito Santo, Brazil, from February to October 2021. These farms were located in the communities of Serra do Boi (704m asl), São Luiz da Boa Sorte (680m asl), Piracema (973m asl), and Alto Santa Joana (1045m asl).

2.2 Criteria for selecting the studied farms

The municipality of Afonso Cláudio was initially selected because this is the largest municipality in territorial extension in the highlands of the State of Espírito Santo, one of the main producers of Arabica coffee, particularly specialty coffees. Coffee cultivation has been part of the history of this municipality, and this is its main economic activity, the main responsible for employment in rural areas (DUMER et al., 2012; IBGE, 2017).

The main criterion for the selection of the four farms was to prioritize coffee growers who do not adoptthe production of specialty coffees. Therefore, it is expected to know the current situation of cultivation, encourage the production of specialty coffees, as well as introduce the principles of sustainability in these farms.

The different altitudes may be justified by the peculiarity of these regions to produce different types of specialty coffees (terroir). Coffee flavors are influenced by several factors, such as sensory characteristics, natural and human factors, in addition to local customs and culture (DIAS et al., 2021; SOUZA et al., 2021).

2.3 Standards for sustainability assessment

The adopted methodology for characterizing the initial benchmark of the farms followed the recommendations of the 'System for the Assessment of Sustainability Standards for Coffee Growing in Espírito Santo' (MARTINUZZO et al. 2021).The standards used on the economic axis were crop productivity efficiency, coffee marketing efficiency, coffee quality management, production cost and income management, good agricultural practices (GAP) - soil analysis, GAP - foliar analysis, GAP - soil conservation, GAP - integrated pest and disease management, GAP – irrigation, good harvest, and post-harvest practices, traceability of production, and coffee bean storage.

On the environmental axis the standards used were the acquisition of pesticides, use of personal protective equipment (PPE); return of empty pesticide packaging bag; pesticide storage; adoption of practices to protect water source areas; waste disposal; licensing of agricultural activities required by law; management of solid and liquid waste generated by agricultural process on the farm; regularization of the legal reserve and permanent protection areas in accordance with the environmental law (CAR); the presence of domestic sewage system in all relevant houses and structures on the farm; no illegal hunting, fishing or trafficking of wild animals and plants; no use of fire without authorization from the competent public bureau.

Standards used in the social axiswere the agricultural pesticide applicator training; training for weed cutting machine and coffee bean picker operator; chainsaw training; training for agricultural implements and machine operator (farm tractor); all agricultural partnership and employee contracts are registered under Brazilian labor law; no children labor; no forced labor; no hazardous conditions of labor; freedom of employees organization, and partners; employee payment are according to the law; access to education; access to the health service.

The four selected farmers were interviewed according to the items in the spreadsheet, and the obtained information was certified through documents. Also, visual observationswere carried out through visiting standard-

specific items of the crop, the post-harvest processing system, the coffee bean, and the pesticide storehouses.

III. RESULTS

A gap in the three evaluated axes in all the farms sampled was noted. The average of the standards of the economic axis was 37, with scores ranging from 32 to 47.

For the environmental axis, the average was 68, ranging from 56 to 79, and in the social axis the average found was 73, ranging from 67 to 81.The generalaveragesustainability score of the four sampledfarms was 59,ranging from 57 to 61 (figure 2).
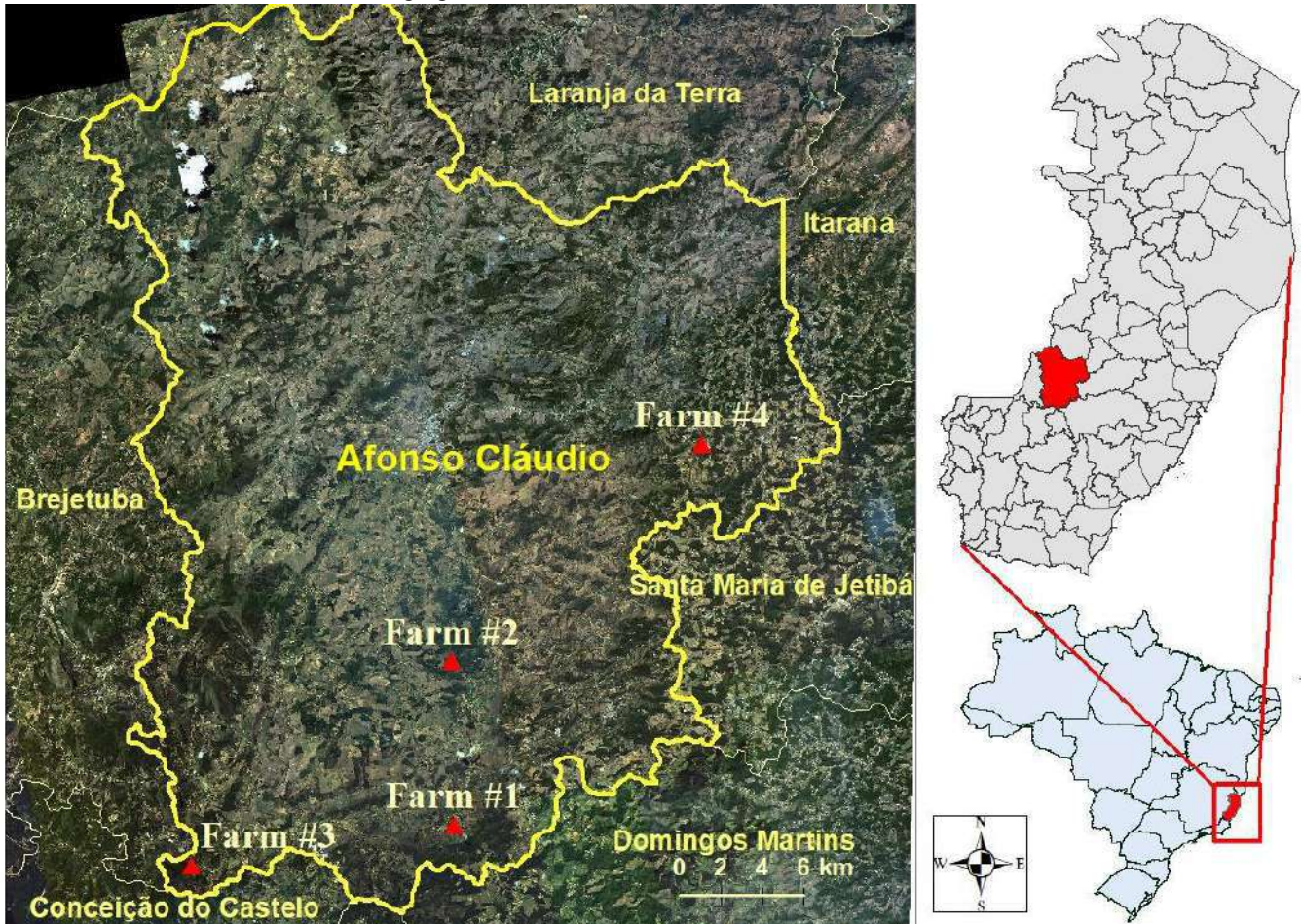
Fig.1 - Map of farm locations according to altitude and community, municipality of Afonso Cláudio, State of Espírito Santo, Brazil. Source: Elaborated by Cecília U. Zandonadi (2022).

3.1 Farm #1

The score 47 was assigned to farm #1 related to the economic axis (figure 2), and the maximum scores (100) were found in the standards productivity, irrigation, and soil conservation efficiency. For integrated pest and disease management, and soil analysis, scores were 75. Marketing, harvest, post-harvest, and coffee bean storage as well as cost and income management, score 50 was assigned. Traceability, coffee quality, and foliar analysis were assigned with 0 (zero) (figure 3A).

The average score obtained by farm #1 in the environmental axis (figure 2) was 56. Maximum scores were obtained in the standards of solid and liquid waste

management, the presence of sewage systems in all houses, and relevant structures on this farm. There was no practice or authorization for hunting, fishing, or illegal trafficking of wild animals and plants, as well as non-practice of burning without authorization from an official bureau, adoption of practices for the protection of water resource areas, and correct disposal of waste. Regularization of the legal reserve and permanent protection areas, in accordance with the environmental law (CAR), proved to be partially adequate, and a score of 75 was attributed to these standards. Scores 0 (zero) were assigned to the standards acquisition of pesticides, use of PPE, return of empty pesticide packaging bag, storage of pesticides, and licensing of agricultural activities required by law (figure 3B).

This farm showed the best scores in the social axis (figure 2), obtaining maximum scores in the standards access to health, education, and training for operators of machinery/agricultural implements; also, the criterion of employee and partners organization showed be regularized, as well as the term of commitment to change service or temporary service were in accordance with Brazilian current labor law. Child labor, forced labor, work in hazardous conditions were not found on this farm. The freedom of employees and partners organization have been respected, and employee payment was compatible with the law. These standards had received maximum scores. On the other hand, the standards training of pesticide applicator, training for weed cutting machine, coffee bean picker, and chainsaw operator, the scores assigned were 0 (zero) (figure 3C).
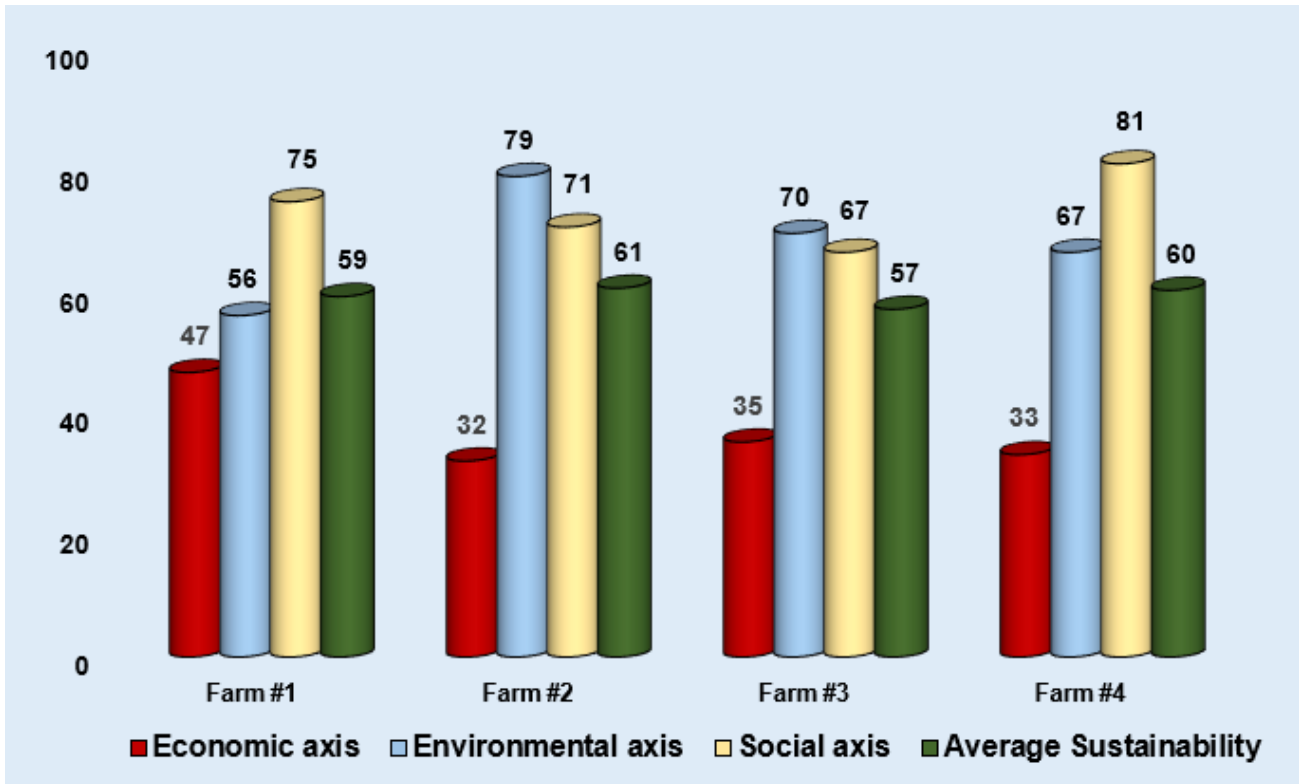
Fig.2 – Scores attributed to the general sustainability standards of the four farms sampled, and the average for the economic, environmental, and social axes. Afonso Cláudio, State of Espírito Santo, Brazil. 2021.

3.2 Farm #2

The lowest score offarm #2 was pointed out on the economic axis (32) (figure 2), and it was the lowest score among all farms evaluated. Zero was assigned to the standards irrigation, coffee quality management, foliar analysis, marketing management, and cost and income management. The productivity efficiency, soil conservation, and integrated pest and disease management reached maximum scores. These were the standards that most contributed to the final score of this farm. The score for the soil analysis was 75. In the traceability, harvest, post-harvest, and coffee bean storage the score was 50 (figure 3D).

The environmental axis had the highest score (79) on farm #2 (figure 2). The standards that most contributed positively to this were the documentation for acquisition of pesticides, return of empty packaging, licensing of agricultural activities, legal reserve and areas of permanent protection, management of solid and liquid waste generated by production, practices to protect water source areas, sewage system, non-practice or permission of hunting, fishing or illegal trafficking of wild animals and plants, and non-practice of burning without authorization from the competent bureau, achieved the maximum score. The appropriate waste disposal obtained a score 50. The score 0 (zero) was assigned to the pesticide storage, and use of PPE, due to their total inadequacy to the used criteria (figure 3E).

In the social axis (figure 2) a score of 71 was assigned, reaching the maximum score in the access to health, education, training for machinery and agricultural implements operator, no occurrence of child labor, forced labor and work in risky conditions, freedom of employee and partners organization, and employee payment compatible with the law. Training of pesticide applicator, weed cutting machine, coffee bean picker, and chainsaw

operator, and the term of commitment for exchange of service or temporary service was found as totally inadequate, and the scores assigned were 0 (zero) (figure 3F).

3.3 Farm #3

Farm #3 pointed out the lowest score in the economic axis (35) among the others evaluated (figure 2). Scores 0 (zero) were assigned to the standards quality management, foliar analysis, marketing management, cost and income management, harvest, post-harvest, and coffee bean storage. The irrigation was the only standard that proved to be adequate in this axis, being assigned with the maximum score. Productivity efficiency, soil conservation, and traceability were partially adequate, and the score assigned was 50. Integrated pest and disease management, and soil analysis, a score of 75 was assigned (figure 3G).

The environmental axis (figure 2) was relatively well suited on this farm, reaching a score of 70, the highest score among the axes of farm #3. The negative points found in environmental sustainability were in the standards of pesticide storage, and use of PPE, with a score 0 (zero). In the proper disposal of waste, the score was 50. The standards documentation of the acquisition of pesticides, return of empty pesticide packaging bags, licensing of agricultural activities, legal reserve, and permanent protection areas, management of solid and liquid waste, practices of protection of water source areas, sewage system, non-practice or permission of hunting, fishing or illegal trafficking of wild animals and plants, non-practice of burning without authorization from the competent bureau reached maximum score (figure 3H).

The social axis of this farm reached an average score of 67 (figure 2), and maximum scores were assigned in the following social standards: access to health, and to education, training for the operator of machinery, term of commitment for exchange of service or temporary service, child labor, forced labor, work in hazardous conditions, freedom of employee and partners organization, employee payment compatible with the law. However, scores assigned to the training of pesticide applicator, weed cutting machine, coffee bean picker, and chainsaw operator were 0 (zero) (figure 3I).

3.4 Farm #4

Farm #4 showed the lowest score on the economic axis (33) among the other evaluated farms (figure 2). The maximum score was obtained only in the productivity efficiency followed by the soil analysis standard (75). In decreasing scores, we observed the standards soil conservation, irrigation, integrated pest, and disease management, harvest, post-harvest, coffee bean storage and marketing management (50), cost and income

management (25). Quality management, leaf analysis, and production traceability had the lowest scores (0) (figure 3J).

The environmental axis of this farm #4 received an average score of 67 (figure 2) with the main deficiencies observed being related to waste disposal, pesticide storage, and use of PPE (0) followed by proper disposal of solid and liquid waste (50). The documentation of the acquisition of pesticides and return of empty pesticide packaging bags, licensing of agricultural activities, legal reserve and permanent protection areas, practices to protect water source areas, sewage system, non-practice or permission of illegal hunting, fishing, or animal trafficking, and wild plants, non-practice of burning without authorization from the competent bureau reached maximum scores (figure 3K).

The best evaluation (81) of this farm was found in the social axis (figure 2). The maximum score was observed in the standards access to health, education, training for machinery and agricultural implements operator (tractor), child labor, forced labor, work in hazardous conditions, freedom of employee and partners organization, employee payment are compatible with the law. The standards training for pesticide applicator, weed cutting machine, coffee bean picker, and chainsaw operator were found to be totally non-compliant, and score 0 (zero) was assigned (figure 3L).

IV.   DISCUSSION

Based on the individual evaluation of each farm, a result was generated that allows the identification of the level of its adequacy. Thus, it is possible to apply some actions related to the good agricultural practices in coffee production and post-harvest processes in order to improve the performance of each deficient standard, and so, in the general sustainability of each one of the farms.

4.1 Economic axis

The economic axis provided the lowest scores in all the four farms sampled. Thus, this axis was the one that most needed changes.

The maximum score for the average productivity of arabica coffee was just reached if it was over 30% above the average productivity of the State of Espírito Santo (1,5 ton/ha). The score is gradually reduced as productivity decreases. Three farms obtained the maximum score, and only one of them reached a score of 50. Thus, just one farm needs more severe interventions in order to increase productivity. The use of GAP must be implemented. However, these results do not dispense interventions in the

other farms because they can increase their income through the use of techniques that allow new gains in productivity.

Productivity is directly related to the profit and profitability of the rural enterprise, supporting the production structure. Techniques that increase product quality, as well as the productivity, should be encouraged, implemented, and used in coffee crops (REZENDE et al., 2010). A tool that may increase productivity with no additional costs is the development of arabica coffee cultivars. These cultivars must present greater production, tolerance/resistance to pests and diseases, and adaptation to the climatic conditions of the different coffee growing regions. Using new cultivars, it is still possible to increase the stand of plants/ha, providing significant increases in productivity (KROHLING et al., 2021; EMBRAPA, 2022a).

Another factor worth mentioning is the use of GAP. Satisfactory levels of adequacy to the soil analysis were observed. This practice has been carried out every two years and follows technical recommendations made by a qualified professional. Soil recovery and conservation practices should deserve more attention with appropriated technologies being used. The maintenance of vegetation covering the soil and/or the use of leguminous plants or grasses to protect the soil should be more used in the farm, as well as the increasing use of periodic mowing with the sporadic use of herbicides to manage natural vegetation. Because this is a sloped and highland region, the

technologies recommended should be adapted or developed specifically to this situation (ALIXANDRE et al., 2020). Thus, direct benefits will be obtained for the farm costs, such as savings fertilizer use, increased productivity, and longevity of production of coffee crops (ROCHA et al., 2000; MARTINUZZO et al. 2021), with direct effects on increasing sustainability.

Annual foliar analysis, as well as the technical recommendation for corrections in the appropriate nutrient levels, is another standard that needs to be better worked in order to increase coffee yields. This standard was extremely important to reduce the scores of the farms, as none of them carry out this agricultural practice. Monitoring soil and leaf fertility is another practice that may be used as a routine in the coffee industry. Soil sampling requires criteria to better show its characteristics, avoiding incorrect fertilization and liming. Leaf analysis is important in complementing soil analysis, identifying the need for adjustments and dosage in macro and micronutrients (REZENDE, 2022).

Several management strategies can still be adopted to increase the sustainability of the standard production, such as the use of renewable natural resources, recycling oforganic waste, organic fertilization, use of natural pesticides, biological and mechanical control of pests and weeds, crop diversification, intercropping and crop rotation. Thestrategiescan still beapplied together, in
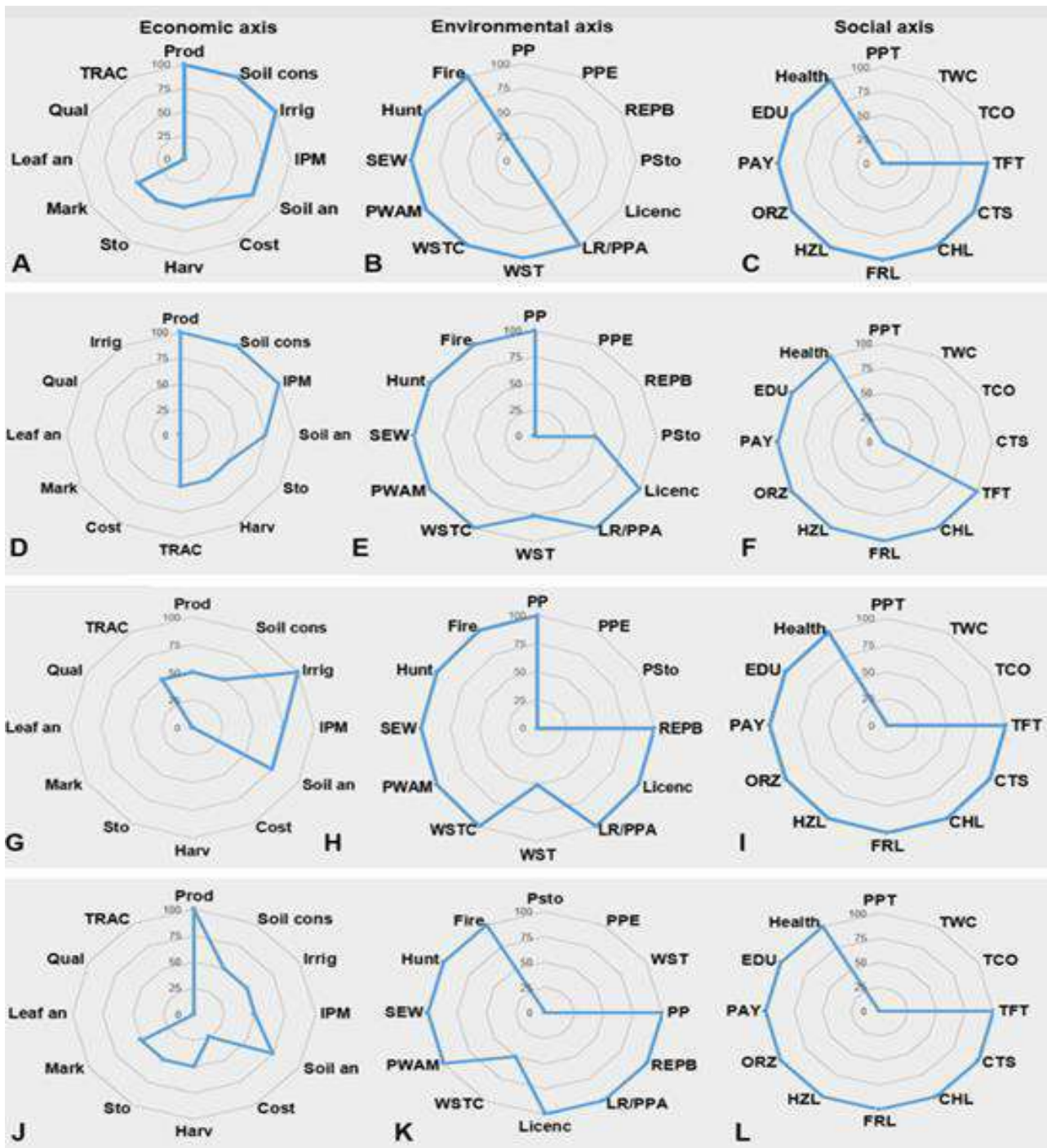
Fig.3 – Evaluation of the standards of the economic, environmental, and social axes of the evaluated farms 1 (A, B, C), 2 (D, E, F), 3 (G, H, I), and 4 (J, K, L). Afonso Cláudio, State of Espírito Santo, Brazil, 2021. Prod-crop productivity efficiency; Mark-marketing efficiency; Qual-grain quality management; Cost – costs and incomes management; Soil an-Good Agricultural Practices (GAP) of soil analysis; Leaf an.-GAP leaf analysis; Soil cons-GAP soil conservation; IPM-GAP integrated pest and disease management; Irrig-GAP irrigation; Harv-GAP harvest and post-harvest; TRAC-production traceability; Sto-coffee beans storage; PP-purchase of pesticides; PPE-use of personal protective equipment; REPB-return of empty pesticide packaging bag; PSto-pesticide storage; PWAM-protection of water source áreas management; WST-correct disposal of waste; Licenc-licensing of agricultural activities as required by the law; WSTC-management of solid and liquid waste from coffee production; LR/PPA-regularization of the legal reserve and permanent protection areas; SEW-sewer system in all relevant houses and structures on the farm; Hunt-prohibition of hunting, fishing or trafficking of wild animals and plants; Fire-no use of burning without authorization from the competent bureau; PPT-pesticide applicator

training; TWC-training for weed cutting machine and coffee bean picker operator; TCO-training for chainsaw operator; TFT - training for agricultural implements and machine operator (farm tractor); CTS - employees and partners have contract, term of commitment for exchange of service or temporary service in accordance with current labor law; CHL - no child labor; FRL-no forced labor; HZL-no labor in hazardous conditions; ORZ- freedom of organization of employees and partners; PAY-employees payment are suitable for the market; EDU-access to education system; Health-access to health system.

order to form an adequate and viable production system for each farm and more suited to the cultural values of each coffee grower (DE MUNER et al., 2019; VERDIN FILHO, et al 2019; TRISTÃO et al., 2019; ALIXANDRE et. al., 2020).

The IPM is another standard that needs to be better adapted to coffee growers with the use of the systematic monitoring of the pest population. Furthermore, biological control can be stimulated, aiming at reducing and/or replacing the use of chemical pesticides. It should be noted that the GAP recommends that only pesticides registered in Brazil for coffee cultivation should be used, respecting the time limit for use from application to berry harvest. The coffee IPM contributes to the maintenance of high yields and fruit quality, reducing the cost of production and the potential of negative impacts of chemicals (FORNAZIER et al., 2017; GUERRA et al. 2021).

Pests and diseases can cause significant damage to arabica coffee crops if not properly managed. Several diseases and pests occur associated with coffee in the State of Espírito Santo. The rust and the coffee berry borer are the two main limitations to productivity and must be properly managed due to the big damage caused directly and indirectly to coffee productivity and quality. Biological control should be encouraged, but the use of chemicals is also an important tool for reducing pest infestation, particularly when observing and using the concepts of ecological and physiological selectivity to natural enemies, and the management of pest resistance to pesticides (FORNAZIER et al, 2017; MESQUITA, 2016; ALIXANDRE et al. 2020).

Irrigation, when necessary, requires a project and a management plan to achieve maximum efficiency with water savings. This standard needs to be better worked on in two sampled farms. The adoption of irrigation significantly increases the productivity of coffee plantations, and this practice has been increasingly widespread. In addition, irrigation it makes possible to produce Arabica coffee in areas not suitable for this coffee species due to water restriction (GUERRA et al. 2021). On the other hand, it is worth noting that the farms sampled were located in a region with satisfactory rainfall, with no need to use the irrigation technique.

The farm must have at least 50% of its production of special Arabica coffee to obtain the maximum score in the quality management standard. All the sampled farms received a score 0 (zero). However, this was already an

expected result due to poor coffee quality being the main standard for selecting the farms to participate in the government project to adjust coffee beverage quality indices. Specialty coffees are beans free of impurities and defects and that have differentiated sensory attributes, such as a clean and sweet drink, balanced body, and acidity, which add value to the drink. In addition to intrinsic quality, specialty coffees must have proven traceability, environmental respect, economic and social sustainability criteria at all stages of production, Thus, they enable the aggregation of value in the commercialization and conquest of new and differentiated consumer markets (BSCA, 2022).

Management of costs and income of farm activities was the main challenge for coffee growers in the four sampled farms. Some factors directly interfered in the final result, such as the low control of production costs, farm costs and incomes. This deficiency may be explained by the low level of regular education and by the deficient qualification/training of coffee growers in administrative and management of farm activities. Making notes of the basic items that make up the cost of coffee production, such as noting the dates and services performed, the inputs purchased and places where they were applied, may improve the organization and management of the farms (DINIZ et al., 2016).

All farms showed low performance in the harvest and post-harvest processes due to the traditional practices used, which do not allow obtaining superior quality coffees. In order to obtain the maximum grade, it is essential that the farm adopt the ten essential commandments for the production, preparation, coffee bean storage, and commercialization of specialty coffees (INCAPER, 2013). Several adjustments are necessary for these harvest and post-harvest processes, such as the coffee berry need to be harvested when ripe and quickly transported to the post-harvest processing site (ALIXANDRE et al 2020; EMBRAPA, 2022b).

Another major challenge for the coffee growers was in managing the marketing of coffee beans. The scores obtained regarding the coffee beverage qualities of the four farms sampled were very low and associated with the Rio beverage - type 7. This level of quality does not allow the valuation of the coffee beans and does not allow value aggregation as a result, value-added to coffee beans does not occur and farm incomes remain low. Marketing management helps the farmers to plan their sales, may control the farm expenses, may reduce the production cost, and is a protection from market price fluctuations. Furthermore, the use of appropriate marketing tools makes it possible to increase the average value of coffee sales increasing farm incomes (DINIZ et al., 2016). Specific formal courses for the use of these tools should be carried out for these coffee growers in order to improve marketing management. Also, courses that allow them to previously know the quality of the different coffees produced on the farm must be given.

For production traceability, it is essential that the farmers have the map/sketch of the farms with identification of the individualized coffee plots, as well as the records of the different batches of coffee beans produced (ALIXANDRE et al., 2020). This is a process that allows traceability from the yield to the coffee bean storage within the farm. All farms did not achieve satisfactory scores in this standard because the traceability process is not yet implemented.

None of the four sampled farms met all the necessary criteria for the proper coffee bean storage, and this affected the final scores. In order to adjust them, it is necessary homogeneous coffee batches according to the coffee beverage and type, the coffee bean bags must be placed on wooden pallets, and away from the wall. The coffee bean storage must be very clean, free of pests, airy, closed, and must have controlled lighting. Jute bags or plastic eco-bags should be used. The grains can be stored in the form of coconut or parchment, and the internal humidity of the coffee beans must be kept around 11 - 12% (DINIZ et al., 2016; ALIXANDRE et al 2020).

4.2 Environmental axis

The farms sampled showed variations in the final scores, ranging from 56 to 79 in the environmental axis. However, the same deficiencies were repeated in several of the standards used. These standards were related to the pesticide's storehouse, acquisition and return of empty pesticide packaging bags, use of PPE, and proper disposal of the farm's waste.

Pesticide acquisition standard showed that coffee growers do not always purchase these chemicals with the

prescriptions required by the Brazilian law, and under technical support; this was the cause of all sampled farms receiving the score 0 (zero). Article 84 of Law 7,802 (literature) obliges the pesticide user to follow this standardization described as a standard, as well as coffee growers must follow the technical specifications of the chemical for coffee cultivation (ALENCAR, 2010).

Another standard that had not been observed in the sampled farms was the storage of pesticides according to specific Brazilian law. One of the farms had partial adequacy. The specifications for this standard are based on the NR 31 of the Brazilian Association of Technical Standards - ABNT (literature): the storehouse construction must be located in a place distant at least 30 m from homes and water sources, must have an impermeable floor, a pesticide leakage containment system, a ventilation system, natural lighting, cannot allow access to animals, and must be signed with danger symbols. Pesticides cannot be kept together with human and animal feed, seeds, or medicament, and must be stored by type (e.g., fungicides, herbicides, insecticides) (COSTA, 2019).

Evidence of the return of empty pesticide packaging bags was also not a reason for attention on the farms, and this was the reason why the average score of this standard on the environmental axis be reduced. Empty pesticide packaging bags must be sent to specific collection points, together with their respective purchase receipts, within a period of up to one year after purchase. Before, however, they must receive the triple washing, and be perforated to make their reuse unfeasible. Furthermore, the proof of this process must remain kept by the farmers. The use of empty pesticides packaging bags is expressly prohibited for any purpose (DINIZ, 2016).

The use of PPE was one of the standards with the lowest score due to the non-use of complete equipment. The use of this PPE is individual, and each farm must have at least one complete PPE for each pesticide applicator. PPE aims to protect workers' health and reduce the risk of intoxication resulting from exposure to pesticides. Brazilian labor legislation (literature citation) determines the mandatory use of this PPE, as well as its correct conservation (DINIZ et al.,2016; COSTA, 2019). The challenge in this standard is to encourage applicators to participate in training courses for the correct use of PPE, keep their PPE in good condition, and replace any damaged part.

Three of the four farms reached maximum scores in the management of solid and liquid waste generated on the farm. This standard establishes that waste collection must be selective and recyclable materials must be separated from those that are not recyclable (DINIZ, 2016;

MARTINUZZO et al., 2021). The main challenge found was related to the public structure of waste collection in rural areas of the municipality, with a great irregularity in service in regions within the municipalities. Thus, the farms have difficulties in guaranteeing the correct destination of the waste. However, it was found that farmers were aware of this need and, to solve that situation, they periodically took solid waste for previously defined collection points in the urban area of the municipality. There is the possibility of adapting the destination of some residues within the farms such as food remains, water from the post-harvesting process, as well as the coffee husk. So, organic waste has been transformed into fertilizer, through a composting process, and reused on the farms. The proper disposal of waste consists of minimizing its impacts on the environment and for the people. Agricultural activities are subject to licensing, as regulated by Law 6,938/1981 and Complementary Law 140/2011. The domestic sewage system must receive adequate disposal, using septic tanks, biodigesters, or other appropriate treatment ((DINIZ, 2016; IDAF, 2022).

All the farms sampled were regularized for the standard legal reserve and permanent preservation area in accordance with the environmental law, through Rural Environmental Registry (CAR). Furthermore, all of them were visually evaluated, and supported by adequate documentation; thus, they received the maximum score. This demonstrated the environmental awareness of the farmers regarding the preservation of the native flora of the Atlantic Forest biome in which the farms are inserted. According to Law No. 12,651, of May 25, 2012, the farm must present the regularization of the legal reserve and permanent protection areas in accordance with CAR, electronic registration of national scope with the competent environmental agency. Registration is mandatory for all farms, in order to integrate environmental information from farm, with monitoring, environmental and economic planning, and combating deforestation (IDAF, 2022). Permanent Preservation Areas (APP) are areas protected by Law 12,651/2012, whether or not covered by native vegetation; they have the environmental function of preserving water resources, landscape, geological stability, biodiversity, the gene flow of fauna and flora, protecting the soil and ensure the well-being of human populations. The suppression of vegetation in these APP can only be authorized in cases of public utility or social interest (SNIF, 2019).

The standard water source areas protection also received the highest score in all sampled farms because the non-presence of water source areas was found in any of them. Adoption of preservation and recovery practices, such as soil protection, vegetation enrichment, fencing of the water

source areas with soil and water contamination control, and the restriction of access to protection this area is necessary to be adopted if there are any water source areas on the farm. (CARVALHO, 2004).

Espírito Santo State Law No. 6,613, of February 6, 2001, and Law No. 5,197, of January 3, 1967, determine the prohibition of hunting, fishing, or illegal trafficking of wild animals and plants in addition to illegal fire, restricting the use of burned without authorization from a competent bureau (IDAF, 2022). All farms achieved maximum scores because none of them use these practices such as illegal activities, and demonstrated a very high degree of awareness regarding the preservation of native fauna.

4.3 Social axis

The social axis presented the highest score in all farms, ranging from 67 to 81 points. The main standard that contributed to this highest score was the adjustments found in relation to the current labor law. Employees and partners were regularized under labor law, child labor or forced labor was not found, and no labor was found in hazardous conditions. Three of the four coffee growers reached 100 points, since they are the owners, work with their own family, and do not use external labor, a characteristic that raised the scores in this standard. Just one of them did not show the required documentation of the partnership agreement, partially reducing the grade. Employees' freedom of organization was respected, and their payments were compatible with the labor market. Access to education and health services also received maximum scores because these two standards were fully regularized in all sampled farms.

The employer, whether an individual or a legal company, must legally hire its employees through a contract and a work record booklet for permanent and temporary employees, in accordance with Laws nº 5.889/1973, 9.300/1996. The farmer must give equal treatment to any worker, including family members, regardless of race, sex, religion, and political affiliation, whether at the time of hiring, during the period of service provision, or on dismissal (DINIZ et al., 2016).

Access to public education is offered by the municipality government, and schools and transport are available for different age groups of the rural population. Access to health is provided by the Brazilian Unified Health System (SUS, 2022), and family care is carried out by public health agents in specific programs.

In the training standards (application of pesticides, cutting machine, coffee bean picker, and chainsawoperator), the farms did not show satisfactory scores because it is necessary to prove the training through

the presentation of certificates, which is not the reality of these farms. Therefore, most farmers use this equipment without the necessary training, based on their own experience and need just within their farms. The National Rural Apprenticeship Service (SENAR, 2022) has continuously offered courses for the education and training of workers in rural areas. Among these training is the application of pesticides, in which it is possible to learn about all the technology for the safe use of these chemical or biological products. In addition, it is possible to understand the importance of using PPE in pesticide manipulation, as well as the need for the professionalization of this activity. The certificate of the course operators of agricultural machinery is required to comply with the standard if there is an agricultural tractor on the farm; if not, the maximum score is assigned. For these cases, it has been recommended that training be carried out (SENAR, 2022).

The real need for intervention in the four farms sampled, in order to increase the level of their sustainability, was pointed out from the evaluation of the three axes. Mainly the standards related to the economic axis were the ones that most affect the final grade of adequacy in sustainability in the four farms sampled, followed by the standards of the environmental and social axis, which also showed a lack, although in smaller proportions. In order to understand the sustainability process of the farms, it is necessary to interrelate the component aspects of the three axes evaluated in a dynamic and holistic way. It is necessary clearly comprehend that sustainability is a dynamic process, in constant change and that it can undergo changes that interfere with the relative degree of farm sustainability. Thus, it is necessary to outline clear goals, choose the path and strategies to achieve them, as well as adjust the time to reach these goals, respecting the elements that make up the culture and the desire of the farmers involved in the process. This comprehension is mainly for the maintenance and development of sustainability levels on farms (ASTIERet al. 2008).

V.   CONCLUSIONS

- The proposed methodology proved to be efficient for diagnosing the levels of economic, environmental, and social adequacy of farms;
- The main intervention needs to improve sustainability levels of the four farms were related to the economic standards, followed by the environment and social;
- In general, the main needs were related to the quality management of coffee beans, production costs and incomes, improvement in the harvest and post-harvest

processes, training in manual machines, and the correct use and application of pesticides;

- There is a need for individualized interventions in the farms; however, the ownerfamily's values and their limitations, particularly the cultural, must be respected;
- Different intervention techniques must be used on each farm in order to reach the maximum levels of adequacy, according to sustainability standards criteria. However, the results of farm adjustments must be achieved in different ways and at different times;
- Finally, interventions that need to be improved may enable to increase the production of specialty coffees on the studied farms and adjust them to the requirements of several international coffee certifiers. Thus, these farms will be able to export specialty coffees to new international markets, add value to coffee beans, increase incomes on the farms, and develop the level of the economic sustainability axis,as well as the quality of life for these householder's families.

REFERENCES

[1] Alencar, J.A. (2010). Normas gerais sobre o uso de agrotóxicos. Embrapa Semiárido: Sistemas de Produção: Cultivo da Videira [s. l.], v. 1, ed. 2.

[2] Alixandre, F.T.; De Muner, L.H.; Krohling, C.A.; Ferrão, M.A.G.; Fornazier, M.J. (2020). Cafeicultura sustentável: boas práticas agrícolas para o café arábica. Vitória- ES. 48 p. (Incaper. Documentos, 270).

[3] Astier, M.; Masera, O.; Galván-Myioshi, Y. (Eds.) (2008). Evaluación de sustentabilidade: Un enfoque dinâmico y multidimensional. Spain. 200p.

[4] BSCA (BrazilSpecialtyCoffeeAssociation). (2022). Cafés especiais do Brasil. Availableat: <https://brazilcoffeenation.com.br/a-bsca>.

[5] Carvalho, S.L. (2004). Medidas que preservam nascentes e mananciais. UNESP, Departamento de Fitossanidade, Engenharia Rural e Solos. Jornal Sem Limites, Castilho/SP.Available at: <https://www.trabalhosfeitos.com/ensaios/Medidas-Que-Preservam-Nascentes-e-Mananciais/69116356.html >.

[6] CONAB (Companhia Nacional de Abastecimento). (2020). Observatório Agrícola. V. 6. Safra Café, 2020. Primeiro Levantamento. Jan. 2020. Availableat: <https://www.conab.gov.br/info-agro/safras/cafe>.

[7] Costa, G.M. (2019). Guia prático de tecnologia de aplicação de herbicida e segurança no trabalho na cultura do café. Alvo Consultoria, 33p.

[8] De Muner, L.H.; Caporal, F.R.; Fornazier, M.J.; Ronca, P.P.F.; Brando, J.A.; Padovan, M.P. (2019). Sustainable conilon coffee cultivation. Conilon Coffee, - Vitória, ES: Incaper. V.3, p.778-821.

[9] Deponti, C.M. (2001). Indicadores para avaliação da sustentabilidade em contextos de desenvolvimento rural local. Monografia (Especialista em Desenvolvimento Rural e Agroecologia) – Universidade Federal do Rio Grande do Sul, Porto Alegre.165 p.

[10] Dias, R.S.; Alixandre, F.T.; Fornazier, M.J.; Krohling, C.A.; Guarçoni, R.C.; De Muner, L.H. (2021). Indicação Geográfica: Café Montanhas do Espírito Santo. Incaper em Revista, Vitória, v. 11 e 12, p. 06-24, jan. 2020/dez. DOI: 10.54682/ier.v11e12-p06-24.

[11] Diniz, C.V.C.; Souza, C.; Candiano, C.A.C.; Sampaio, E.; Trevisan, E.; Ochoa J., M.; Monéa, N. Costa, O.M.; Ronca, P.P.F.; Padilha Neto, S.M. (2016). Guia de Implementação do Currículo de Sustentabilidade do Café (CSC). Programa Café Sustentável, Plataforma Global do Café. Availableat: https://archive.globalcoffeeplatform.org/assets/files/Resources/Guia-de-Implementa%C3%A7%C3%A3o-do-CSC_rev_mar.2017.pdf.

[12] Dumer, M.C.R.; Vieira, A.; Schwanz, K.C.A. (2012). Contabilidade de custos na visão dos produtores de café de Afonso Claudio-ES: análise da percepção de importância-desempenho pela matriz de Slack. XIX Congresso Brasileiro de Custos, Bento Gonçalves, RS. Availableat: <https://anaiscbc.emnuvens.com.br/anais/article/view/197/197>.

[13] EMBRAPA (Empresa Brasileira de Pesquisa Agropecuária). (2022a). Soluções tecnológicas. Availableat: <https://www.embrapa.br/busca-de-noticias/-/noticia/53805667/sustentabilidade-dos-cafes-do-brasil-tem-inicio-com-a-escolha-correta-de-cultivares-produtivas-com-resistencia-a-doencas>.

[14] EMBRAPA (Empresa Brasileira de Pesquisa Agropecuária). (2022b). Colheita e pós-colheita: etapas importantes para garantir qualidade e agregação de valor aos Cafés do Brasil. Available at: <https://www.embrapa.br/busca-de-noticias/-/noticia/52862730/colheita-e-pos-colheita-etapas-importantes-para-garantir-qualidade-e-agregacao-de-valor-aos-cafes-do-brasil>.

[15] Fornazier, M.J.; Martins, D.S.; Fanton, C.J.; Benassi, V.L.R.M. (2017). Manejo de pragasdo café conilon. In: Ferrão, R.G.; Fonseca, A.F.A.; Ferrão, M.A.; De Muner, L.H. (Eds.). Café Conilon - 2ª edição:atualizada e ampliada. 2ed.Vitória, ES. p. 399-433.

[16] Greenberg, R. Criteria working group thought paper. (1996). In: Sustainable Coffee Congress, 1., Washington, DC. Proceedings... Washington, DC: Smithsoniam Migratory Bird Center, 1997. p. 403-411.

[17] Guerra, A.F.; Santos, J.F.; Ferreira, L.T.; Rocha, O.C. (2021). Cafés do Brasil: Pesquisa, sustentabilidade e inovação. Tecnologias Poupa-Terra. EMBRAPA, Brasília. Cap.5, p. 63-75.

[18] IBGE (Instituto Brasileiro de Geografia e Estatística). (2017). Censo Agropecuário 2017. Availableat: <https://www.ibge.gov.br/estatisticas/economicas/agricultura-e-pecuaria/21814-2017-censo-agropecuario.html?=&t=o-que-e>.

[19] IDAF (Instituto de Defesa Agropecuária e Florestal do Espírito Santo). (2022). Legislação. Available at: <https://idaf.es.gov.br/legislacao-idaf>.

[20] INCAPER (Instituto Capixaba de Pesquisa, Assistência Técnica e Extensão Rural). (2013). Arábica: produza seu café com excelência de qualidade. Documento nº 217, Incaper, ISSN: 1519-2059, Vitória- ES.

[21] Krohling, C. A.; Alixandre, F. T.; Guarçoni, R. C.; Fornazier, M. J. (2021). Café arábica no Espírito Santo, Brasil. Café Conilon: Conilon e Robusta no Brasil e no mundo, Alegre - ES, p.87-102.

[22] Martinuzzo, M.B; Alixandre, F.T.; Krohling, C.A.; Verdin Filho, A.C.; Sousa, D.G.; Fornazier, M.J.; Guarçoni, R.C.; De Muner, L.H. (2021). Sistema para avaliação de indicadores de sustentabilidade da cafeicultura do Espírito Santo. Vitória, ES: Incaper. 14 p. – (Incaper, Documentos, 283).

[23] Mesquita, C. M.; et al. (2016). Manual do café: distúrbios fisiológicos, pragas e doenças do cafeeiro (*Coffeaarabica* L.). Belo Horizonte: Emater. 62 p.

[24] Rezende, F.C., Arantes, K.R., Oliveira, S.R., Faria, M.A. (2010). Cafeeiro recepado e irrigado em diferentes épocas: Produtividade e qualidade. Coffee Science, Lavras, v. 5, n. 3, p. 229-237.

[25] Rezende, J.E. (2022). Série Tecnológica Cafeicultura: Amostragem de solos. EMATER, Minas Gerais, p. 1-6.

[26] Rocha, A.C.; Prezotti, L.C.; Dadalto, G.G. (2000). Práticas de conservação de solo em café arábica na região serrana do Espírito Santo. Simpósio de Pesquisa dos Cafés do Brasil - EMBRAPA, Poços de Caldas - MG, v. 1, p. 1376-1378.

[27] Rosset, J.S.; Coelho, G.F.; Greco, M.; Strey, L.; Gonçalves Junior, A.C.(2014). Agricultura convencional versus sistemas agroecológicos: modelos, impactos, avaliação da qualidade e perspectivas. Scientia Agraria Paranaensis, 13:80–94. DOI: 10.18188/sap.v13i2.7351. Availableat: <https://saber.unioeste.br/index.php/scientiaagraria/article/view/7351>.

[28] SEAG (Secretaria de Estado da Agricultura – Espírito Santo). (2021). PEDEAG 3 – 2015/2030. Available at: https://seag.es.gov.br/Media/Seag/Documentos/PEDEAG_Completo_sem%20ficha%20t%C3%A9cnica%20(1)-1.pdf.

[29] SENAR (Serviço Nacional de Aprendizagem Rural). (2022). Catálogo de Cursos. Availableat: <https://ead.senar.org.br/cursos>.

[30] SNIF (Sistema Nacional de Informações Florestais). Áreas de Preservação Permanente. Serviço Florestal Brasileiro. (2019). Available at: <https://snif.florestal.gov.br/pt-br/conservacao-das-florestass/183-areas-de-preservacaopermanente#:~:text=%C3%81reas%20de%20Pr eserva%C3%A7%C3%A3o%20Permanente%20(APP,e%20 flora%2C%20proteger%20o%20solo>.

[31] Souza, M.A.; Simão, J.B.P.; Silva, M.V.; Zanuncio Jr., J.S. (2021). Denominação de origem Caparaó para café arábica. Incaper em Revista, Vitória, v. 11 e 12, p. 49-60, jan. 2020/dez. DOI: 10.54682/ier. v11e12-p49-60

[32] Sulzbacher, A.W.; David, C. (2009). Agroindústria familiar rural: uma estratégia para melhorar a qualidade de vida no espaço rural. Geosul, Florianópolis, v. 24, n. 47, p. 69-90, jan/jun. DOI 10.5007/2177-5230.2009v24n47p69.

[33] SUS (Sistema Único de Saúde). Estratégia saúde da família. Availableat: <https://aps.saude.gov.br/ape/esf/>.

[34] Tristão, F. A.; Krohling, C. A.; De Muner. L. H.; Souza, M. F.; Fornazier, M. J. (2019). Trends for sustainability of arabica coffee in highland regions. Incaper em Revista, 10:105-124. Available at: <https://www.researchgate.net/publication/338802522_Tren ds_for_sustainability_of_arabica_coffee_in_highland_regio ns_Tendencias_para_a_sustentabilidade_da_cafeicultura_de _arabica_em_regioes_de_montanha>.

[35] Verdin Filho, A.C.;Comério, M.;Pilon, A.M.; Rodrigues, W.M;Colodetti, T.V.; Fornazier, M.J.; Pereira, L.L.; Moreli, A.P.(2019). Trends for sustainability of Conilon coffee crops. Incaper emRevista, 10:125-141. Available at: <https://www.researchgate.net/publication/338802114_Tren ds_for_sustainability_of_Conilon_coffee_crops_Tendencias _para_a_sustentabilidade_da_cafeicultura_de_Conilon>.

Mild peri-intraventricular hemorrhage (PIVH): factors associated with neurodevelopment and the parents' perception

Luara Fernandes Argenton Duarte[1], Gloria M. A. S. Tedrus[2,*]

[1]Master's in Health Sciences. Physiotherapist, Pontifical Catholic University of Campinas. Campinas, SP, Brazil.
[2]Professor - Health Sciences Program, Pontifical Catholic University of Campinas. Campinas, SP, Brazil.

Abstract— Objective:To evaluate the relationship between clinical aspects and neurodevelopment in premature children with mild PIVH aged 6 to 24 months. The data were compared with that of children without PIVH. The parents' perception and adherence to the physiotherapy treatment was evaluated.

Methods: Clinical aspects were related to data in the Denver II Test of premature children with mild PIVH and without PIVH, with statistical tests and p <0.05. The parents' perception of developmental delay and adherence to physiotherapy treatment were related to clinical aspects.

Results:We evaluated 34 children with mild PIVH and 36 children without PIVH, with a gestational age of 29 weeks. Risk of developmental delay was observed in 27 (79.4%) children with PIVH and in 10 (27.7%) children without PIVH. The risk factors associated with the occurrence of developmental delay, measured by the Denver II Test, were the presence of PIVH and the use of mechanical ventilation. In the regression test, it was observed that 12 (32.4%) parents noticed a developmental delay in the gross motor sector and was associated with the type of delivery, birth weight, gestational age, the presence of PIVH, the use of mechanical ventilation for> 7 days, and physiotherapy.

Conclusion: Premature children with mild PIVH had a worse neuropsychomotor outcome when compared to children without PIVH. Developmental delay was associated with the presence of PIVH and the use of mechanical ventilation. The parents' perception of neuropsychomotor delay was low and was associated to the low adherence to treatment.

I. INTRODUCTION

The prognosis of neuropsychomotor development in premature children with peri-intraventricular hemorrhage (PIVH) depends on a complex interaction between biological and environmental factors acting on the immature brain of these children. Some studies highlight several risk factors; however, the results are not yet unanimous and there is no single factor that can predict child development, despite the advances in perinatal and neonatal medicine.[1-8]

PIVH often occurs in the first 24 hours or the first days of life and is classified as mild or severe[9-12]. There are still controversies about the relationship between the degree of PIVH and vulnerability to deficiencies in neuropsychomotor development. There is a growing

number of studies that associate mild PIVH with neurodevelopmental impairment.[3-5]

On the other hand, it is known that rapid and effective early intervention in children with delayed neurodevelopment is of fundamental importance for the prognosis. The family's participation is decisive for the success of the therapeutic processes, however, there are still gaps in the knowledge of the parents' perception regarding the prognosis and adherence to the proposed treatment.

Thus, the objective of this study is to evaluate the relationship between clinical aspects with neurodevelopment data in premature children with mild PIVH, aged 6 to 24 months. Data from children with and without PIVH were compared. The perception of parents and/or guardians about developmental delay and adherence to physiotherapy treatment were related to obstetric, perinatal, and neonatal data.

II. METHODS

This is a cross-sectional, prospective, and observational study carried out at the outpatient clinic for the monitoring of high-risk newborns at the PUC-Campinas University Hospital, during the routine consultation at the pediatric services and the multidisciplinary team, in the period between August 2018 and July 2019.

Seventy children from 6 to 24 months of corrected age who were born prematurely at the PUC-Campinas University Hospital and who underwent the transfontanellar ultrasound examination before hospital discharge participated in this study.

Children with congenital malformations and genetic syndromes were excluded.

The Human Research Ethics Committee of the *Pontifícia Universidade Católica de Campinas*(PUC-Campinas,Pontifical Catholic University of Campinas) under protocol #73249517300005481, approved the study. Parents or guardians who agreed to participate in the research signed the informed consent form.

Procedures

Parents and/or legal guardians were evaluatedin the following aspects:

Clinical data: Maternal age and educational level, as well as obstetric, perinatal, and neonatal data were obtained from the hospital's medical records.

Questionnaire to evaluate the perception of parents and/or guardians.The following question was applied: "Is your child's development normal or what problem did you observe?" - whichis part of the Parents' evaluation of developmental status questionnaire.

The children were submitted to a clinical evaluation and the Denver II Test.

Denver Developmental Screening (Denver II Test) 13: a screening test, which evaluates areas of neurodevelopment, being a standardized test, of rapid application, and widely used in Brazil.

Statistical analysis

Data were analyzed using the IBM SPSS Statistics software, version 22. The significance level adopted for the statistical tests was p <0.05.

We described categorical variables using absolute values and percentages, and continuous variables as means and standard deviations.

Univariate and multivariate logistic regression were performed to determine which factors are associated with PIVH, and demographic aspects (the child's sex, and the mother's educational level and age) and obstetric, perinatal, and neonatal data (type of delivery, an Apgar test in the first and fifth minutes of life, birth weight and gestational age).

Perinatal data (pulmonary bronchodysplasia, hyaline membrane disease, persistence of the ductus arteriosus, jaundice and anemia, the need for mechanical ventilation [> 7 days and non-invasive], and the occurrence of transient tachypnea) were evaluated, which are associated with PIVH in univariate and multivariate logistic regression.

Obstetric, perinatal, and neonatal data associated with the risk of developmental delay in the Denver II Test and parents' perception in univariate and multivariate logistic regression were evaluated.

III. RESULTS

A total of 34 children with mild PIVH (PIVH grade I, n = 20; PIVH grade II, n = 14), 17 (50%) of which were girls, and 36 children without PIVH, 17 (50%) of which were girls, all of them with a gestational age of 29 weeks, were evaluated. The birth weight of the 70 children was less than 1500 grams. At the time of the evaluation, the age group was 6 to 24 months old. There was no statistically significant difference in sex, age, and birth weight between children with mild PIVH and without PIVH.

It was observed that the prenatal and perinatal risk factors associated with PIVH were vaginal delivery (3.84; 95% CI; 1.19 - 12.38, p = 0.024), gestational age (0.637; 95% CI; 0.509 - 0.797, p <0.001) and birth weight (0.755; 95% CI OR; 0.648 - 0.878, p <0.001) in univariate and

multivariate logistic regression. The other aspects had no statistical significance and were excluded from the equation.

Postpartum factors associated with PIVH in univariate and multivariate logistic regression were pulmonary bronchodysplasia (OR 1.0 -0.11; 95% CI OR; 0.03 - 0.42; p = 0.011), hyaline membrane disease (OR 1.0 - 6.00; 95% CI OR; 1.52 - 23..74; p <0.001), mechanical ventilation> 7 days (OR 1.0 - 7.14; 95% CI; 2.35 - 21.70; p <0.001), non-invasive mechanical ventilation (OR 1.0 - 3.69; 95% CI OR; 1.16 - 11.80; p = 0.028), and transient tachypnea (OR 1.0 -0.11; 95% CI OR; 0.03 - 0.42; p = 0.001). The other variables were excluded from the equation.

Risk of neurodevelopmental delay

Risk of developmental delay, measured by the Denver II Test,was observed in 27 (79.4%) children with PIVH and in 10 (27.7%) children without PIVH. It was observed that the developmental delay in the gross motor, fine-adaptive motor, and language areas occurs significantly more in children with PIVH when compared to children without PIVH (Table 1).

When evaluating the risk factors associated with the occurrence of developmental delay using the Denver II Test, it was observed that only the presence of PIVH and the use of mechanical ventilation remained in the regression equation (Table 2).

Perception of parents and/or guardians and Adherence to physiotherapy treatment

Among children at risk of developmental delay in only 12 (32.4%) cases, there was a perception of delay by parents and/or guardians. This perception was associated with the delay in the gross motor sector, measured by the Denver II Test.

In the regression test, there was an association between the perception of developmental delay by parents and/or guardians with the type of delivery, birth weight, gestational age, the presence of PIVH, the use of mechanical ventilation for a period longer than 7 days, and physiotherapy follow-up (Table 3).

Among the 12 children (with and without PIVH) at risk of developmental delay in the Denver II Test, four parents and/or guardians did not adhere to the physiotherapy treatment and justified it because they did not have the perception of the delay and/or for other reasons (Table 4).

Table 1. Presence of delayed neuropsychomotor development in the Denver II Test in children with and without PIVH.

	Mild PIVH (n=34)	Without PIVH (n=36)	p-value	OR	95% CI OR
Gross motor	24 (70.5%)	4 (11.1%)	<0.001*	64.39	3.60 – 1150.93
Fine-adaptive motor	12 (35.2%)	3 (8.3%)	0.002*	8.75	2.23 – 34.40
Personal-social	10 (29.4%)	0	0.051	4.33	0.99 – 18.81
Language	23 (67.6%)	9 (25%)	0.010*	8.18	1.64 – 40.86

PIVH: Peri-intraventricular hemorrhage;OR: Odds Ratio. *p<0.05.

Table 2. Factors associated with risk of developmental delay, according to the Denver II Test (n = 70).

Variables	Categories	p-value	OR	95% CIOR
HPIV	No (ref.)	---	1.00	---
	Yes	<0.001*	8.71	2.58 – 29.36
Mechanical ventilation	No (ref.)	---	1.00	---
	Yes	0.003*	8.35	2.08 – 33.48

PIVH: Peri-intraventricular hemorrhage; OR: Odds Ratio;ref: reference. *p<0.05.

Table 3. Factors associated with the perception of risk of developmental delay (n = 70).

Variable	Categories	p-value	OR	95% CIOR
Mother's educational level	Higher education (ref.)	---	1.00	---
	High school	0.452	1.59	0.07 – 37.44
	Complete elementary school	0.288	2.80	0.14 – 57.48
	Incomplete elementary school	0.071	9.53	0.44 – 207.37

Mother's age	Continuous variable (years)	0.851	0.991	0.903 – 1.088
First son	No (ref.)	---	1.00	---
	Yes	0.151	0.36	0.09 – 1.46
Type of delivery	Cesarean section (ref.)	---	1.00	---
	Vaginal	0.042*	3.83	1.05 – 14.03
Apgar - 1st minute	Continuous variable	0.647	0.943	0.735 – 1.210
Apgar - 5th minute	Continuous variable	0.668	0.843	0.387 – 1.837
Birth weight	Continuous variable (100g)	0.021*	0.786	0.642 – 0.964
Gestational age	Continuous variable (Weeks)	0.019*	0.736	0.569 – 0.952
HPIV	No (ref.)	---	1.00	---
	Yes	0.017*	7.08	1.42 – 35.28
Mechanical ventilation	No (ref.)	---	1.00	---
	Yes	0.006*	7.24	1.74 – 30.05
> 7 days	No (ref.)	---	1.00	---
	Yes	0.140	4.95	0.59 – 41.30
Non-Invasive Mechanical Ventilation	No (ref.)	---	1.00	---
	Yes	0.036*	4.11	1.10 – 15.36
Monitoring with Physiotherapy	No (ref.)	---	1.00	---
	Yes	<0.001*	32.84	1.86 – 581.14

PIVH: Peri-intraventricular hemorrhage; OR: Odds Ratio; ref: reference *$p<0.05$.

Table 4. Perception of delay in neurodevelopment and justifications for parents and/orlegal guardians.

Age (months)	PIVH	Physiotherapy	Denver II Test - Sector with Change				Reason
			Personal-social	Fine-adaptive motor	Language	Gross motor	
11	Yes	Yes	No	No	Yes	Yes	Delay in sitting
11	Yes	Yes	No	No	Yes	Yes	Delay in sitting
20	Yes	Yes	No	No	Yes	Yes	Still does not speak
10	Yes	No	Yes	Yes	Yes	Yes	Born premature
13	Yes	No	No	No	Yes	Yes	Still does not speak
13	Yes	No	Yes	Yes	Yes	Yes	Born premature
8	Yes	Yes	No	Yes	Yes	Yes	Does not sit yet
8	Yes	Yes	Yes	Yes	No	Yes	Does not sit
9	Yes	Yes	No	No	Yes	Yes	Does not sit yet
6	Yes	Yes	No	Yes	Yes	Yes	Does not sit
8	Yes	No	No	No	Yes	Yes	Born premature
6	No	Yes	No	No	No	Yes	Born premature
21	No	Yes	No	No	Yes	Yes	Cannot speak

PIVH: Peri-intraventricular hemorrhage.

IV.   DISCUSSION

The results of our study show a high risk of neurodevelopmental delay in children aged 6 to 24 months, who were premature, with PIVH grades I and II, and significantly higher than that observed in children without PIVH. These data suggest that lesions in the germinal matrix caused by PIVH affect the neuronal and glial precursor cells involved in the process of neural migration, causing impairment of myelination and cortical and subcortical development, with worse outcomes and short and long-term neurological sequelae.[11,12]

Our data showed that the gross motor, fine-adaptive motor, and language areas were the ones of greatest risk of developmental delay,according to the Denver II Test, and similar to those found by other authors.[7,8]

The high risk of neurodevelopmental delay observed in children with mild PIVH compared to children without PIVH, aged 6 to 24 months, has been observed in other studies that evaluated children aged 2 to 3 years and at 5 years of age.[4,7,8] In a different way, other studies did not evidence any risks to the neuropsychomotor outcome caused by mild PIVH, when comparing the risks of children without PIVH.[5,12]

Risk factors associated with PIVH and developmental delay

The obstetric, perinatal, and neonatal risk factors for PIVH observed in our study are similar to those described in the literature.[1,9,11,15] However, in a different way, demographic and clinical aspects such as sex, maternal educational level and age, and low Apgar scores were risk factors described by other authors.[10]

The risk factors associated with unsatisfactory neurological development in the Denver II Test were the presence of PIVH and the use of mechanical ventilation. It is known that prolonged assisted ventilation can lead to significant changes in cerebral hemodynamics and to increased intracranial pressure, which are deleterious mechanisms to the developing brain and can lead to motor, cognitive or global damage. These risk factors are similar to those described in other studies. [11,12,16]

Parents' perception: child development

Despite the risk of developmental delay observed in our study, only a third of parents noticed a developmental delay, and the rest stated that their child's development was normal. This finding may be related to the high expectation that parents have about their children or the difficulty and/or reluctance to recognize that children have any changes and/or delays.

The family of children with neurological problems in childhood often faces the crisis of losing a perfect child, often having doubts about the clinical and prognostic profile, and this finding is often associated with cultural factors, social risks, and family prejudices.[17,18]

Adherence to physiotherapy treatment

Of the sample of children with and without PIVH, at risk of developmental delay, approximately half of the cases did not adhere to the indicated physiotherapy treatment. In most cases, parents and/or guardians did not notice adevelopmental delay due to difficulty or underestimating and/or not following the guidelines, which suggests that the parents' perception is fundamental and influences treatment adherence. Similarly, other studies have found that the Denver II test was more capable of detecting the risk of developmental changes than the parents' perception.[19] This data is essential to be considered in public health, as it will interfere in child development in the short and long term, and thus promote health, improve skills, minimize delays, and prevent the functional, cognitive, motor, and behavioral deterioration of children.

V.   CONCLUSION

Premature children with mild PIVH had a worse neuropsychomotor outcome when compared to children without PIVH. Mild PIVH and the use of prolonged mechanical ventilation had a significant impact on the outcome of neurodevelopment in premature children. The parents' perception of neuropsychomotor delay was low and was associated with the low adherence to treatment.

Highlights

• Premature children with mild PIVH had a worse neuropsychomotor outcome when compared to children without PIVH.

• Mild PIVH and the use of prolonged mechanical ventilation had a significant negative impact on the neurodevelopment of premature children.

• The parents' perception of neuropsychomotor delay was low and was associated with the low adherence to treatment.

REFERENCES

[1] Coskun Y, Isik S, Bayram T, Urgun K, Sakarya S, Akman I. A clinical scoring system to predict the development of intraventricular hemorrhage (IVH) in premature infants. *Childs Nerv Syst*. 2018;34(1):129-136. doi: 10.1007/s00381-017-3610-z.

[2] Radic JA, Vincer M, McNeely PD. Outcomes of intraventricular hemorrhage and posthemorrhagic hydrocephalus in a population-based cohort of very preterm infants born to residents of Nova Scotia from 1993 to 2010.

J NeurosurgPediatr. 2015;15(6):580-588. doi: 10.3171/2014.11.

[3] Reubsaet P, Brouwer AJ, van Haastert IC, Brouwer MJ, Koopman C, Groenendaal F, de Vries LS. The Impact of Low-Grade Germinal Matrix-Intraventricular Hemorrhage on Neurodevelopmental Outcome of Very Preterm Infants. *Neonatology*. 2017;112(3):203-210. doi: 10.1159/000472246.

[4] Patra K, Wilson-Costello D, Taylor HG, Mercuri-Minich N, Hack M. Grades I-II intraventricular hemorrhage in extremely low birth weight infants: effects on neurodevelopment. *J Pediatr*. 2006;149(2):169-173. doi: 10.1016/j.jpeds.2006.04.002.

[5] Payne AH, Hintz SR, Hibbs AM, et al. Neurodevelopmental outcomes of extremely low-gestational-age neonates with low-grade periventricular-intraventricular hemorrhage. *JAMA Pediatr*. 2013;167(5):451-459. doi: 10.1001/jamapediatrics.2013.866.

[6] Mukerji A, Shah V, Shah PS. Periventricular/Intraventricular Hemorrhage and Neurodevelopmental Outcomes: A meta-analysis. *Pediatrics*. 2015;136(6):1132-1143. doi: 10.1542/peds.2015-0944.

[7] Bolisetty S, Dhawan A, Abdel-Latif M, Bajuk B, Stack J, Lui K, New South Wales and Australian Capital Territory Neonatal Intensive Care Units' Data Collection. Intraventricular hemorrhage and neurodevelopmental outcomes in extreme preterm infants. *Pediatrics*. 2014;133(1):55-62. doi: 10.1542/peds.2013-0372.

[8] Klebermass-Schrehof K, Czaba C, Olischar M, et al. Impact of low-grade intraventricular hemorrhage on long-term neurodevelopmental outcome in preterm infants. *Childs Nerv Syst*. 2012;28(12):2085-2092. doi: 10.1007/s00381-012-1897-3.

[9] Roze E, Kerstjens JM, Maathuis CG, ter Horst HJ, Bos AF. Risk factors for adverse outcome in preterm infants with periventricular hemorrhagic infarction. *Pediatrics*. 2008;122(1):e46-52. doi: 10.1542/peds.2007-3305.

[10] Marba ST, Caldas JP, Vinagre LE, Pessoto MA. Incidence of periventricular/intraventricular hemorrhage in very low birth weight infants: a 15-year cohort study. *J Pediatr (Rio J)*. 2011;87(6):505-511. doi: 10.2223/JPED.2137.

[11] Ballabh P. Pathogenesis and prevention of intraventricular hemorrhage. *ClinPerinatol*. 2014;41(1):47-67. doi:10.1016/j.clp.2013.09.007

[12] Peixoto S, Amaral J, Resende C, Faria D, Taborda A. Low-grade intraventricular hemorrhage and neurodevelopment at 24 months of age. *Sci Med*. 2018;28(3):ID29354. DOI: 10.15448/1980-6108.2018.3.29354.

[13] Frankenburg WK, Dodds J, Archer P, Shapiro M, Bresnick B. The Denver II: a major revision and restandardization of the Denver developmental screening test. *Pediatrics* 1992; 89:91-97.

[14] Volpe JJ. Impaired neurodevelopmental outcome after mild germinal matrix-intraventricular hemorrhage. *Pediatrics*. 2015;136(6):1185-1187.

[15] Rugolo LMSS. Growth and developmental outcomes of the extremely preterm infant. *J Pediatr*. (Rio J). 2005;81(1 Suppl):S101-S110.

[16] Romantsik O, Calevo MG, Bruschettini M. Head midline position for preventing the occurrence or extension of germinal matrix-intraventricular hemorrhage in preterm infants. *Cochrane Database Syst Rev*. 2017 Jul 20;7(7):CD012362. doi: 10.1002/14651858.CD012362.

[17] Spittle AJ, Treyvaud K, Lee KJ, Anderson PJ, Doyle LW. The role of social risk in an early preventative care programme for infants born very preterm: a randomized controlled trial. *Dev Med Child Neurol*. 2018;60(1):54-62. doi: 10.1111/dmcn.13594.

[18] Damião EBC, Angelo M. A experiência da família ao conviver com a doença crônica da criança. *RevEscEnferm USP*. 2001; 35(1):66-71.

[19] Gannam SSA, Costa JRC, Ballester D. How parents and Teachers perceive child development. *ActaPaediatrica*. 2010;99:76-76.

Profile of creative thinking ability in junior high school in solving flat-building geometry problems in term of van hiele's level and students visual learning styles

P Maharani, Susanto, N Yuliati, M A Kusuma

Department of Mathematics Education, University of Jember, Indonesia

Abstract— The purpose of this study was to describe the creative thinking profile of junior high school grade VIII in solving geometry problems based on van Hiele's level and student's visual learning style. The subjects used were junior high school students in grade VIII. Data collection in this study used tests and questionnaires, the test consisted of the van Hiele test consist of 25 multiple choice questions and 2 geometric questions designed based on indicators of creative thinking, namely fluency, flexibility, originally, and ellaborasy. 1) Students at the visualization level in solving geometry problems are students who are able to meet the fluency indicators, while for the indicators of flexibility, authenticity, and details students cannot fulfill them because the answer sheets are still not visible. In addition, at the time of the interview, the students were also unable to give. 2) Students at the analytical level in solving geometry problems are students able to meet all indicators of creative thinking, namely fluency, flexibility, originality and detail. 3) Informal deduction level students in solving geometry problems are students able to meet the indicators of fluency, flexibility and detail, while the informal deduction level students' authenticity indicators have not been able to fulfill them.

I. INTRODUCTION

Education is very important and in essence cannot be separated from human life. Education is a conscious effort made by families, communities, and governments, through lifelong guidance, teaching or training activities that take place in schools and outside schools, to prepare students to play roles in various living environments appropriately in the future [1]. The young generation of the Indonesian nation is a layer of society who has a major influence on the progress of the Indonesian nation, besides that, Indonesian youth are also expected to be able to compete in facing the development of science and technology that continues to develop in accordance with the progress of the times. Mathematics is a subject that has a big influence on this. According to Suherman, mathematics grows and develops because of the thought process, therefore logic or thinking is the basis for the formation of mathematics [2].

One of the branches of mathematics, namely geometry, is a very important branch in mathematics, this is because many mathematical materials use geometry.

Geometry is a branch of mathematics that deals with objects, surface area, points, lines, angles and the relationships they create, properties, and all applicable measures, including the positions of points, lines and corner in space.

The ability to think creatively is related to the ability to produce or develop something new, which is unusual and different from the ideas of most people [3]. In working on geometry problems, creativity is needed by students because geometry is abstract.Criteria for the creativity aspects used in this study refer to the criteria of creativity aspects [4]. To find out the creative thinking skills of students, it can be seen from the following creative thinking indicators.

Table 1. Indicators of Creative Thinking

Indicator	Description
Fluency	Students are able to build problem-solving ideas from story problems smoothly
Flexibility	Students are able to seek and find many alternative solutions and different answers
Originaly	Students are able to generate new ideas that are different based on the results of their own thoughts
Elaboration	Students are able to detail the steps for solving the problem correctly

Apart from creativity, student learning styles are an important element that must be considered in the learning process. Each student has a different learning style according to their ability to understand a material. Learning styles refer to the ability of learner to perceive and process information in learning situations. The ability to understand students' learning styles can increase the educational outcomes [5]. Students' favorites and style totheir own learning play an important role in educational consequences and these favorites are conveyed into different learningstyles [6].

Students under visual learning styles, which play an important role in learning are eyes/eyesight (visual), so that the way teachers in the learning process must focus on the media/visuals by showing them directly or draw it on the board. Visual style students must look at the teacher's body language and facial expressions to understand the material. Students with auditory learning styles, which play an important role in learning are ears / hearing, so that the way teachers in the learning process must focus on verbal discussion activities both inside and outside the classroom and the teacher explains the material in a clear voice because students with auditory learning styles listen to what the teacher has to say. Students with kinesthetic learning styles, which play an important role in learning through movement, touch, and practice. Students with this learning style find it difficult to sit still for hours, so the teacher's way of the learning process is not to force these students to study for hours, invite the children to study while exploring the environment.

The formulation of geometry questions in this study chose van Hiele's theory as the basis for classification, the theory was chosen because van Hiele's theory focuses on geometric material, examines levels of understanding in learning geometry, explains general descriptions at each level which are described in a more operational description. Based on the description above, the researcher wants to know how the creative thinking profile of junior high school class VIII in solving geometry problems based on van Hiele level and student's visual learning styles.

II. RESEARCH METHOD

This study used in this research is descriptive research. The approach used is a qualitative approach. Descriptive research is aimed at describing the creative thinking profile of grade VIII junior high school students in solving geometry problems based on van hiele level and learning styles. The subjects used in this study were students of class VIII SMP. There are four instruments used, namely van hiele test from Usiskin, learning style questionnaire, geometry test about flat shapes, and interview guidelines. The validation of the study was carried out by the validator to determine the validity of the geometry test questions and interview guidelines used when collecting data.

The data collection methods used in this study were the test and interview methods. Data collection began by giving van Hiele questions from Usiskin [7] as many as 25 questions in the form of multiple choice, each level divided into 5 questions. Level 0 (visualization) on questions number 1-5, level 1 (analysis) on questions number 6-10, level 2 (informal deduction) represents questions number 11-15, level 3 (deduction) represents questions number 16-20, and level 4 (rigor) on questions number 20-25, then analyzed the van Hiele test questions by looking at the results of the tests that have been carried out by grouping students based on the level that van Hiele has the students. Students who answer questions with at least 3 correct answers from each level will be stated that the student meets that level, if the answer is less than 3 then the student has not been categorized as meeting the level. Following are the research steps used in this study.
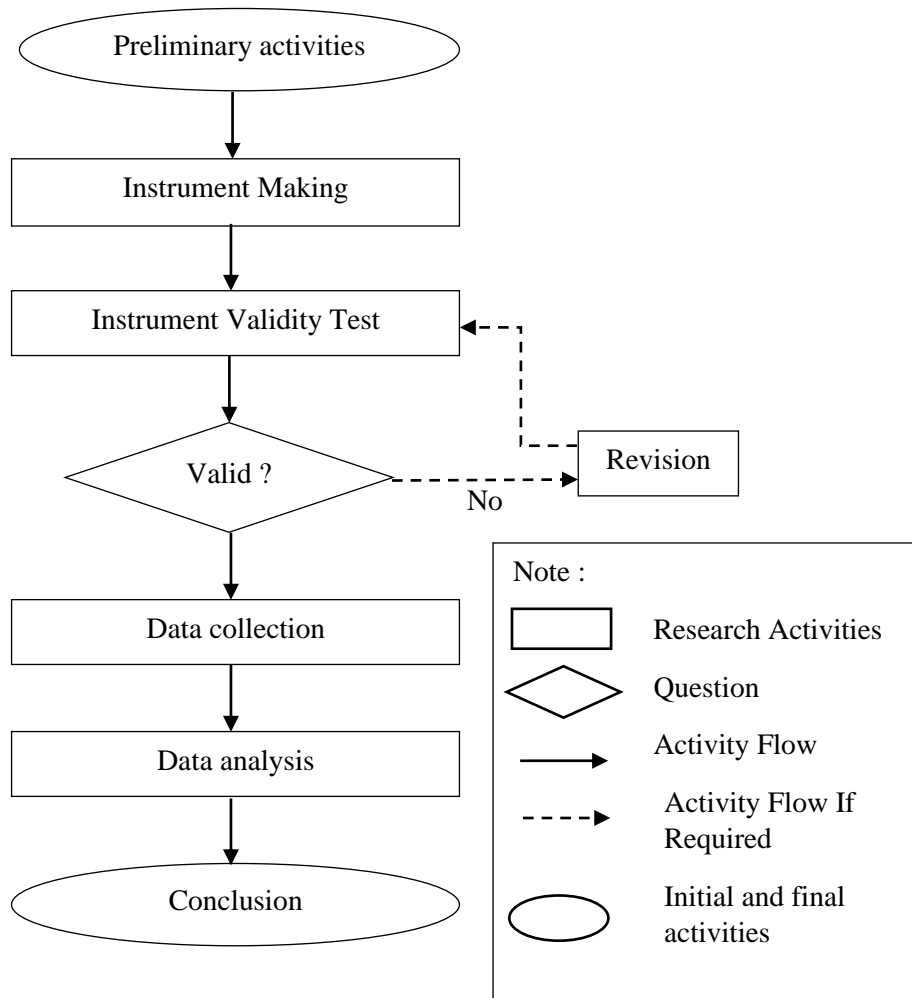
Fig.1. Research Procedure

The second test was conducted using a learning style questionnaire consisting of 30 multiple choice questions to determine the type of learning style of each student. If the highest score is obtained from questions on visual learning styles, then the student has a visual learning style. If the highest score is obtained from questions on the auditory learning style, then the student has an auditory learning style. If the highest score is obtained from questions on the kinesthetic learning style, then the student has a kinesthetic learning style. The last test is a test of flat geometry questions which are arranged based on indicators of creative thinking, then collecting data from the interview results is used for a more in-depth analysis to find something that does not exist or does not appear when working on the problem solving test.

There are three data analysis methods used in this study, namely the analysis of the validity of the instrument, the analysis of the test results, and the analysis of the interview results. The validity analysis of the instruments was carried out by two lecturers from the Mathematics Education at the University of Jember and one

mathematics teacher. The analysis of the test results was carried out after the students took the van hiele test, learning style questionnaires and geometry test questions. Students who have a visual learning style are then grouped based on the results of the van Hiele test that the students have done and taken by two students at each level. Then do a geometry test of material based on creative thinking indicators. The next step is to conduct interviews with the five students to find out more detailed information and ensure that the answers are written on the answer sheet. The results of the interviews that have been obtained are then reduced to obtain the desired interview data, then do the presentation of the interview data and make conclusions on the results of the interview. Then triangulation is carried out to check the correctness of the data or information that has been obtained. The triangulation used was method triangulation, namely methods of tests and interviews. In this study, the researcher has a direct role in carrying out research starting from research planning, data collection to the process of

analyzing data that has been obtained through tests and interviews with research subjects.

III. THE RESULTS AND DISCUSSION

Based on research that has been carried out in class VIII A, from the results of the first test, namely the Van Hiele Geometry Test, it was found that 1 student was classified as level 2 (Informal Deduction), 6 students belonged to level 1 (Analysis), and 11 students belonged to level 0 (Visualization) and 3 students are classified as previsualization. The percentage of van Hiele thinking level of students at level 2, 1, 0, and excluding Van Hiele level is 5%, 29%, 52%, and 14%, respectively. This means that most VIII A students are at level 0 (visualization). Based on the results of the first test, namely the Van Hiele Geometry Test which was given to 21 students in class VIII A, the data presented in the pie chart below was obtained.

Precentage of Students' Van Hiele Level
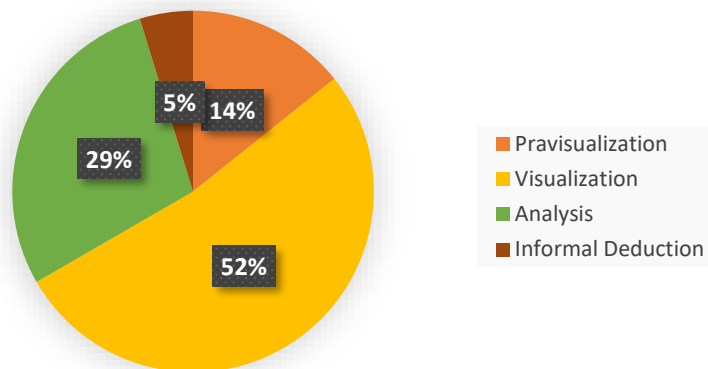
Fig.2. Precentage of Students' Van Hiele Level for Class VIII A

In the diagram above, it can be seen that the thinking level of junior high school students in learning geometry according to Van Hiele's theory has reached the second level, namely the level of informal deductive thinking. This is in line with the opinion of Van De Walle which states that most SMP/MTs students are between level 0 (visualization) to level 2 (informal deduction). This research is also in line with research conducted by Sunardi which states that the level of thinking of students in geometry for junior high school students tends to be at the visualization level [8]. Research conducted by Agustiningsih also shows the same results, namely the Van Hiele Geometry Test results obtained that the percentage of Van Hiele thinking levels of students at levels 2, 1, 0, and excluding Van Hiele Levels are 29%, 10, respectively. %, 48%, and 13%, meaning that the most studied students are at level 0 (visualization) [9]. In addition, research conducted by Sunardi and Yudianto also states that most students in schools are still in the first three levels of student thinking according to van Hiele's theory, namely the level of visualization, analysis, and informal deduction [10].

Based on data analysis that has been carried out on five students who have a visual learning style and have been grouped by van Hiele's level the results show that the students' ability in creative thinking achieved by the five students in solving mathematical problems with geometric material is different. Data collection was obtained from the results of tests carried out by one class of VIII grade students, then the results showed that students who have visual learning styles have different van Hiele levels, in this study the van Hiele level to be analyzed is at level 0, namely visualization, level 1 is analysis, and level 2 is informal deduction. In accordance with the provisions set out in this study, 2 students were taken from each van Hiele level at random. The five subjects in this study were students with the code S1, S2, S3, S4, and S5. The following is the table for the five students' levels of van hiele.

Table 1. Students' Van Hiele Levels

No.	Subjek	No. Soal					Level van Hiele Geometry Test
		1-5	6-10	11-15	16-20	21-25	
1.	S1	3	1	2	1	1	Visualization
2.	S2	4	2	2	2	1	Visualization
3.	S3	5	4	2	1	0	Analysis
4.	S4	4	3	2	1	1	Analysis
5.	S5	5	4	3	0	1	Informal Deduction

The creative thinking profile of the first visualization level student (S1) in solving problem number 1, namely S1 can correctly state the information contained in the problem, namely triangles ABC, BDE, and CEF are isosceles triangles, the length of CF is equal to 10 cm, then the length of side BC is the same with sides DE and EF with a length of 16 cm. S1 can explain the information contained in the questions in his own language, even though the sentences he uses are like repeating sentences in the questions. S1 understands that the Pythagorean formula is used to find the height of a triangle. S1 can also calculate the height of the triangle CEF using the Pythagorean formula with the correct answer of 6 cm. In question number 1, S1 only wrote one alternative answer, namely calculating the total area of the shaded area by calculating the area of triangle ABC and calculating the height of the triangle BDE using the Pythagorean formula, but on the answer sheet S1 did not calculate the area of the triangle BDE and CEF, so the answer he gave writing is still incomplete. At the time of the interview S1 can continue his calculations to calculate the area of the triangle BDE and CEF correctly, so that the calculation of the total area of the shaded area is correctly generated. When asked to look for other ideas, S1 found a second alternative answer, which was to calculate the total area of the shaded area by adding up the area of the triangle ABC and the area of the parallelogram which is a combination of the triangles BDE and CEF, but S1 could not correctly state the formula for the area of the parallelogram. The second alternative answer S1 can only write the steps in general without getting the final result. In question number two, S1 can correctly state the information contained in the question, namely the number of matches of 36 sticks with a length of 5 cm each, the circumference of the shape What will be formed is the number of matches belonging to Pak Khoirul. S1 can also explain questions using their own language, even though it looks similar to the sentences in the questions. S1 only wrote one alternative answer, which was to make a square using 36 matchsticks with 9 sticks on each side, S1 was also able to calculate the

actual side length of the square correctly, which was 45 cm. S1 can find the area of a square using the formula and get the correct calculation results. During the interview, S1 found another flat shape that could be formed, namely a rectangle, but when asked to determine the length and width, S1 found it difficult to determine the length and width of the rectangle.

The creative thinking profile of the second level of visualization (S2) in solving problem number 1 is that S2 can correctly state the information contained in the problem, namely triangles ABC, BDE, and CEF are isosceles triangles, the length of CF is equal to the length of the sides BD, BE, and CE which is 10 cm, then the length of the side BC is equal to the sides DE and EF with a length of 16 cm. In question number 1, S2 can write two alternative answers, first calculate the total area of the shaded area by adding up the area of triangle ABC, area of triangle BDE and triangle CEF. Second, add up the area of a rectangle which is another form of triangle ABC by moving half of the triangle to the other side, then the area of triangle BDE and triangle CEF. At first S2 was wrong when calculating the area of triangle ABC, S2 was wrong in calculating multiplication using the formula, finally at the time of the interview S2 was able to calculate the area of triangle ABC using the triangle area formula correctly. S2 can also calculate the height of the triangle BDE using the Pythagorean formula with the correct answer. In the second alternative answer, S2 can calculate the total area of the shaded area with the correct final result. At the time of the interview S2 could not find new ideas to solve problem number one. In question number 2, S2 could correctly state the information contained in the question, namely S2 could state what was known and asked in the question. S2 can also explain questions using their own language. S2 can write two alternative answers, namely making square and rectangular shapes. In the initial square shape, S2 drew the shape with the wrong match position, finally during the interview S2 was able to correct the square shape he drew and was able to determine the length of the side of the square which was 9 sticks, S2 was also

able to calculate the actual side length of the square correctly, which was 45 cm . S2 can find the area of a square using the formula and get the correct calculation results. To get a rectangle, on the answer sheet S2 is also wrong when drawing, he puts the matchstick position not according to the instructions in the question. At the time of the interview, S2 realized that the picture was wrong and could correct the picture, but when asked to determine the length and width he found it difficult so that S2 could not determine the length and width of the rectangle.

The profile of creative thinking of students at the first level of analysis (S3) in solving problem number 1 is that S3 can explain the meaning of the questions using their own language. S3 can correctly state the information contained in the problem, namely triangles ABC, BDE, and CEF are isosceles triangles, the length of CF is equal to the length of the sides BD, BE, and CE which is 10 cm, then the length of side BC is equal to the sides DE and EF with length 16 cm, the height of triangle ABC is 15 cm. In question number 1 S3 can write two alternative answers, first calculate the total area of the shaded area by adding up the left half of the triangle ABC area, the area of the right half triangle ABC, the area of the triangle BDE and the triangle CEF. Second, add up the area of triangle ABC (directly into one shape) and the area of a rectangle which is a combination of triangle BDE and triangle CEF. S3 can also calculate the height of the triangle BDE using the Pythagorean formula correctly. During the interview, S3 can find another alternative answer, namely calculating the total area of the shaded area by adding up the area of triangle ABC and the area of a parallelogram which is a combination of the BDE triangle and the CEF triangle, S3 can calculate a new alternative answer with the correct final result. S3 also found another alternative answer, namely adding up the area of the kite (a combination of triangles ABC and BDE) and the area of the triangle CEF, but he couldn't calculate the area because S3 couldn't correctly mention the formula for finding the area of the kite.

In question number 2, S3 can correctly state the information contained in the question. namely S3 can state what is known and asked in question number 2 smoothly and correctly. S3 can also explain questions using their own language. S3 can write three alternative answers, namely making squares, rectangles and triangles. In the shape of a square, S3 can determine the length of the side of the square, which is 9 bars, S3 can also calculate the actual side length of the square correctly, which is 45 cm. S3 can find the area of a square using a formula and get the correct calculation results. In rectangular shapes, S3 can determine the length and width, namely 11 bars and 7 bars, S3 can correctly state the formula for the area of a

rectangle, S3 is able to calculate the area of a rectangle correctly. To build a triangle initially on the answer sheet he could not determine the size of the sides of the triangle, finally at the time of the interview he was able to determine the size of the sides of the triangle, namely 12, 12, 12, but S3 could not calculate the area of the triangle because he found it difficult to calculate the height of the triangle using the Pythagorean formula, S3 has difficulty calculating the size of the sides of the triangle which is substituted in the Pythagorean formula. During the interview, S3 can find alternative answers, namely making a rectangular shape with a length of 12 rods and a width of 6 rods, S3 can also calculate the area of a rectangle correctly.

The profile of students' creative thinking at the second level of analysis (S4) in solving problem number 1 is that S4 can explain the meaning of the question using their own language. S4 can correctly state the information contained in the problem, namely triangles ABC, BDE, and CEF are isosceles triangles, the length of CF is equal to the length of the sides BD, BE, and CE which is 10 cm, then the length of side BC is equal to the sides DE and EF with length 16 cm. In question number 1, S4 can write three alternative answers, first calculate the total area of the shaded area by adding up the area of triangle ABC, area of triangle BDE and triangle CEF. Second, add up the area of triangle ABC and the area of the trapezoid which is the combination of the three triangles below and then subtract the area of the unshaded triangle. Third, add up the area of triangle ABC, the area of the rectangle is subtracted from the area of the unshaded triangle, then the area of the two lower right triangles. S4 can also calculate the height of the triangle BDE using the Pythagorean formula with the correct answer.

When solving problem number 2, S4 can correctly state the information contained in the question. S4 can state what is known and asked in question number 2 smoothly and correctly. S4 can also explain questions using their own language. S4 can write two alternative answers, namely making square and rectangular shapes. In the shape of a square, S4 can determine the length of the side of a square with 9 bars, S4 can also calculate the actual side length of the square correctly, which is 45 cm. S4 can find the area of a square using the formula and get the correct calculation results. In the rectangular shape, initially S4 was able to determine the length and width, namely 8 sticks and 5 sticks, but it turned out that the measurements were still wrong. S4 was able to correct the length and width of the rectangle at the time of the interview, which was 13 bars long and 5 bars wide, S4 correctly stated the formula for the area of a rectangle, S4 was able to calculate the area of the rectangle correctly. During the

interview, S4 found another shape, namely a parallelogram with a base length of 13 rods and a width of 5 rods, but S4 could not calculate the area of a parallelogram because S4 could not determine the height of a parallelogram using the Pythagorean formula. S4 also found another alternative answer, namely making build a rectangle with a length of 14 bars and a width of 4 bars, S4 can also calculate the area of the rectangle correctly.

The profile of students' creative thinking at the informal deduction level (S5) in solving problem number 1 is that S5 can explain the meaning of the questions using their own language. S5 can correctly state the information contained in the problem, namely triangles ABC, BDE, and CEF are isosceles triangles, the length of CF is equal to the length of the sides BD, BE, and CE which is 10 cm, then the length of side BC is equal to the sides DE and EF with length 16 cm. In question number 1 S5, you can write three alternative answers, firstly calculating the total area of the shaded area by adding up the area of triangle ABC, area of triangle BDE and triangle CEF. Second, add up the area of triangle ABC and the area of a parallelogram which is a combination of triangles BDE and CEF. Third, add up the area of the kite (a combination of triangle ABC and triangle BDE) and the area of triangle CEF. S5 can also calculate the height of the triangle BDE using the Pythagorean formula with the correct answer. During the interview, S5 found another alternative answer, namely forming a triangle ABC into a rectangular shape, so to find the total area of the shaded area, namely adding up the area of the rectangle, the area of the triangle BDE and the area of the triangle CEF. Another alternative answer that S5 found was adding up the area of triangle ABC and the area

of a rhombus (a combination of triangles BDE and CEF), S5 was also able to calculate the area correctly.

In question number 2, S5 can correctly state the information contained in the question, namely S5 can state what is known and asked in question number 2. S5 can also explain the problem using his own language. S5 can write three alternative answers, namely making squares, rectangles, and triangles. In the shape of a square, S5 can determine the length of the side of the square, which is 9 bars, S5 can also calculate the actual side length of the square correctly, which is 45 cm. S5 can find the area of a square using a formula and get the correct calculation result. In the rectangular shape, S5 can determine the length and width, namely 12 rods and 6 rods, S5 can mention the formula for the area of a rectangle and is able to calculate the area of the rectangle correctly. To build a triangle, S5 can determine the size of the sides of the triangle, namely 12, 12, 12, but S5 cannot calculate the area of the triangle because S5 finds it difficult to calculate the height of the triangle using the Pythagorean formula. At the time of the interview, S5 found a new size of the triangle shape, namely 10,10,16, S5 was able to calculate the height of the new triangle using the Pythagorean formula and calculate the area of the triangle correctly. S5 also found other alternative answers, namely to build a rectangle with a length of 14 rods and a width of 4 rods, and a rectangle with a length of 10 rods and a width of 8 rods, S5 was also able to calculate the area of the two rectangles correctly.

The results of student work based on indicators of creative thinking in solving two problems describing the material for flat triangles and quadrilaterals can be seen in the following table.

Table 2. Results of Analysis of Flat Shape Geometry Test

Research Subject	Question Number							
	1				2			
	A	B	C	D	A	B	C	D
S1	√	x	x	x	√	x	x	x
S2	√	x	x	x	√	x	x	x
S3	√	√	√	√	√	√	√	√
S4	√	√	√	√	√	√	√	√
S5	√	√	x	√	√	√	x	√

Information:

A : Fluency

B : Flexibility

C : Originally

D : Elaboration

√ : Meets

x : Not yet fulfilled

Based on the analysis and discussion that has been described previously, there are similarities between the five students, namely that all students have previously received flat-shaped material, but the questions given are different from the questions in the study. In this study, it was found that students at the analytical level were able to write new alternative answers that were different from other students, while for the level of visualization and informal deduction, there was no update when providing alternative answers. This raises the assumption that the van Hiele level of the students has a discrepancy which is thought to be caused by the test questions used to measure the van Hiele level which are still optional consisting of several multiple choice options. So that it is possible that when students answer the question, they only give answers by trial and error, which causes the ability of students to answer the next question, namely the geometry problem, which is not in accordance with the van Hiele level of the student. This study shows that the creative thinking ability of each student is different. The results of this study are in line with Van Hiele's theory which says that the process of developing students' creative thinking is not determined by age or biological maturity, but rather depends on the teaching from the teacher and the learning process that students go through. In addition, this research is also in line with research conducted by Mukharomah et al which states that not all students who are at a high level in van Hiele, have a high level of creative thinking [11]. Likewise, students at low levels at van Hiele also do not always show low levels of creative thinking.

IV. CONCLUSION

Based on the results of the analysis and discussion of the data, it can be concluded that the creative thinking profile of students who have a visual learning style at level 0 (visualization), level 1 (analysis), and level 2 (informal deduction) in solving geometry problems are as follows. 1) Students at the visualization level in solving geometry problems are students who are able to meet the fluency indicators, while for the indicators of flexibility, authenticity, and details students cannot fulfill them because the answer sheets are still not visible. In addition, at the time of the interview, the students were also unable to give. 2) Students at the analytical level in solving geometry problems are students able to meet all indicators of creative thinking, namely fluency, flexibility, originality and detail. 3) Informal deduction level students in solving geometry problems are students able to meet the indicators of fluency, flexibility and detail, while the informal deduction level students' authenticity indicators have not been able to fulfill them. So it can be concluded that students with different van Hiele levels also have different

creative thinking abilities, and not always students who are at a higher van Hiele level can fulfill all indicators of creative thinking and the otherwise. This can be caused by the different experiences of students in solving geometry problems and the level of concentration of students when working on problems. In addition, it was also suspected that when doing the van Hiele test students answered trial and error, so that the resulting van Hiele level grouping was inaccurate. Based on these findings, the recommendation in this study is to make a new VHGT test package (Van Hiele Geometry Test) which is adapted to the situation of students or the existing curriculum in Indonesia.

REFERENCES

[1] Mudyahardjo R 2001 *Pengantar Pendidikan (Sebuah Studi Awal Tentang Dasar-dasar Pendidikan Pada Umumnya dan Pendidikan di Indonesia)* (Jakarta: PT. Rajagrafindo Persada)

[2] Suherman E, Turmudi, Suryadi, D, Herman T and Suhendra 2001 *Strategi Pembelajaran Matematika Kontemporer* (Bandung: JICA- Universitas Pendidikan Indonesia)

[3] Dewi OAS and Winarti ER 2019 Students' creative thinking ability in solving problems with double loop problem solving model. *Unnes Journal of Mathematics Education*. 8(2) 111–118

[4] Mahmudi A 2008 Tinjauan Kreativitas Dalam Pembelajaran Matematika. *Jurnal Pendidikan Matematika*. UNY. 4(2) 37-49.

[5] Hussein I R and Hussein D A 2016 Assessment of visual, auditory, and kinesthetic learning style among undergraduate nursing students. *International Journal of Advanced Nursing Studies*. 5(1) 1

[6] Leung K, and Weng L 2007 Validation of Kolb's structuralmodel of experiential learning using Honey and Mumford's Learning Style Questionnaire. *Journal of Medical Education* 11 234-243

[7] Usiskin Z 1982 *Van Hiele Levels and Achievemant in Secondary School Geometry* (Chicago: The University of Chicago)

[8] Sunardi. 2016. *Pembelajaran Geometri Sekolah dan Problematikanya.* Surabaya: Unesa University Press

[9] Agustiningsih, N. 2018. *Proses Berpikir Kreatif Siswa*

Dalam Menyelesaikan Masalah Geometri Berdasarkan Level van Hiele. Tesis. Fakultas Keguruan dan Ilmu Pendidikan. Magister Pendidikan Matematika. Universitas Jember: Jember.

[10] Sunardi, S., & Yudianto, E. (2015). Antisipasi Siswa Level Analisis Dalam Menyelesaikan MasalahGeometri. *AdMathEdu : Jurnal Ilmiah Pendidikan Matematika, Ilmu Matematika DanMatematika Terapan*, *5*(2), 203–216

[11] Mukharomah, dkk. 2017. Profil Kemampuan Berpikir Kreatif Berdasarkan Tingkat Berpikir Van Hiele Siswa Kelas VII Dalam Menyelesaikan Soal Segiempat. *Kadikma* 8 (3), 48-57.

Hydrodynamic analysis of different baffle layouts in a facultative pond to mitigate operational problems through computational fluidodynamics

Leandro Conti Garcia, Flávia Aparecida Reitz Cardoso[*], Flávia Vieira da Silva Medeiros, Thiago Morais de Castro and Eudes José Arantes

Post-Graduation Program of Technological Innovation (PPGIT), Federal University of Technology – Paraná (UTFPR), Campo Mourão, 87301-005, Brazil

*reitz@utfpr.edu.br

Abstract— *The main operational problems found in facultative ponds are the dead zones, short circuit zones of recirculation zones, caused mainly by the accumulation of solids in the bed. The use of baffles is one way of mitigating these problems. Thus, the objective of this work is to compare four baffle installation formats in an optional pond using computational fluid dynamics, and subsequently to identify the occurrence of the main operational problems in each model. For the development of the study, the software Ansys 14.5®was used, where the geometry of the analyzed pond was replicated, including in each model a different layout of the baffles. The use of deflectors allowed the mitigation of the main problems, such as the accumulation of sediments, and it was able to increase the flow velocity in all scenarios, as well as bringing the hydraulic retention time closer to that of the project. According to the data obtained, and the visual analysis of the simulations, it is possible to affirm that the baffle layouts assessed in scenario four would be more adequate to mitigate the operational problems found in the studied pond, as this arrangement conditions the flow of the piston type, which provides less sediment accumulation and the development of dead zones and short circuit zones in the bed. It was concluded that the installation of baffles could mitigate the operational problems of stabilization ponds by directing the flow. Likewise, there was a need for continuous studies to improve wastewater treatment systems.*

I. INTRODUCTION

Silva (2007) defines baffles, or deflectors, as transversal, vertical, or longitudinal barriers capable of altering the movement of a fluid within a pond by dividing it into several channels. The layout of the baffles is related to the intended purpose of the installation. According to Takeuti (2003), longitudinal baffles form parallel channels in the ponds, conditioning the flow to the piston flow, attributing greater efficiency to the treatment system than other hydraulic models, such as dispersed flow and complete mixing, in the case of facultative ponds.

Another way of arranging deflectors in ponds is in a transversal way, increasing the path taken by the fluid between the inlet and the outlet of the pond. This arrangement is indicated for cases where the operational hydraulic retention time is less than the theoretical HRT, because with the increase in the route, the longer the time necessary for the fluid to travel the entire length of the

pond. This layout allows greater exposure of the effluent to UV rays, for example, helping to remove pathogenic organisms (Kellner; Pires, 1998)

The use of baffles aids in the removal of various classes of pollutants. The regulation of the sedimentation rate, the increase in HRT, the longer time of exposure to sunlight, are factors resulting from the use of baffles in ponds and they condition the improvement of the treatment system in the removal of organic pollutants such as BOD, from the remaining pathogenic organisms, in addition to nitrogen compounds that are not eliminated in the previous steps (Von Sperling, 2017)

Based on the change in flow caused by the installation of baffles and its influence on the deposition of solids in the pond beds, this study aims to compare four baffle installation layouts in a facultative pond in the city of Campo Mourão, then analyzing the main operational problems of each installation format.

II. MATERIAL AND METHODS

With the pond sizing information obtained from the analysis of the treatment plant implementation project, the facultative pond three-dimensional geometry was replicated on the solid creation platform available in the Ansys 14.5® *software*, a high-performance program used for computer simulation. It generated four models, all with dimensions equal to the original, but using baffles to direct the fluid in its path. The four models of baffles were:

1. Four lateral baffles, two-thirds the length of the pond, arranged as follows: the first baffle, parallel to the fluid inlet duct, the rest, parallel to the outlet ducts, having an equivalent distance of approximately 25m between them (Figure 1).
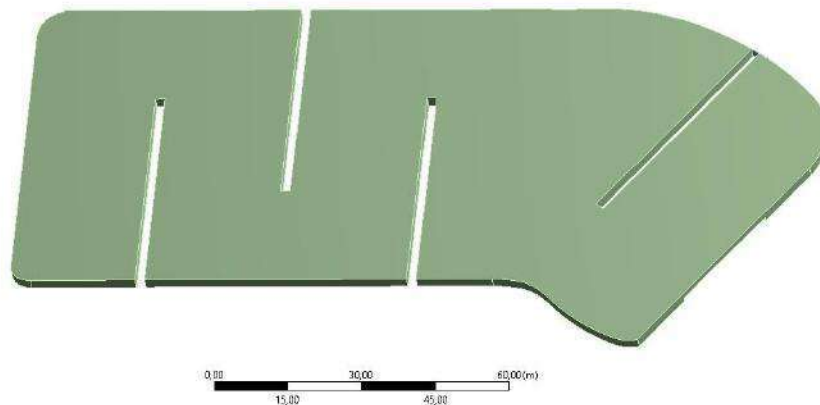
Figure 1 First layout model of the four baffles in the WWTP pond

2. Four lateral baffles, with dimensions and distances equal to the previous case. However, all arranged parallel to the outlet ducts (Figure 2).
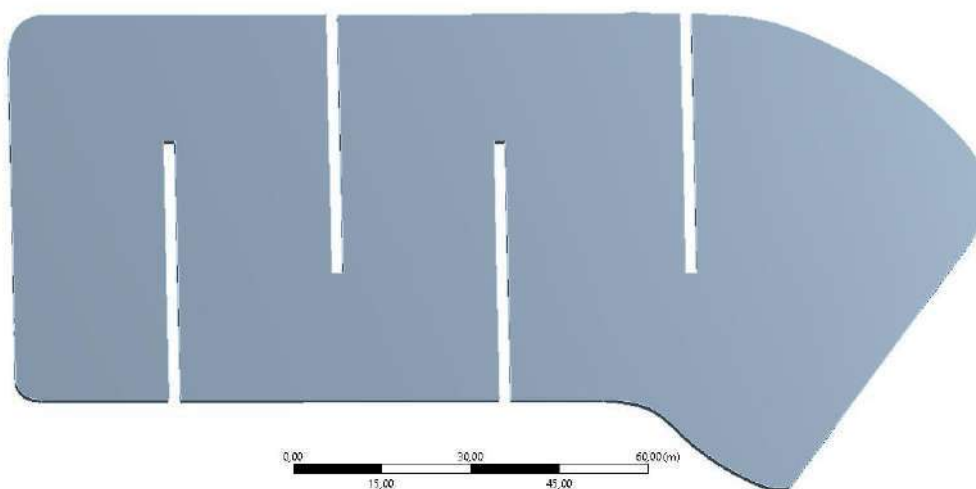
Fig.2 Second layout model of the four baffles in the WWTP pond

3. Two central baffles plus four lateral baffles. In this situation, the central baffles were two-thirds the width of the pond, and they were arranged alternately with the lateral baffles, which were one-third the length of the pond. The spacing remained equivalent between them. The first baffle was central and parallel to the inlet duct, and the others parallel to the outlet ducts (Figure 3).
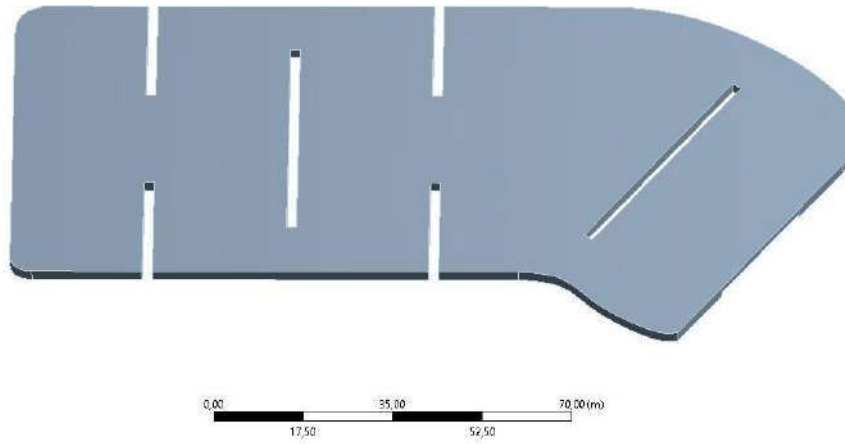
Fig.3 Model of central and lateral baffles at the WWTP

4. Three central baffles, longitudinally arranged, perpendicular to the inlet and outlet ducts, with a length of two-thirds of the total length of the pond and a distance of approximately 17m (Figure 4).
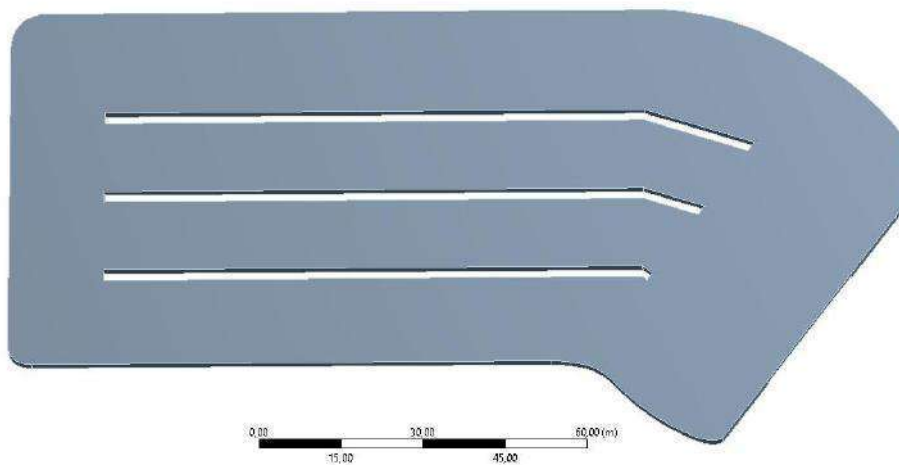
Fig.4 Longitudinal baffle layout model

The results were analyzed by comparing four different flow models with barriers (baffles). The function of this comparison was to verify the model that presented less operational problems, such as controlled flow velocity, generation of short-circuit zones, or dead zones, in addition to retromixing zones.

In addition to being able to find the best model for the disposition of baffles, the comparison also made it possible to justify the creation of the floating baffle model, which can be used in different formats and installed in ponds already in operation.

III.   RESULTS AND DISCUSSION

To demonstrate the mitigation potential of the baffles for the operational problems already elucidated, four models of the layout of the barriers inside the pond are presented below, and the consequence of these

different dispositions in the flow of the liquid mass in the bed.

Case 1: baffle arrangement on the sides and center of the pond, parallel to the inlet and outlet ducts (Figure 5).
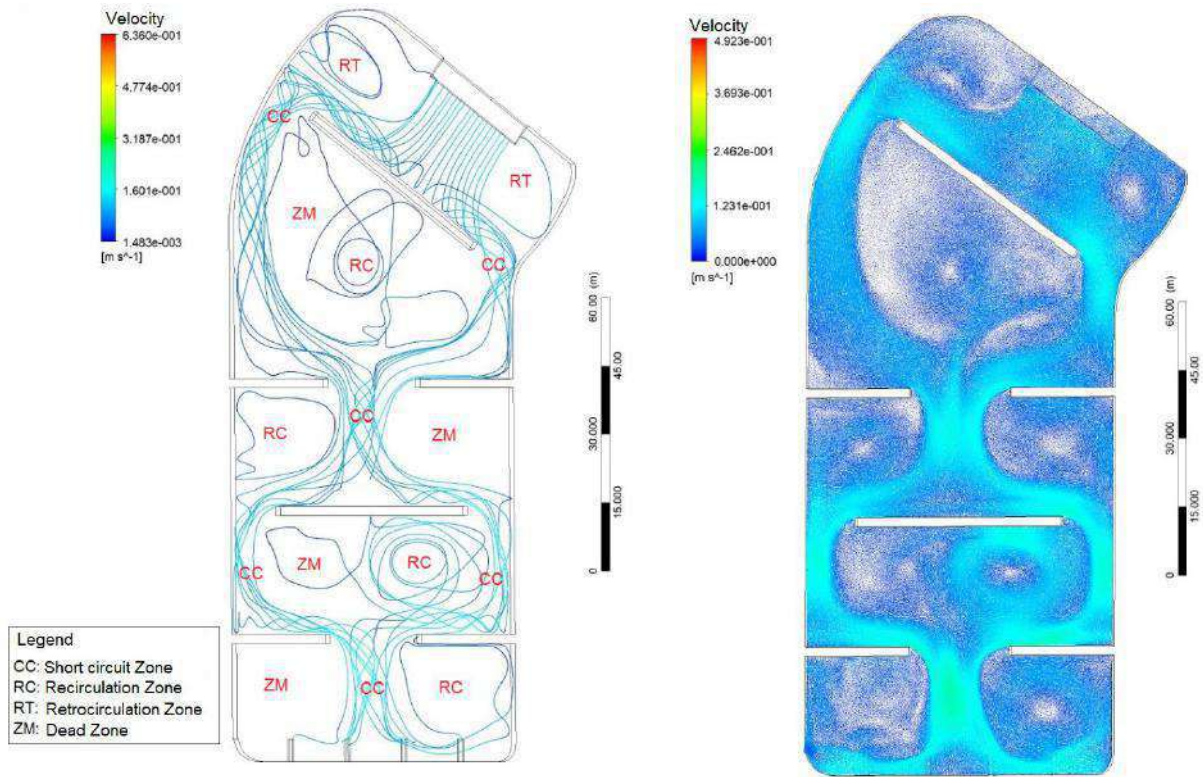
Fig.5 Scenario 1 - central and lateral baffles

The baffle located near the inletof the pond contributed to the dispersion of the liquid throughout the available area, preventing the fluid from being directed in the same direction. However, due to the proximity of the inlet duct and the velocity of the flow, there was the formation of recirculation zones on the sides of the pond, as well as the creation of a large dead zone after the baffle.

In the rectangular region, the fluid behaved uniformly, dispersing throughout the available area and no longer forming low-velocity regions. In this scenario, it is possible to predict the formation of a sediment bank in the region of the first baffle, close to the inlet, just as it happens in the original layout. The current lines show the

formation of the recirculation zones and the large low-velocity region right after the first baffle.

The velocity in this scenario increases proportionally to the proximity of the outlet ducts, varying between 0.002 m/s and 0.221 m/s. This characteristic is because the flow is continuous, and the inlet volume is equal to that of the outlet, reducing, therefore, the possibility of significant dead zones. This fact is explained by the area of the outlet ducts being smaller than the area of the inlet duct, and for the flow to remain the same, the flow velocity must be greater.

Case 2: four lateral baffles, with the first parallel to the inlet duct and the others parallel to the outlet ducts (Figure 6).
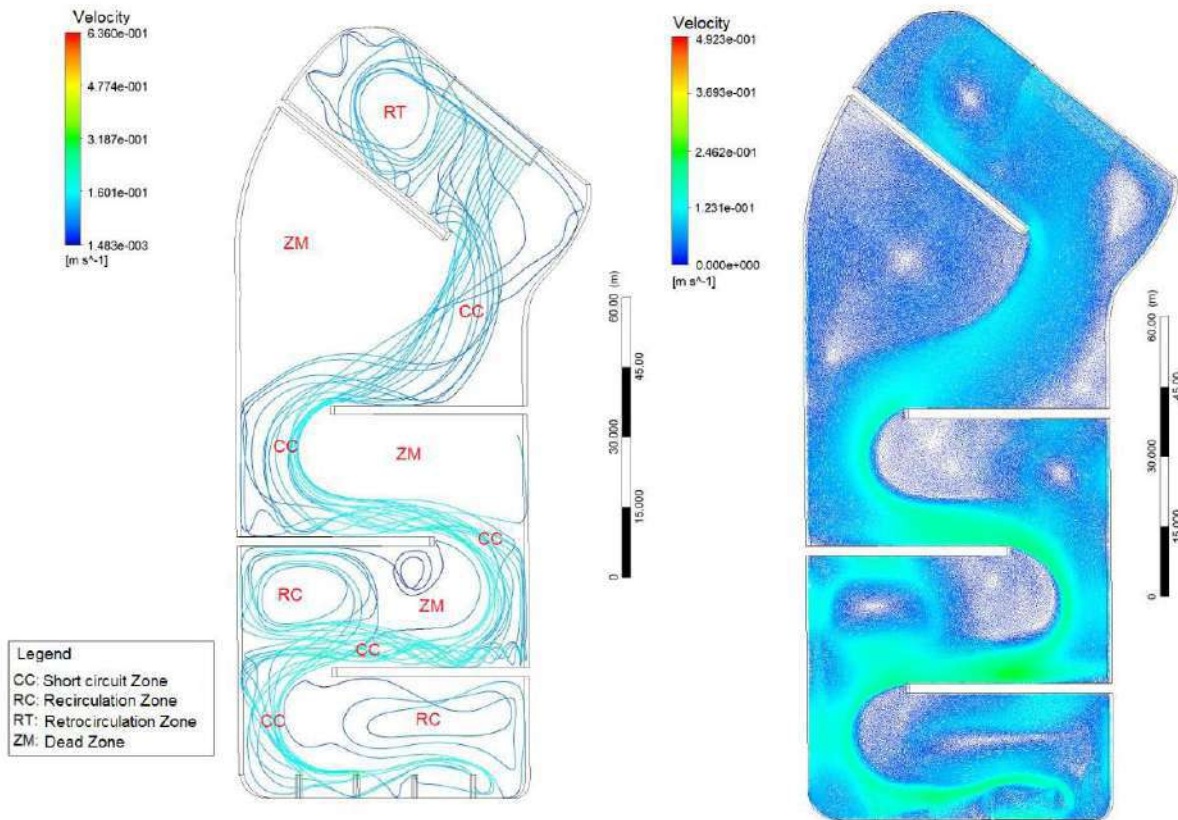
Fig 6 *Scenario 2 - lateral baffles, with the first parallel to the inlet*

As in the first case, there is the formation of several recirculation regions and a large dead zone after the first baffle. The fluid, in the rectangular area, is distributed in a way to form a channel, and the fluid starts to behave as in meandering natural water bodies, that is, it starts to drag sediments on the outside of the curves and to accumulate on the part internal. Thus, in this conception of barriers, the accumulation of sediments would happen mainly behind the baffles, increasing according to the proximity of the slopes.

The presence of a baffle parallel to the inlet duct induces the formation of dead zones, a fact related to the inlet velocity of the fluid into the pond and, therefore, dependent on the flow of the effluent. The velocity ranged between 0.002 m/s and 0.324 m/s. However, the images show that most of the flow presented an average velocity of around 0.121 m/s.

Case 3: four baffles arranged parallel to the outlet gates (Figure 7)
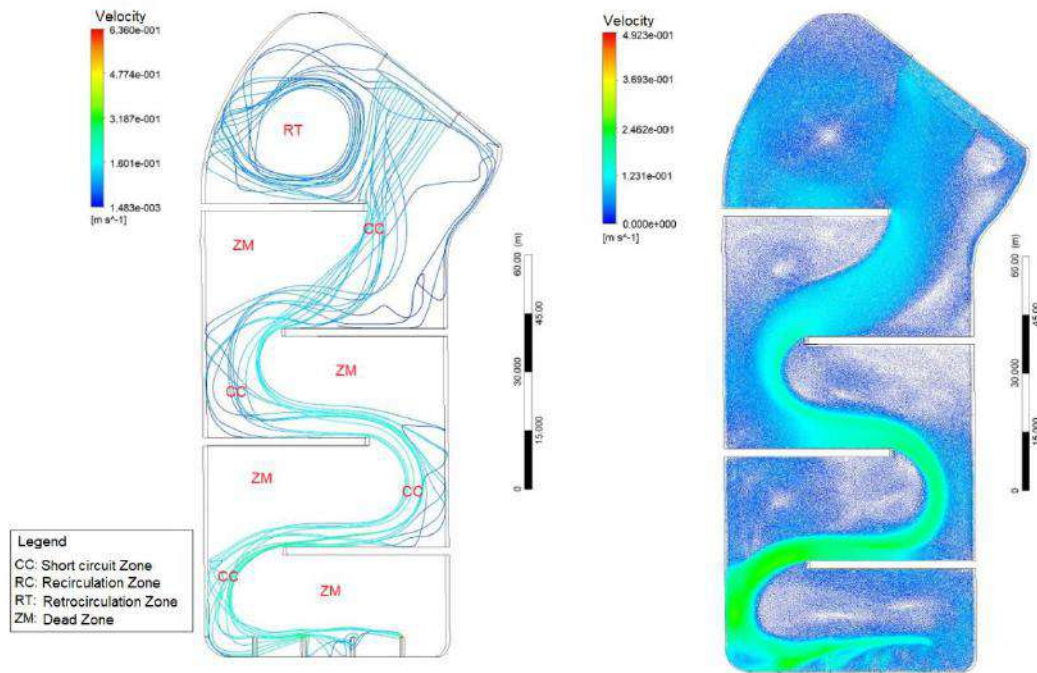
Fig.7 Scenario 03 - side baffles parallel to the outlet

This layout was adopted to verify if the change in the orientation of the first baffle would affect the formation of dead zones, reducing them, or even eliminating them.

What is observed is that the angulation of the first baffle interferes with the formation of dead zones, since it directs the flow to the curved margins of the pond, making the fluid that reaches the back of the baffle have a lower velocity than that of the flow.

When the orientation of the baffle is changed, a large recirculation zone is then observed. The fluid, when it encounters the barrier, still has a high-velocity variation due to the inlet conditions. When colliding, it separates into two currents: one follows the flow to the outlet. At the same time, the second is directed to the slope, then returns to the inlet region and follows the initial flow again.

In this layout, it was also noted the expressive increase in velocity at the end of the route, reaching 0.326 m/s. With the reduction of dead zones, the volume of sewage in circulation increases. Therefore, the velocity at the end of the path must be higher so that the flow inlet and outlet remain the same, as mentioned above.

The model presents dead and recirculation zones concentrated behind the baffles, increasing according to the proximity to the slope, as in the previous layout, showing that the length of the barriers needs to be shorter to avoid that the flow of the liquid mass does not reach the entire available pond area.

Case 4: three baffles perpendicular to the inlet and outlet ducts (Figure 8).
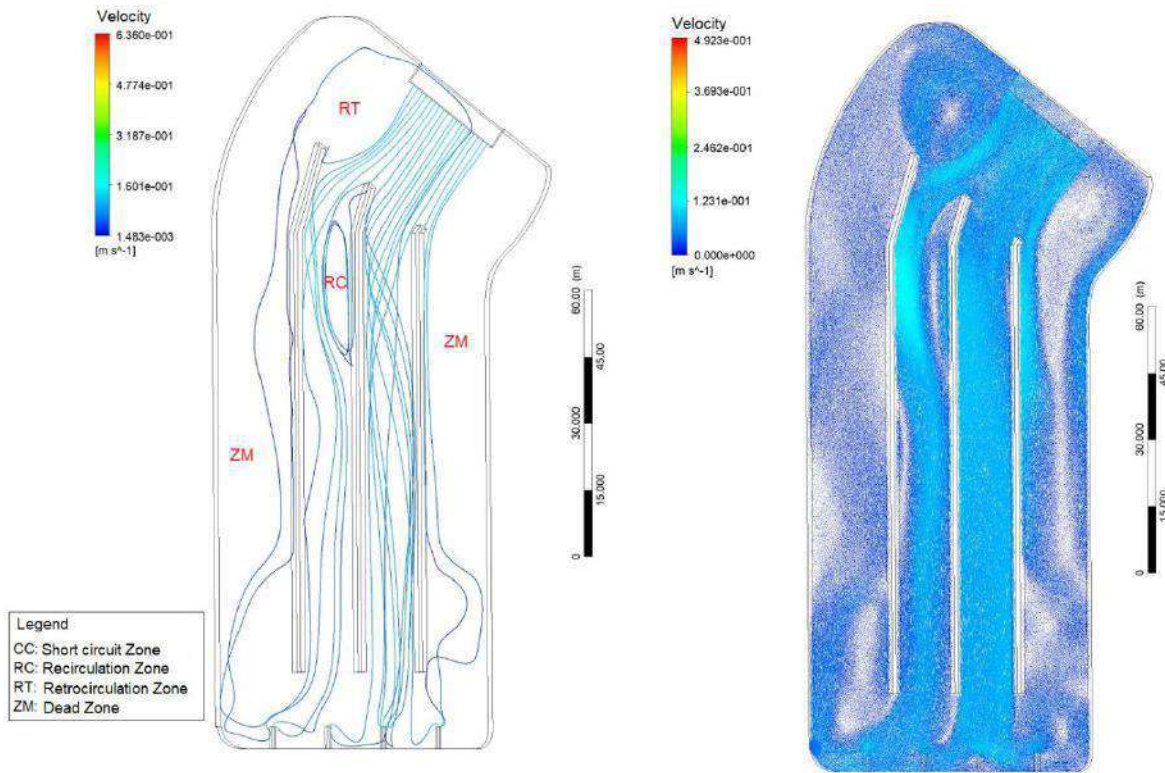
Fig.8 Scenario 4 - baffles perpendicular to the inlet and outlet

As the last proposal, a model was elaborated where the baffles were arranged perpendicularly to the inlet and outlet. This configuration replicates the geometry of the pond in smaller dimensions, forming a flow for each of the outlets, in the form of piston flow. The absence of parallel barriers prevents the formation of dead zones due to the inlet velocity and redirection of the flow. However, the irregular shape of the pond, once again, contributed to the development of some operational problems.

When entering the pond, the current goes mainly to the central channels formed by the baffle, forming a small recirculation zone, the only one developed in this model. This recirculation zone contributes to the flow not being able to travel through the last channel (above the recirculation zone) with a velocity equivalent to that of entering the pond. This layout denotes characteristics of decanters for this area, where the gravitational forces are greater than the drag forces, thus leading to the sedimentation of suspended solids. In this way, this region would be the one that would possibly suffer from the greatest accumulation of sediments.

A small part of the inlet flow goes to the first channel, and its movement follows the disposition of the baffle. In this situation, there will also be the formation of a denser sediment layer. However, the flow velocity close to the baffle will contribute to this accumulation being less than that of the last channel.

The two channels formed in the center of the pond receive most of the sewage flow that enters the pond. The fluid behaves evenly in these spaces, covering the entire area available for the flow, and there is no formation of recirculation zones or dead zones. The velocity varies between 0.002 m/s and 0.167 m/s, thus demonstrating that the distribution of liquid flow in the pond has not overloaded any circuit.

From the observation of the effects of the different baffle dispositions in the models presented, it is possible to propose some changes in the original pond to mitigate the problems found. The main source of such problems is, in fact, the shape of the pond, but the volume of operation also has a great influence. The original pond has very large dimensions, out of proportion to the sewage flow for which it is used. The fact of having a very large area provides the loss of fluid velocity, increasing the sedimentation rate and the hydraulic retention time, thus having a characteristic lentic environment, ideal for the development of algae.

Then considering the decrease in the sedimentation rate, the ideal scenario would be reached with the increase in the operation flow and installation of baffles perpendicular to the inlet and outlet ducts, as in the

last case presented. If it is impossible to increase the operating flow, reducing the pond area would be another alternative. This new layout could be achieved by extending the first and last baffle to the inlet and outlet margins, and the new format would encompass only the central circuits presented in case 4.

IV.   CONCLUSIONS

With the analysis of the hydrodynamic behavior in the different models of the baffle arrangement, it was clear that the movement of the fluid within the analyzed space can be reoriented, smoothing the accumulation of sediments at the beginning of the pond, passing to its uniform distribution along the bed. The scenarios showed that the longitudinal arrangement of the barriers presents less formation of dead zones, retromixing zones, and short-circuit zones, being, therefore, the indicated for the mitigation of problems through low investments.

It was also concluded with the analyses, that ponds with smaller dimensions and the choice of systems with piston flow are better adapted to the treatment of effluents, and prevent the accumulation of sludge in specific posts of the bed, leading to continuous and uniform sedimentation. The choice of units with capacity for lower volumes and smaller dimensions is justified by the fact that the largest volume of deposited sediments was found close to the margins, where the fluid did not have enough velocity to drag the particles through the bed. This accumulation was also greater in the regions where the geometry shows curvature, so rectangular geometries should be chosen in the dimensioning and elaboration of the pond projects for wastewater treatment.

REFERENCES

[1] Kellner E, Pires EC (1988). **Lagoas de estabilização:** projeto e operação. Abes, Rio de Janeiro, 244 p.

[2] Silva JVN (2007). **Evaluation of the influence of baffles and inlet and outlet structures on the performance of stabilization ponds**. Dissertation, Federal University of Campina Grande, Campina Grande.

[3] TakeutiMRS (2003). **Performance evaluation of a sewage treatment plant by stabilization ponds with baffles**. Dissertation, Universidade Estadual Paulista Julio Mesquita Filho.

[4] Von Sperling M (2017). **Lagoas de estabilização**. 3ed.Universidade Federal de Minas Gerais, Belo Horizonte, 196 p.

From Lula to Bolsonaro: The immediate impacts of elections on abnormal returns in B3-listed companies

Alysson Vasconcelos Gomes de Menezes[1], Maycon Peter da Rosa[2], Roberto Pires Soares Júnior[3], Nelson Hein[4], Adriana Kroenke Hein[5]

[1] Department of Accounting, Federal Fluminense University, Macaé, RJ, Brazil.
Email[1]: vasconcelos.alysson@gmail.com

[2,3] Department of Accounting, Regional University of Blumenau, Blumenau, SC, Brazil and Department of accounting, Federal Fluminense University, Macaé, RJ, Brazil.
Email[2]: mayconpeter@id.uff.br
Email[3]: robertopires@id.uff.br

[4,5] Department of Accounting, Regional University of Blumenau, Blumenau, SC, Brazil
Email[4]: hein@furb.br
Email[5]: akroenke@furb.br

Abstract— Events not directly related to the operation of companies, such as elections and changes in laws, can influence the value of shares and impact the stock market as a whole. Considering the proximity of the Brazilian presidential election in 2022, and aiming to assess trends in the value of some shares and the Brazilian stock market, in this paper it is presented the analysis of the Accumulated Abnormal Returns on the value of common shares of large Brazilian companies after presidential elections. It is also presented the immediate reaction of the Brazilian Stock Market (B3). Eight companies were selected for the study, they are: Petrobras, Banco do Brasil, Vale, Itaúsa, Eletrobrás, Itaú Unibanco Holding and JBS. The criterion for this selection was based on the Forbes Global 2000 ranking published from 2008 to 2021, as will be detailed in the methodology. An Event Study was conducted to calculate the Accumulated Abnormal Returns (RAA) on the value of shares after the first round (event 1) and second round (event 2) of the presidential elections of 2002, 2006, 2010, 2014 and 2018. It was concluded that there were abnormal returns arising from the results of the presidential elections and some common shares were more impacted than others. In the joint view (first and second rounds of each election), Petrobras common shares were the only ones that presented a negative joint Accumulated Abnormal Return (RAA_c) after all presidential elections, in addition to obtaining the highest negative RAA_c. About the market reaction, captured through the analysis of the Ibovespa, it was observed that the result was negative in the first victory of Lula (2002), however, in his reelection (2006), it was obtained the highest positive result. Regarding the Bolsonaro election (2018), the Ibovespa ROA_c was 6.6%, being the most optimistic compared to the first election of Lula (2002) and Dilma (2010).

I. INTRODUCTION

Factors unrelated to the operations of the companies cause disturbances in the stock market, one of these of great relevance is the political scenario of a country. During electoral campaigns and based on the prospectus of winners, impacts are noticed in the stock market and, in the market value of companies with shares in the Brazilian Stock Market (B3). This phenomenon is easy to understand qualitatively, considering that during political campaigns it is possible to identify promises related to privatization, tax reform, labor reform, social security reform, and many others. These promises, if fulfilled, will culminate in increased or decreased spending for companies operating in the country, attractiveness for private capital investments in specific sectors of the economy, and so on. Thus, the result of the presidential elections generates expectations and uncertainties that cause changes in the value of stocks that are divergent from those that would be generated due to the normal movements of the stock market. It is from these unforeseen variations that the abnormal returns in stock value are calculated. In this context, this research is delimited to the quantitative evaluation of the impacts of the Brazilian presidential elections of 2002, 2006, 2010, 2014 and 2018 on the common stock price of eight large Brazilian companies, which were selected based on the Forbes Global 2000 ranking published in the period from 2008 to 2021. The cumulative abnormal returns of each stock were calculated using the Event Study methodology, and the events analyzed were the first and second rounds of each election. Additionally, the joint impact (first and second rounds) on the value of each share and the Accumulated Observed Return of Ibovespa after each round and in the joint view were calculated and analyzed.

II. LITERATURE REVIEW

According to Brealey, Myers, & Allen (2011), and Nasdaq (2021), abnormal returns are a portion of a stock's return that is not due to the price movement of the market as a whole. In other words, it is the difference between the current return and that which is expected due to market movements (normal return).

In the literature there are several studies about events that cause variations in stock prices and that can generate opportunities for attentive investors. In Costa, Galdi, & Nossa (2013), the authors suggest that it is possible to set up an investment strategy in a period immediately after an airplane crash. According to the authors, an area of studies known as behavioral finance reveals that certain situations can generate misperceptions of reality. Costa, Galdi, & Nossa (2013), apud Kaplanski and Levi (2010), found

evidence that after an air crash there are losses of more than $ 60 billion in the market value of companies while it is estimated that the actual loss is no more than $1 billion. The price reversal occurs in approximately two days.

Other research has evaluated abnormal returns arising from the involvement of companies in scandals, such as Costa, Souza, Duval, Pimenta, & Rosa (2017), which analyzed the impact of Operation Weak Meat on the shares of some large meatpacking plants targeted by this investigation; and Bastos, Rosa, & Pimenta (2016), which evaluated the impact of Operation Lava Jato and the 2014 global oil crisis on Petrobras shares.

In Smith & Aggarwal (2015), the authors analyzed the impact of U.S. presidential election cycles over a period of more than forty years on more than seventy industries and concluded that by observing who is ahead in the polls ninety days before the presidential election, they could plot investment strategies and earn significant abnormal returns. The authors listed several articles that showed abnormal returns earned by companies in the face of presidential election results and pointed out that this phenomenon is observed in several countries. Still on presidential elections, Jacob Júnior & Souza (2020) evaluated the impacts of the 2018 elections in Brazil on the share price of Banco do Brasil, Bradesco, and Santander, with one of their conclusions being that investors in these companies earned higher than expected returns as a result of the elections. Schmidt, Martin, & Quadrado (2020) analyzed the abnormal returns of Petrobras, Banco do Brasil, and Eletrobras in the 2018 elections and concluded that the first two had less relevant abnormal returns when compared to those observed in Eletrobras shares.

In Salazar (2007), the author evaluated the phenomenon of abnormal returns arising from the inclusion and exclusion of stocks in the theoretical portfolio of the Bovespa Index (Ibovespa). This is the main indicator of the average performance of stock quotes traded on B3. The index is calculated on a theoretical portfolio of stocks that corresponds to about 80% of the financial volume of the capital market, and is re-evaluated every four months. The author concluded that "the re-evaluation of the Bovespa Index Theoretical Portfolio has informational content because the event of its publication guides the market to invest or not in the stocks that experience the mentioned inclusion and exclusion occurrences".

Other authors have also evaluated abnormal stock returns arising from the disclosure of accounting results of the companies, as can be seen in Sarlo Neto (2004), and Sarlo Neto, Galdi, & Dalmácio (2009); and, more comprehensively, they also evaluated the impacts of news

published in the Valor Econômico newspaper on the value of stocks, as can be consulted in Ferrer (2008). In all these cases it was possible to verify the existence of correlation between the events and the reflection on the share prices of the companies involved.

It can be seen, therefore, that there are several studies that have found the existence of abnormal returns on the value of the shares of certain companies as a result of various events.

III. THEORETICAL BACKGROUND

An event study consists of evaluating the impacts of a given event on the stock value of a given company. According to Campbell, Lo, & MacKinlay, p. 149 (1998), the technique has been widely used in academia to assess the most diverse events such as company mergers, publication of earnings, changes in the regulatory environment, and others. The analysis of impacts of a given event can be conducted following the steps:

1) Definition of the event: consists in determining the event of interest and identifying the period in which the values of the shares will be evaluated. This period is known as the event window. According to Campbell, Lo, & MacKinlay, p. 151 (1998), generally the event window is expanded to a period of two days, the day of the announcement and the subsequent day.

2) Definition of the selection criterion: this is the criterion used to include a particular company in the study.

3) Normal return and abnormal return calculation: To evaluate the impact of an event it is necessary to measure the abnormal return. This return is observed after the event. The normal return, on the other hand, is the one expected if the event does not occur. The Stock Return, $R_{i,t}$, and the Market Return, R_m, can be calculated according to Sarlo Neto, p. 120 (2004) as:

$$R_{i,t} = \frac{P_{i,t} - P_{i,t-1}}{P_{i,t-1}}, \tag{1}$$

$$R_{m,t} = \frac{Ind_t - Ind_{t-1}}{Ind_{t-1}}, \tag{2}$$

where:

$R_{i,t}$: is the rate of return of stock i in period [$t,t-1$];

$P_{i,t}$: is the price of share i at date t;

$P_{i,t-1}$: is the price of share i at date $t-1$;

$R_{m,t}$: is the market rate of return in period [$t, t-1$];

Ind_t: is the value of the market index (Ibovespa) at date t;

Ind_{t-1}: is the value of the market index (Ibovespa) at date $t-1$.

To calculate the normal return it will be used the market model, presented in (3), where α_i and β_i are calculated by linear regression of the returns of a stock, $R_{i,t}$, and the market rate of return, $R_{m,t}$, using the Ordinary Least Squares (OLS) method.

$$R_{i,t} = \alpha_i + \beta_i R_{m,t} + e_{i,t}, \tag{3}$$

where:

α_i: is the intercept obtained by liner regression for company i;

β_i: is the coefficient of variation obtained by linear regression for company i;

$e_{i,t}$: is the error obtained in the linear regression for company i;

Once the parameters α_i and β_i have been calculated, the expected returns for a stock in a given period can be calculated using (4).

$$E[R_{i,t}] = \alpha_i + \beta_i R_{m,t}, \tag{4}$$

where:

$E[R_{i,t}]$: is the normal return (expected return) of stock i in period t according to the market line.

Finally, the difference between the observed return of stock i in period t, $R_{i,t}$, and the expected return, $E[R_{i,t}]$, is the Abnormal Return for firm i in period t, $RA_{i,t}$, as per (5).

$$RA_{i,t} = R_{i,t} - E[R_{i,t}], \tag{5}$$

The Accumulated Abnormal Return (*RAA*) is defined by (7) and represents the accumulated abnormal percentage change in the observation window after the event. In the literature it is also referred to as Buy and Hold Abnormal Return (BHAR), as can be seen in Dutta & Dutta, p. 28 (2015), and Barber & Lyon, p. 4, (1997).

$$RAA = Accumulated\ Observed\ Return - Accumulated\ Expected\ Return,$$

$$RAA = ROA - REA. \tag{6}$$

Algebraically, (6) can be written according to (7):

$$RAA = \prod_{t=1}^{N}(1 + R_{i,t}) - 1 - \left[\prod_{t=1}^{N}(1 + E[R_{i,t}]) - 1\right],$$

$$RAA = \prod_{t=1}^{N}(1 + R_{i,t}) - \prod_{t=1}^{N}(1 + E[R_{i,t}]), \tag{7}$$

where:

RAA: is the Accumulated Abnormal Return in the observation window after the event;

t: is a sample for which the abnormal return is being calculated. It assumes values from 1 to *N*, covering the entire observation window after the event;

N: represents the last sample of the observation window after the event.

Fig. *1* shows a temporal scheme of an Event Study, which is composed of three intervals: the estimation window, which is the reference interval for calculating the parameters α_i and β_i used in the calculation of the expected return; the event window, which is the interval of occurrence of the observed event; and the post-event window, which is the interval where the expected stock returns will be compared with the obtained returns, i.e., it is the window for calculating the abnormal returns.
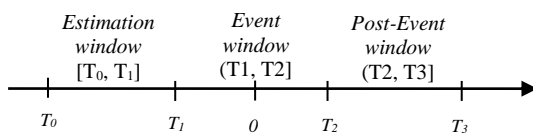
Fig. 1: Timeline for an Event Study.

4) Estimation procedure: to estimate abnormal returns it is necessary to classify what is normal return. The normal return is estimated using a data set from the estimation window. The estimation window should not contain the event window, in order to avoid influence of the event on the estimation of the normal return. This window is chosen before the event window and in the literature it is possible to verify the use of different periods. In Costa, Galdi, & Nossa (2013) the authors used, as an estimation window, sixty closing prices of the stock before the date of the accident. In Costa, Souza, Duval, Pimenta, & Rosa (2017), the estimation window was thirty days before the date of the event.

5) Test procedure: with the defined parameters for calculating the normal return, the next step is to calculate the abnormal returns according to (6).

6) Presentation of results, interpretation and conclusions: data analysis and discussion step.

IV. METHODOLOGY

To develop this research, an event study was conducted following the steps detailed in the theoretical background. The first and second rounds of the presidential elections of 2002, 2006, 2010, 2014, and 2018 were established as events to be analyzed.

The sample consisted of the eight publicly traded companies that between 2008 and 2021 were most often listed in the Forbes Global 2000 ranking among the twelve largest companies in Brazil. This ranking has been published since 2003 and is based on four criteria: sales, profit, assets, and market value, to indicate which are the two thousand largest publicly traded companies in the world. For simplification purposes, only the common shares of the companies were evaluated.

Table 1 shows the selected companies and the number of times each of them was among the twelve largest in Brazil in the 14-year period comprised from 2008 to 2021.

Table 1: Selected companies.

Company	Recurrences
Petrobras (PETR3)	14
Banco Bradesco (BBDC3)	14
Banco do Brasil (BBAS3)	14
Vale (VALE3)	14
Itaúsa (ITSA3)	14
Eletrobrás (ELET3)	11
Itaú Unibanco Holding (ITAU3/ITUB3)[1]	10
JBS (JBSS3)[2]	10

Note 1: The founding of Itaú Unibanco Holding S.A. (ITUB3) took place in 2008, with the merger of Banco Itaú and Unibanco, thus, prior to 2008 it was evaluated the impacts of the presidential elections on Banco Itau (ITAU3).

Note 2: The historical quotes of JBS are available starting in 2007, thus the impacts of presidential elections on this company were evaluated only in the 2010, 2014, and 2018 elections.

After selecting the companies, the **closing values** of the historical prices of the common shares and Ibovespa were obtained by consulting databases available on the website https://br.investing.com. Due to the normal volatility and fluctuation of stock prices in one day, it was decided to calculate and present the **accumulated returns** in the post-event window.

The parameter estimation window was defined as one hundred and twenty stock closing prices preceding the date of the presidential election in the first round. The parameters α_i and β_i of the market model, (3), were calculated in the estimation window using the Microsoft Excel® Data Analysis tool to run the linear regressions by the Ordinary Least Squares method. In all regressions the

T-test of Student was performed. The null hypothesis of the T test is that the parameter associated with the independent (or explanatory) variable is equal to zero. This hypothesis can be rejected if the *t* modulus is greater than two. The P value associated with each of the T-tests was also checked. In all cases, the parameters where the null hypothesis was rejected with a significance equal to or less than 5% (P- value < 5%) were considered. Appendix A presents a summary of the results obtained in the linear regressions to determine α and β.

The event window corresponds to the election date in each year. This window was defined as only one day because price variations in the shares were verified sometimes higher than 7% already in the first quotation after the election. That is, immediately after the election, it was observed an influence on the price of some stocks.

Both the first and second rounds of the elections of 2002, 2006, 2010, 2014, and 2018 were evaluated, so in each election two events were analyzed. Table 2 shows the dates of the presidential elections held since 2002, the candidates for the second round, those who were elected (highlighted in bold), their respective political parties, and the percentage of votes they obtained in each round.

Table 2: Summary of presidential election results from 2002 to 2018.

Year	Round	Candidate	Political party	Votes (%)
2002	First 10/06/2002	Luiz Inácio Lula da Silva	PT[3]	46,44
		José Serra	PSDB[4]	23,19
	Second 10/27/2002	**Luiz Inácio Lula da Silva**	PT	61,27
		José Serra	PSDB	38,72
2006	First 10/01/2006	Luiz Inácio Lula da Silva	PT	48,61
		Geraldo Alckmin	PSDB	41,64
	Second 10/29/2006	**Luiz Inácio Lula da Silva**	PT	60,83
		Geraldo Alckmin	PSDB	39,17
2010	First 10/03/2010	Dilma Rousseff	PT	46,91
		José Serra	PSDB	32,61
	Second 10/31/2010	**Dilma Rousseff**	PT	56,05
		José Serra	PSDB	43,65
2014	First 10/05/2014	Dilma Rousseff	PT	41,59
		Aécio Neves	PSDB	33,55
	Second 10/26/2014	**Dilma Rousseff**	PT	51,64
		Aécio Neves	PSDB	48,36
2018	First 10/07/2018	Jair Bolsonaro	PSL[5]	46,03
		Fernando Haddad	PT	29,28
	Second 10/28/2018	**Jair Bolsonaro**	PSL	55,13
		Fernando Haddad	PT	44,87

Source: https://pt.wikipedia.org/

[3]PT: Party of the Workers (*Partido dos Trabalhadores*).

[4]PSDB: Brazilian Social Democracy Party (*Partido da Social Democracia Brasileira*).

[5]PSL: Social Liberal Party (*Partido Social Liberal*).

The post-event window, in which abnormal returns are calculated, was defined as seven stock closing prices after each event window, that is, after the dates of the first and second rounds. Table 3 shows a summary of the parameters defined for the event studies developed in this research.

Table 3: Parameters used in the Event Study.

Event definition	Event 1: first round of the Brazilian presidential elections from 2002 to 2018. Event 2: second round of the Brazilian presidential elections from 2002 to 2018.
Criterion for selection of the companies	Eight most recurrent companies among the twelve largest in Brazil according to the Forbes Global 2000 ranking in the period between 2008 and 2021.
Estimation window	One hundred and twenty closing prices of shares that precede the date of the presidential elections in the first round.
Evenw window	Window of event 1: day of the first round of voting; Window of event 2: day of the second round of voting.
Post-event window	Window 1: seven closing prices of shares after the first round of voting; Window 2: seven closing prices of shares after the second round of voting.

It is necessary to emphasize that it was not verified if there were other events that occurred simultaneously to the presidential elections and that may have caused some impact on the prices of the shares of the evaluated companies. To minimize this possibility of interference from other events, the estimation window was defined close to the event of interest and the observation period (pos-event window) is a short interval soon after the event

of interest. Furthermore, the methodology applied has a limitation concerning the analysis of simultaneous events since there is no way to predict the percentage of impact attributed to more than one event if they occur simultaneously.

To evaluate the market reaction to the results of the presidential elections in the first and second rounds, the Accumulated Observed Return of the market index, ROA_m defined by (8), was calculated in the intervals after the events. The market index used was the Ibovespa.

$$ROA_m = \prod_{t=1}^{N}\left(1 + R_{m,t}\right) - 1 \qquad (8)$$

Finally, the joint Accumulated Abnormal Return, RAA_c, is given by (11):

$$ROA_c = (1 + ROA_{1° t})(1 + ROA_{2° t}) - 1, \qquad (9)$$

$$REA_c = (1 + REA_{1° t})(1 + REA_{2° t}) - 1, \qquad (10)$$

$$RAA_c = ROA_c - REA_c, \qquad (11)$$

where:

ROA_c: is the joint Acumulated Observed Return. It represents the cumulative observed impact of the first and second shifts on the stock price;

REA_c: is the joint Accumulated Expected Return. It represents the cumulative expected impact of the first and second shifts on the stock price;

$ROA_{x° t}$: is the Accumulated Observed Return after round x°. x = 1 or 2; and

$REA_{x° t}$: is the Accumulated Expected Return after round x°. x = 1 or 2.

V. RESULTS AND DISCUSSIONS

After calculating the parameters α_i and β_i, it was found that the intercept, α_i, proved to be non-significant for all models, i.e., equal to zero (α_i= 0). This means that the fixed rate of return can be disregarded in the models. Moreover, in the subsequent data analyses, it must be clear that:

- Whenever only mentioned 'expected return', 'observed return', 'abnormal return', 'expected increase', 'expected decrease', these expressions are referring to the values accumulated in the post-event windows;
- JBSS3 shares have a historical record of share prices only from 2007 onward, which is the year the company entered the B3. Thus, only the impacts after 2007 on the stock value were evaluated.

Evaluation of impact on common shares

Table 4 shows *β, ROA*, *REA* and *RAA* after the first and second rounds. It is also presented the joint impact of the two rounds of each election on the analyzed common shares. In the 'Pos.' column there is a sequence in descending order of absolute value of the *RAA*. Finally, it is possible to consult the accumulated observed return of the Ibovespa after each round and in the joint view.

Elections of 2002

The linear regression with VALE3 prices in the estimation window returned parameters *α* and *β* with p-value greater than 5%, therefore, not significant. Thus, the returns of these common shares were not calculated in 2002.

It was found that in the historical quotes of ITSA3 in 2002 there are only 115 days of stock prices recorded. In the same year, there are 249 days in which the Ibovespa value is recorded, so, for some unknown reason, there are no records of the historical quotes of this common share on all business days in 2002. Given the scarcity of data, the estimation window (120 quotations prior to the date of the first round) reached the year 2001. Additionally, while the second round of elections took place on 10/27/2002, the first record of quotations after this date is from 11/04/2002, i.e. there was a gap of quotations from 10/28/2002 to 11/01/2002, a period fully comprised in the post-event window of the second round. In order to not distort the analysis due to this gap, ITSA3 returns in 2002 were not calculated.

It was also noted that there were only 184 quotations for ITAU3 in 2002. Additionally, in this year the first round occurred on 10/06/2002 and while Ibovespa has historical data from 10/07/2002, the first ITAU3 quote is from 10/09/2002, that is, only three days after the election date. It was also verified that until 10/15/2002, Ibovespa had seven historical values after the date of the event. For ITAU3, this post-event window closed only on 10/24/2002. In order to not distort the analysis due to these information gaps, the returns of ITAU3 in 2002 were not calculated.

In the first round, Lula and Serra were selected to run in the second with 46.44% and 23.19% of the votes, respectively. After the results of the first round, PETR3 showed *ROA* of -16.34%, the largest drop observed that year, being -9.12% the abnormal return, also the largest in absolute value. In a joint analysis of the returns in the first and second rounds, PETR3 had -20.3% ROA_c, being -11.8% the RAA_c this year. Among the stocks analyzed, in 2002 PETR3 was the one that presented the greatest impact in the combined view of the two rounds, followed by BBAS3.

In this year Lula was elected for his first mandate and the market reacted negatively, presenting a ROA_c of -9.5%.

Elections of 2006

It was observed that the regression statistics indicated the coefficient β significant (P-value < 5%), however, the R^2 parameter was very low, in the order of 5%. Thus, there must be other models that better represent the variations in the ITSA3 share price in 2006. For this reason, the returns of this stock in the year were not calculated.

In the first round, Lula and Alckmin were elected to run in the second with 48.61% and 41.64% of the votes, respectively. With these results, PETR3 had the most negative RAA (-6.98%) and BBAS3 the most positive (3.26%). Lula was elected in the second round and, in a view of the accumulated impact of the two rounds, PETR3 was again the stock that presented the highest negative accumulated abnormal return (RAA_c = -8.2%).

This year Lula was elected for a second mandate and the market reacted positively, presenting ROA_c of 11.5%, the most positive reaction in the five elections analyzed.

Elections of 2010

Dilma and Serra were selected with 46.91% and 32.61% of the votes, in that order, to dispute the second round. Facing these results ELET3 presented the highest RAA (12.11%) and PETR3 the lowest (-8.42%). Dilma was elected for her first term in office and, on the combined impact view, PETR3 presented the most negative RAA_c for the third consecutive election (-4.7%) and ELET3 presented RAA_c equal to 9.2%, which was the highest in these elections.

The stock market reacted positively with Dilma's election, with ROA_c of Ibovespa equal to 3.5%.

Elections of 2014

Dilma and Aécio were chosen with 41.59% and 33.55% of the votes, in that order, to run in the second round. Facing this result, JBSS3 presented the most negative RAA_c (-3.20%) and BBAS3 the most positive (19.21%). In the second round Dilma was elected and PETR3 was for the fourth time the stock with the most negative RAA_c (-16.8%). On the other extreme, BBAS3 had RAA_c equal to 27.1%, which was the highest in this election.

Ibovespa reacted positively to Dilma's reelection and the joint accumulated observed return was equal to 11.4%, the second most positive reaction of this indicator among the five elections analyzed.

Elections of 2018

In 2018 Bolsonaro and Haddad were selected in the first round with 46.03% and 29.28% of the votes, respectively. In this scenario, the highest and lowest RAA were 6.19% and -1.72% of JBSS3 and ITSA3, respectively. With Bolsonaro's election in the second round the biggest joint impacts in absolute value were on JBSS3 (10.4%) and BBDC3 (7.2%). This year the market reacted positively, presenting ROA_c of 6.6%.

To present a concise view of the stocks that were most influenced by the election results, in Table 5 the five highest positive and the five highest negative abnormal returns were consolidated after the first and second rounds and in the combined view. PETR3 led among the most negatively impacted stocks occupying three of five positions after the first round, two of five positions after the second round and three of five positions in the joint impact.

Regarding the three highest positive RAA, BBAS3 was the stock that presented the highest values after the first round, second round and in the combined view.

To verify the companies less influenced by the election result in the global view, the joint accumulated abnormal return with an absolute value equal to or less than 2% ($|RAA_c| \leq 2\%$) was classified as neutral. The stocks that fell within this range were VALE3 in 2006 (0.2%), ELET3 in 2018 (-0.7%), and VALE3 in 2010 (1.3%).

Evaluation of impact on Ibovespa

Error! Reference source not found. Thus, the first victory of Lula represented at the time a rupture in ideologies and in the governing plan for the country. In this scenario, it is believed that this partisan discontinuity may be contributed to the fall of Ibovespa soon after the election result and the $ROAc$ was equal to -9.5% this year.

In 2006 and 2014, in the re-elections of Lula and Dilma, the $ROAc$ was 11.5% and 11.4%, respectively, which were the most positive immediate reactions of the stock market. It is believed that the continuity of government ideologies influenced this positive result.

Table 6 shows the candidates selected in each round of elections, the accumulated observed return on Ibovespa, ROA_m, and the joint impact, ROA_c, calculated according to (8) and (9), respectively.

Only in 2002, in Lula's first victory, which was also the first victory of a PT-affiliated presidential candidate, the reaction of the stock market was negative. Before this election, Brazil had been presided over by Fernando Henrique Cardoso since 1995, who was a member of the PSDB and whose PT was in opposition.

Table 4: Abnormal returns per election and in order of decreasing absolute value of RAA in the second round.

Year	Company	β	After first round ROA (%)	REA (%)	RAA (%)	Pos.	After second round ROA (%)	REA (%)	RAA (%)	Pos.	Joint view ROAc (%)	REAc (%)	RAAc (%)
2002	Banco do Brasil	1,153	-4,90	-9,36	4,46	3°	5,77	-1,82	7,58	1°	0,6	-11,0	11,6
	Eletrobras	1,112	-8,13	-9,02	0,89	4°	2,26	-1,74	4,00	2°	-6,1	-10,6	4,6
	Petrobras	0,887	-16,34	-7,22	-9,12	1°	-4,70	-1,34	-3,36	3°	-20,3	-8,5	-11,8
	Itaú	NA*	NA*				NA*				NA*		
	Bradesco	0,839	-12,96	-6,84	-6,12	2°	-3,57	-1,26	-2,31	4°	-16,1	-8,0	-8,1
	Itaúsa	NA*	NA*				NA*				NA*		
	Vale	NA*	NA*				NA*				NA*		
	JBS	NA*	NA*				NA*				NA*		
	Ibovespa (BVSP)	NA*	-8,13	NA*			-1,54	NA*			-9,5	NA*	
2006	Itaúsa	NA*	NA*				NA*				NA*		
	Itaú	1,069	7,22	6,47	0,75	5°	-1,14	5,46	-6,60	1°	6,0	12,3	-6,3
	Bradesco	0,834	6,20	5,04	1,16	3°	-0,64	4,25	-4,88	2°	5,5	9,5	-4,0
	Eletrobras	1,298	9,03	7,88	1,15	4°	2,81	6,65	-3,84	3°	12,1	15,0	-3,0
	Petrobras	0,913	-1,46	5,52	-6,98	1°	3,69	4,65	-0,96	4°	2,2	10,4	-8,2
	Banco do Brasil	1,212	10,61	7,35	3,26	2°	5,60	6,20	-0,60	5°	16,8	14,0	2,8
	Vale	1,005	6,24	6,08	0,16	6°	5,16	5,13	0,037	6°	11,7	11,5	0,2
	JBS	NA*	NA*								NA*		
	Ibovespa (BVSP)	NA*	6,05	NA*			5,1	NA*			11,5	NA*	
2010	Petrobras	0,902	-6,57	1,86	-8,42	2°	5,37	1,23	4,13	1°	-1,5	3,1	-4,7
	Itaú Unibanco	0,969	4,79	1,99	2,80	5°	4,49	1,32	3,17	2°	9,5	3,3	6,2
	Eletrobras	0,699	13,55	1,44	12,11	1°	-1,74	0,96	-2,70	3°	11,6	2,4	9,2
	Bradesco	0,921	4,88	1,90	2,98	4°	3,84	1,26	2,58	4°	8,9	3,2	5,7
	Vale	1,242	1,42	2,55	-1,13	8°	4,11	1,69	2,42	5°	5,6	4,3	1,3
	JBS	0,944	-0,79	1,94	-2,74	6°	-0,53	1,29	-1,82	6°	-1,3	3,3	-4,6
	Itaúsa	0,623	2,90	1,29	1,62	7°	2,23	0,86	1,38	7°	5,2	2,2	3,0
	Banco do Brasil	0,942	6,49	1,94	4,55	3°	2,16	1,29	0,87	8°	8,8	3,3	5,5
	Ibovespa (BVSP)	NA*	2,06	NA*			1,37	NA*			3,5	NA*	
2014	Petrobras	1,996	16,68	12,51	4,17	3°	-9,26	9,04	-18,30	1°	5,9	22,7	-16,8
	Vale	0,531	4,09	3,41	0,68	8°	-12,17	2,54	-14,71	2°	-8,6	6,0	-14,6
	JBS	1,186	4,33	7,54	-3,20	4°	12,92	5,54	7,38	3°	17,8	13,5	4,3
	Eletrobras	1,432	11,34	9,06	2,28	6°	-0,33	6,63	-6,96	4°	11,0	16,3	-5,3
	Itaú Unibanco	0,994	8,81	6,33	2,47	5°	10,92	4,68	6,25	5°	20,7	11,3	9,4
	Banco do Brasil	1,380	27,95	8,74	19,21	1°	11,63	6,40	5,23	6°	42,8	15,7	27,1
	Bradesco	1,272	8,81	8,07	0,74	7°	10,40	5,92	4,47	7°	20,1	14,5	5,7
	Itaúsa	1,061	25,19	6,75	18,43	2°	5,45	4,98	0,47	8°	32,0	12,1	19,9
	Ibovespa (BVSP)	NA*	6,37	NA*			4,7	NA*			11,4	NA*	
2018	Petrobras	1,570	11,01	6,47	4,55	3°	-2,69	3,57	-6,26	1°	8,0	10,3	-2,2
	Banco do Brasil	1,728	11,13	7,09	4,04	4°	-2,27	3,90	-6,17	2°	8,6	11,3	-2,7
	Bradesco	1,381	6,91	5,72	1,20	6°	8,72	3,16	5,56	3°	16,2	9,1	7,2
	Eletrobras	1,889	13,07	7,72	5,35	2°	-1,27	4,23	-5,51	4°	11,6	12,3	-0,7
	Itaú Unibanco	0,939	4,48	3,93	0,55	7°	7,18	2,19	4,99	5°	12,0	6,2	5,8
	Itaúsa	0,996	2,44	4,16	-1,72	5°	6,46	2,32	4,14	6°	9,1	6,6	2,5
	JBS	0,590	8,68	2,49	6,19	1°	5,16	1,39	3,77	7°	14,3	3,9	10,4
	Vale	0,570	2,28	2,41	-0,13	8°	3,58	1,35	2,23	8°	5,9	3,8	2,1
	Ibovespa (BVSP)	NA*	4,18	NA*			2,33	NA*			6,6	NA*	

NA: not applicable or not calculated;   RAA: Accumulated Abnormal Return;

ROA: Accumulated Observed Return;   *ROA$_c$*: Joint Accumulated Observed Return;

REA: Accumulated Expected Return;

REA$_c$: Joint Accumulated Expected Return;

RAA$_c$: Joint Accumulated Abnormal Return.

Table 5: Five highest positive abnormal returns and five highest negative abnormal returns.

	Position	RAA after 1° round (Share/Year/Value %)			RAA after 2° round (Share/Year/Value %)			RAA_c Share/Year/Value %)		
(+)	1°	BBAS3	2014	19,2	BBAS3	2002	7,6	BBAS3	2014	27,1
	2°	ITSA3	2014	18,4	JBSS3	2014	7,4	ITSA3	2014	19,9
	3°	ELET3	2010	12,1	ITUB3	2014	6,2	BBAS3	2002	11,6
	4°	JBSS3	2018	6,2	BBDC3	2018	5,6	JBSS3	2018	10,4
	5°	ELET3	2018	5,3	BBAS3	2014	5,2	ITUB3	2014	9,4
(-)	1°	PETR3	2002	-9,1	PETR3	2014	-18,3	PETR3	2014	-16,8
	2°	PETR3	2010	-8,4	VALE3	2014	-14,7	VALE3	2014	-14,6
	3°	PETR3	2006	-7,0	ELET3	2014	-7,0	PETR3	2002	-11,8
	4°	BBDC3	2002	-6,1	ITAU3	2006	-6,6	PETR3	2006	-8,2
	5°	JBSS3	2014	-3,2	PETR3	2018	-6,3	BBDC3	2002	-8,1

Thus, the first victory of Lula represented at the time a rupture in ideologies and in the governing plan for the country. In this scenario, it is believed that this partisan discontinuity may be contributed to the fall of Ibovespa soon after the election result and the ROA_c was equal to -9.5% this year.

In 2006 and 2014, in the re-elections of Lula and Dilma, the ROA_c was 11.5% and 11.4%, respectively, which were the most positive immediate reactions of the stock market. It is believed that the continuity of government ideologies influenced this positive result.

Table 6: Accumulated Observed Return on the Ibovespa (ROAₘ) immediately after the presidential elections.

Year	After 1st round		After 2nd round		Joint view
	Candidates	ROA_m (%)	Elected	ROA_m (%)	ROA_c (%)
2002	Lula (46,44%) Serra (23,19%)	-8,13	Lula (61,27%)	-1,54	-9,5
2006	Lula (48,61%) Alckmin (41,64%)	6,05	Lula (60,83%)	5,10	11,5
2010	Dilma (46,91%) Serra (32,61%)	2,06	Dilma (56,05%)	1,37	3,5
2014	Dilma (41,59%) Aécio (33,55%)	6,37	Dilma (51,64%)	4,70	11,4
2018	Bolsonaro (46,03%) Haddad (29,28%)	4,18	Bolsonaro (55,13%)	2,33	6,6

In 2018, Bolsonaro was elected president and at that time he was a member of the PSL, a party that was in opposition to PT. Thus, there was again a major ideological discontinuity of government. At that time, the country was also going through strong political instability with the arrest of former president Lula and the interruption of Dilma's mandate through impeachment. In this unstable scenario, after the victory of Bolsonaro the ROA_c was equal to 6.6% and represented a positive reaction from the stock market. It is believed that this ideological discontinuity contributed to this positive result right after the election.

VI.   CONCLUSION

In this research the Accumulated Abnormal Returns, *RAA*, of the common shares of eight Brazilian companies immediately after the presidential elections of 2002, 2006, 2010, 2014, and 2018 were calculated and analyzed. The companies that were most often listed among the twelve largest in Brazil according to the Forbes Global 2000 ranking, published annually from 2008 to 2021, were selected for the analysis, and they are: Petrobras (PETR3), Bradesco (BBDC3), Eletrobras (ELET3), Banco do Brasil (BBAS3), Vale (VALE3), Itaúsa (ITSA3), Itaú (ITAU3/ITUB3) and JBS (JBSS3). The events analyzed were the first and second rounds of each presidential election, as well as the joint (cumulative) impact of the two rounds on stock returns. Additionally, to verify the reaction of the Brazilian stock market to the election results, the accumulated observed return of Ibovespa,

ROA_m, was calculated and analyzed after each round and in the combined view.

Regarding the joint impact after each election, PETR3 was the only stock that presented a negative joint Accumulated Abnormal Return, RAA_c, in all elections. The three most negative RAA_c were those of PETR3 (-16.8%), VALE3 (-14.6%) and PETR3 (-11.8%) after the 2014, 2014 and 2002 elections, respectively. At the other extreme, the stocks that presented the three highest RAA_c were BBAS3 (27.1%), ITSA3 (19.9%) and BBSA3 (11.6%), in 2014, 2014 and 2002, in that order. VALE3, on the other hand, in 2006 and 2010, and ELET3 in 2018, presented RAA_c with an absolute value of less than 2%, as can be seen in Table 5, and were the stocks least impacted by the election results considering the joint impact of both rounds.

With regard to the influence of the election results on Ibovespa, it was found that in 2002, the year Lula was elected for his first term, the joint Accumulated Observed Return, ROA_c, of this index was -9.5%, being 2002 the only presidential election in which Ibovespa's ROA_c was negative. On the other hand, the highest ROA_c was 11.5%, after the 2006 election (the year Lula was reelected), and 11.4% in 2014 (the year Dilma was reelected). Thus, the Brazilian stock market reacted pessimistically in Lula's first election, somewhat optimistically in the election of Dilma ($ROA_c = 3.5\%$), the country's first female president, and quite optimistically in the reelections of Lula and Dilma. In 2018, with the first election of Bolsonaro, the ROA_c of Ibovespa was 6.6%, signaling an optimist reaction of the market, which was not as expressive as the elections of 2006 and 2014, however, it was the most optimistic when compared to the first election of Lula (2002 / -9.5%) and Dilma (2010 / 3.5%).

As future research, it is suggested to categorize companies into sectors (agribusiness, financials, energy, etc.) and evaluate the impact of the presidential elections on each sector individually. Another suggestion consists in verifying the impacts of elections on companies in the same sector, but with different capital structures, e.g., companies where the government is the controlling shareholder versus companies where the government is not the controlling shareholder.

REFERENCES

[1] Barber, B. M., & Lyon, J. D. (1997). Detecting long-run abnormal stock returns: empirical power and specification of test statistics. *Journal of Financial Economics*, pp. 341-372.

[2] Bastos, E. d., Rosa, M. P., & Pimenta, M. M. (Set de 2016). Os Impactos da Operação Lava Jato e da Crise Internacional do Petróleo nos Retorno Anormais e Indicadores Contábeis da Petrobras 2012 - 2015. *Pensar Contábil, 18*, 49-56.

[3] Brealey, R. A., Myers, S. C., & Allen, F. (2011). *Principles of corporate finance* (10 ed.). New York: McGraw-Hill.

[4] Campbell, J. Y., Lo, A. W., & MacKinlay, A. C. (1998). *The Econometrics of Financial Markets.* Princeton, New Jersey: Princeton University Press.

[5] Costa, A. V., Souza, E. N., Duval, L. D., Pimenta, M. M., & Rosa, M. P. (2017). Um Estudo sobre os Impactos da Operação Carne Fraca nos Retornos Anormais e nas Demonstrações Financeiras da BRF S.A. e JBS S.A. *VIII Congresso Brasileiro de Administração e Contabilidade - AdCont 2017.* Rio de Janeiro, RJ.

[6] Costa, M. R., Galdi, F. C., & Nossa, S. N. (junho de 2013). Estratégia de investimentos baseada em acidentes aéreos: há retornos anormais? *Revista de Educação e Pesquisa em Contabilidade (REPeC), 7*, 184-198.

[7] Dutta, A., & Dutta, P. (2015). Measuring long-run security price performance: a review. *Investment Management and Financial Innovations, 12*(2), 26-32.

[8] Ferrer, B. d. (2008). *Estudo de Evento sobre o Impacto de Notícias Veiculadas no Jornal Valor Econômico sobre o Valor das Ações.* Pontifícia Universidade Católica do Rio de Janeiro, Rio de Janeiro.

[9] Jacob Júnior, A. B., & Souza, J. F. (Jan - Jun de 2020). Reação do mercado às eleições presidenciais de 2018: um estudo de eventos em instituições financeiras de capital aberto. *Latin American Journal of Business Management*, pp. 142-152.

[10] Nasdaq. (s.d.). *Abnormal returns*. Acesso em 15 de Setembro de 2021, disponível em Nasdaq: https://www.nasdaq.com/glossary/a/abnormal-return

[11] Salazar, J. N. (set de 2007). O fenômeno de retornos anormais decorrentes da inclusão e exclusão das ações na carteira teórica do índice Bovespa. *Contabilidade & Finanças, 18*, 73-82.

[12] Sarlo Neto, A. (2004). *A Reação dos Preços as Ações à Divulgação dos Resultados Contábeis: Evidências Empíricas sobre a Capacidade Informacional da Contabilidade no Mercado Acionário Brasileiro.* Fundação Instituto Capixaba de Pesquisas em Contabilidade, Economia e Finanças - FUCAPE, Vitória.

[13] Sarlo Neto, A., Galdi, F. C., & Dalmácio, F. Z. (maio / agosto de 2009). Uma pesquisa sobre o perfil das ações brasileiras que reagem à publicação dos resultados contábeis. *Revista de Contabilidade e Organizações, 3*(6), 22-40.

[14] Schmidt, P., Martin, M. d., & Quadrado, G. M. (Out - Dez de 2020). Impactos das eleições presidenciais nas empresas federais. *Pensamento Contemporâneo em Administração, 14*.

[15] Smith, F., & Aggarwal, A. K. (April de 2015). Investing in presidential elections: using poll data to earn abnormal returns. *Journal of Business and Economics*, pp. 625-633.

APPENDIX A

Company	Year	R²	Intercept			Coefficient of variation		
			α	Stat t	P-Value	β	Stat t	P-Value
Petrobras (PETR3)	2002	0,405865	0,000916	0,412085	0,681024	0,886948	8,978197	5,19E-15
	2006	0,542967737	5,04705E-05	0,037689	0,969999	0,913253111	11,84008	8,54E-22
	2010	0,402705297	-0,001606082	-1,12557	0,26263	0,901986329	8,919497	7,12E-15
	2014	0,801476	0,000359	0,307982	0,758639	1,996169	21,82626	3,04E-43
	2018	0,39138359	0,001889895	0,736557	0,462854	1,569870904	8,711049	2,19E-14
Bradesco (BBDC3)	2002	0,408947	-0,00114	-0,546779248	0,585562899	0,839265	9,035683585	3,80307E-15
	2006	0,41534	0,000216	0,136555318	0,891615004	0,834222	9,155691038	1,98712E-15
	2010	0,619501	0,001124	1,198893051	0,232971616	0,920761	13,86069491	1,61338E-26
	2014	0,730175	-0,00017	-0,183388843	0,854807673	1,272125	17,8695543	2,32198E-35
	2018	0,729382	-0,00061	-0,555550866	0,579569689	1,380621	17,83362743	2,76284E-35
Banco do Brasil (BBAS3)	2002	0,456299	0,000222	0,085188678	0,932255762	1,153472	9,951429365	2,61519E-17
	2006	0,455396	-0,0002	-0,096033693	0,92365672	1,211638	9,933341196	2,88681E-17
	2010	0,476743	0,000803	0,625942419	0,532561588	0,9423	10,36872964	2,66835E-18
	2014	0,526942	0,000546	0,355635881	0,722748232	1,379935	11,46476804	6,62143E-21
	2018	0,651544	0,000432	0,260631368	0,794831082	1,728291	14,85382993	8,76913E-29
Vale (VALE3)	2002	0,007876195	0,002598331	1,378663106	0,17060669	0,081034406	0,967868393	0,335089683
	2006	0,631836859	-0,000331858	-0,270665803	0,787120945	1,00498067	14,23060386	2,28597E-27
	2010	0,440111231	0,000752594	0,413612892	0,679908378	1,241949384	9,630999296	1,50249E-16
	2014	0,188593249	-0,001536531	-1,187063814	0,237586703	0,531241582	5,237026446	7,21111E-07
	2018	0,160314232	0,002546264	1,48916863	0,139110858	0,570020393	4,746447122	5,86444E-06
Itaúsa (ITSA3)	2002	0,063682458	0,001385933	1,352876226	0,178681663	0,088263217	2,832952755	0,005425599
	2006	0,055927181	0,000366644	0,151649773	0,879722143	0,329729951	2,643928594	0,00930903
	2010	0,217737952	0,000621357	0,399696423	0,69010269	0,623019629	5,731020216	7,79351E-08
	2014	0,474409341	0,000187148	0,14263845	0,886819001	1,061165643	10,32033513	3,47769E-18
	2018	0,496873088	-0,001300199	-0,990193364	0,324105728	0,995581915	10,79505768	2,58428E-19
Eletrobras (ELET3)	2002	0,588182936	-0,003699183	-1,918436244	0,057471685	1,112039875	12,98210283	1,75946E-24
	2006	0,541309913	-0,000592646	-0,310453802	0,756763566	1,297530965	11,80060618	1,05921E-21
	2010	0,291650667	5,74082E-05	0,040588287	0,967692717	0,698695455	6,970256279	1,94473E-10
	2014	0,44914262	-0,000890365	-0,478078515	0,633478827	1,431602141	9,808747418	5,69988E-17
	2018	0,373733164	0,000967763	0,301946302	0,763224525	1,8890511	8,391548625	1,20707E-13
Itaú/Itaú Unibanco Holding (ITAU3/ITUB3)	2002	0,218364224	-0,001093412	-0,44712348	0,655605536	0,580840414	5,74155504	7,42385E-08
	2006	0,522500949	0,000361411	0,220345848	0,825982591	1,068500598	11,36313822	1,15389E-20
	2010	0,616959958	0,000311742	0,314471837	0,753718044	0,968561415	13,78628984	2,39407E-26
	2014	0,653129194	3,12232E-05	0,036690228	0,970793998	0,99408658	14,90584762	6,69229E-29
	2018	0,605791327	-0,00022461	-0,226147765	0,821477754	0,939372479	13,46602578	1,31655E-25
JBS (JBSS3)	2010	0,326939116	-0,001026001	-0,583449982	0,560703943	0,943533851	7,570895819	9,03425E-12
	2014	0,366021202	0,001539982	0,83983479	0,40269939	1,18609234	8,253853529	2,51E-13
	2018	0,1386103	-3,52522E-05	-0,018297894	0,985432111	0,589639882	4,357515267	2,82356E-05

Epidemiological profile of gestational syphilis in the municipality of Cacoal between 2016 and 2020

Perfil epidemiológico de sífilis gestacional no município de Cacoal entre 2016 e 2020

Gleison Faria[1], Gabriely Karise[1], Iuri Santana de Jesus[1], Francisco Leandro Soares de Souza[1], Gilvan Salvador Junior[1], Gesnaquele Souza da Cruz[1], Valérian Santos Souza Semczyszym[1], Taís Loutarte Oliveira[1], Karolayne Soares Cavalcanti[1], Gean Carlos da Silva Saar[1], Dhieniffer Naiara da Silva[1], Vinícius Gabriel Dumer Bressa[1], Ana Karolina Monge Silva Romano Mendonça[1], Elida Will[2], Vanessa Cardoso da Silva[2], Gislaine da Silva Santos[2], Pedro Washington Moreira Antunes[3], Francielly Maira Bordon[4], Davit Matuchaki dos Santos[4], Amanda Carolina Mendes Araujo[4], Wellington Ferreira de Souza[4], Giselen Maleski Cargnin[6], Vanessa Botoni da Silva Nogueira[6], Marco Rogério da Silva[7]

[1]Nurse at the Faculty of Biomedical Sciences of Cacoal – FACIMED – RO, Brazil. E-mail: gleisonfaria@hotmail.com
[2]Graduated from Higher Education in Cacoal, FANORTE, Rondônia, Brazil
[3]Graduating from Faculdade Uneouro - Ouro preto do Oeste - Rondônia, Brazil.
[4]São Lucas University Center, Ji-Paraná, Rondônia, Brazil
[5]Faculty of Education and Culture of Vilhena – UNESC, Vilhena, Rondônia, Brazil
[6]Nurse at the Claretian University Center - CEUCLAR - Porto Velho – RO
[7]Nurse at the University of Vale do Rio dos Sinos – UNISINOS - São Leopoldo, Rio Grande do Sul, Brazil

Abstract— Syphilis is a Sexually Transmitted Infection caused by the bacterium Treponema pallidum, with various forms of clinical presentations and different stages. When not diagnosed and treated early, it can cause harm to the pregnant woman and fetus. The present study aimed to identify the characteristics of the epidemiological profile of pregnant women affected by syphilis in the city of Cacoal between 2016 and 2020. Descriptive, retrospective and quantitative documentary research, where the initial sample consisted of 95 pregnant women who were registered in the database SINAN data with a diagnosis of Gestational Syphilis. The collected data were distributed and presented by means of statistics through tables and/or graphs elaborated after the analysis. The study complies with CONEP Resolution No. 466/2012 and was developed after approval by the CEP under Opinion 5,060,962. As a result of the research, it was identified that the year with the highest notification rate was in 2020, totaling 26% of cases, the predominance of the diagnosis was stopped in the first gestational trimester with 53%, in

relation to age there was a variation between 14 and 41 years. of age, with an average age of 23 years and greater involvement in the young population, from 21 to 30 years of age, comprising 45% of the sample, 33% have completed high school and only 2% have completed higher education. Regarding the clinical classification, 76% of the cases were diagnosed as tertiary syphilis, the rapid test was performed in 84% of the pregnant women and the VDRL in 94%, in both with a predominant reagent result rate, without the occurrence of concomitant non-performance of the tests, it was observed that the titration 8 of VDRL/RPR was predominant, totaling 18% of the cases studied. It is concluded that the increase in the number of cases, the predominance in the young population with complete secondary education, the diagnosis in the first trimester, however prevalently in the tertiary phase, and the failure to perform the rapid test in part of the cases, although the Ministry of Health recommends, highlight the need for improvements in the effectiveness of prenatal care and to outline strategies for prevention, promotion and health awareness.

Resumo— *A sífilis é uma Infecção Sexualmente Transmissível causada pela bactéria treponema pallidum, com várias formas de apresentações clínicas e com diferentes estágios. Quando não diagnosticada e tratada precocemente, pode acarretar agravos para a gestante e feto. O presente estudo teve como objetivo identificar as características do perfil epidemiológico das gestantes acometidas por sífilis no município de Cacoal entre 2016 e 2020. Pesquisa documental descritiva, retrospectiva e quantitativa, onde a amostra inicial constitui-se de 95 gestantes que foram registradas no banco de dados do SINAN com diagnóstico de Sífilis Gestacional. Os dados coletados foram distribuídos e apresentados por meio de estatística através de tabelas e/ou gráficos elaborados após a análise. O estudo está de acordo com a Resolução do CONEP nº 466/2012 e foi desenvolvida a partir da aprovação junto ao CEP sob o parecer 5.060.962. Como resultado da pesquisa identificou-se que o ano com maior índice de notificação foi em 2020 totalizando 26% dos casos, a predominância do diagnóstico se deteve no primeiro trimestre gestacional com 53%, em relação a idade houve uma variação entre 14 e 41 anos de idade, com idade média de 23 anos e maior acometimento na população jovem, de 21 a 30 anos de idade compreendendo 45% da amostra, 33% possuem ensino médio completo e apenas 2% possuem ensino superior completo. Em relação a classificação clínica 76% dos casos foram diagnosticados como sífilis terciária, o teste rápido foi realizado em 84% das gestantes e o VDRL em 94%, em ambos com taxa de resultado reagente predominante, sem ocorrência de não realização concomitante dos testes, observou-se que a titulação 8 de VDRL/RPR foi preponderante totalizando 18% dos casos pesquisados. Conclui-se que o aumento do número de casos, a predominância na população jovem com ensino médio completo, o diagnóstico no primeiro trimestre entretanto prevalentemente na fase terciária e a não realização do teste rápido em parte dos casos, embora preconize o Ministério da Saúde, evidenciam a necessidade de melhorias na efetividade do pré-natal e traçar estratégias para a prevenção, promoção e conscientização em saúde.*

I. INTRODUCTION

Syphilis has been known since the 15th century, and its study has occupied all medical fields, especially dermatology. Its etiological agent has never been cultivated and, despite being described more than 100 years ago and penicillin being used since 1943 as the most effective treatment, it remains an important public health problem in developed or developing countries, since, due to its characteristics and form of transmission, follows the changes in the behavior of society over the years (AVELLEIRA and BOTTINO, 2006).

It is a sexually transmitted infection (STI) caused by the bacterium Treponema pallidum, with various forms of clinical presentations and different stages It can be classified according to time: recent acquired syphilis (less than a year of evolution) and late acquired syphilis (more than one year of evolution) and according to the clinical manifestations in primary, secondary, tertiary and latent, being attributed in the same way in gestational syphilis, which determines the type of treatment to be performed (BRASIL, 2015; BRASIL , 2019).

Although sexual intercourse is the main form of transmission, there are also other forms of contagion, such as: use of sharp objects contaminated by people with syphilis, blood transfusion and vertical transmission (BRASIL, 2010). During pregnancy, detection occurs at the first prenatal visit with the treponemal test: rapid test, performed even without symptoms in the first and third semester, and then confirmation by non-treponemal VDRL tests with titration records . Syphilis, when untreated or not properly treated during pregnancy, can bring serious complications to the fetus such as: abortion, stillbirth, premature birth and congenital syphilis. Syphilis is a disease of transplacental contamination, that is, passed from contaminated blood from the mother to the fetus (HENNIGEN, et al, 2020).

In 1943, benzathine benzylpenicillin was discovered, which is still used today. It is the drug of first choice for the treatment of syphilis, the only one registered with efficacy for the treatment of pregnant women, and there are no records of penicillin resistance registered in the world. Doxycycline and ceftriaxone are used as second-choice treatment (except in pregnant women) in people with sensitivity to benzathine benzylpenicillin (BRASIL, 2019). According to COFEN Resolution No. 03/2017, the administration of benzathine benzylpenicillin can be prescribed by nurses and administered by nursing professionals in basic health units.

Between 2010 and 2020, 783,544 cases of acquired syphilis were reported in Brazil, 4,563 cases were reported in Rondônia, 518 of which in the municipality of Cacoal,

with an increase in the number of cases over the years. In the period from 2010 to 2020, 357,140 cases of syphilis in pregnant women in Brazil and 183,708 cases of congenital syphilis in children under one year of age were reported to Sinan (SINAN, 2021).

Of the total of 24,253 cases of congenital syphilis reported in Brazil in 2019, 88.8% of the children were alive and 8.1% had some unfavorable outcome, of which 1.2% were classified as death from congenital syphilis, 0.7% as death from other causes, 3.7% as abortion and 2.5% as stillbirth and 3.1% had unknown evolution (BRASIL, 2020). In the absence of adequate treatment, 11% of pregnancies will result in fetal death after birth, 13% in premature or low birth weight deliveries, and at least 20% of newborns will show signs of congenital syphilis. On the other hand, the infection is diagnosed in only 1 to 2% of children of women who are adequately treated during pregnancy, compared to 70 to 100% of untreated pregnant women (HENNIGEN et al, 2020).

Due to the absence or little symptomatology of the disease in some stages, most people tend not to know that they are contaminated, leading to the transmission of the disease through sexual intercourse without the use of condoms. When identified late or treated incorrectly, it can affect mainly the nervous system and the cardiovascular system, which can lead to irreversible damage. It is extremely important to carry out the partner's prenatal care, which consists of the involvement of the man in all stages of reproductive planning and pregnancy, since it is in the consultation that the diagnosis and treatment of syphilis of both occur, avoiding after treatment, recontamination of the pregnant woman, and facilitating the monitoring of cases (BRASIL, 2015).

The analysis of the epidemiological profile of pregnant women affected by syphilis is a study of great importance since, in primary care, diagnosis, treatment and guidelines are carried out, avoiding further damage to the health of the patient and fetus, in addition to raising awareness among the population, preventing its dissemination. Prenatal care is of great importance for public health, as it makes possible to identify several problems such as STIs, detectable in the rapid tests performed at the first prenatal consultation, as in the first trimester of pregnancy, being repeated during the following three trimesters . Gestational syphilis, when not diagnosed and treated early, can several sequelae in the fetus, and may be born with congenital syphilis (POLLO & RENOVATO, 2020; BRASIL, 2012).

Taking into account the high level of transmissibility, difficulty in identifying the disease by the patient, health problems, possibility of complications during pregnancy and vertical transmission, it is necessary to collect data on

the population profile of pregnant women affected by syphilis, as if there was increase in the number of cases in Cacoal and to characterize the predominant group, aiming at reducing the number of cases and preventing congenital syphilis.

II. MATERIALS AND METHODS

Descriptive, retrospective and quantitative documentary research, aiming to present the epidemiological profile of patients affected by gestational syphilis between the years 2016 and 2020 in the city of Cacoal-RO. Data were collected and analyzed in October 2020, provided by the Municipal Health Department (SEMUSA) through the compulsory notification forms of gestational syphilis in the database of the Notifiable Diseases Information System (SINAN).

The sample consisted of 95 patients diagnosed with gestational syphilis in the years in question, with data analysis using the following variables: year of notification, age group, education, clinical classification, gestational age, type of test performed and VDRL/ RPR The instrument used was an Excel spreadsheet containing the variables necessary for the research in order to group the data for further analysis. The collected data were distributed and presented by means of descriptive statistics with absolute and relative numbers in a quantitative way through tables and/or graphs prepared in Word and Excel after the analysis, with the inclusion criterion having been diagnosed with syphilis during pregnancy in any gestational age and be notified to the Cacoal Health Department (SEMUSA) between 2016 and 2020 and exclusion criteria incomplete forms.

The study complies with Conep Resolution nº 466/2012, which complies with the precepts for research with human beings and was carried out after the approval and release of the Research Ethics Committee of UNIFACIMED with opinion number 5,060,962, being carried out the Waiver of the Consent Term as it is a documentary research.

III. RESULTS AND DISCUSSION

Between 2016 and 2020, a total number of 95 pregnant women diagnosed with gestational syphilis were reported in the city of Cacoal, the year with the highest number of cases was 2020, as shown in Graph 1.

According to Table 1, the detection of gestational syphilis in the city of Cacoal predominantly occurred in the first trimester of pregnancy, with 53% of cases,

however 47% were diagnosed in the following trimesters, which can compromise the treatment and make it inappropriate, as According to the protocol of the Ministry of Health (MS), in order to be considered adequate, the treatment must be done with benzathine penicillin and started up to thirty days before delivery (BRASIL, 2015).

Graph 1: Annual distribution of reported cases of gestational syphilis in the city of Cacoal-RO between 2016 and 2020
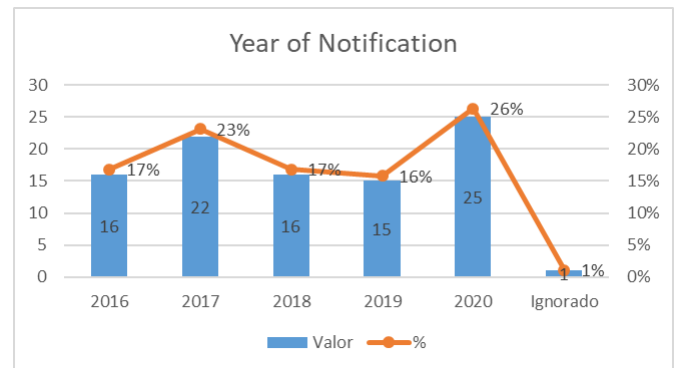
Source: GERA; FERNANDES; SILVA; SOARES, 2021.

Table 1: Distribution of the gestational trimester in which the diagnosis of gestational syphilis occurred in the city of Cacoal-RO between 2016 and 2020.

Gestational trimester	Value	%
1	50	53%
2	28	29%
3	17	18%
Total	**95**	**100%**

Source: GERA; FERNANDES; SILVA; SOARES, 2021.

The diagnosis of gestational syphilis in the first trimester occurs with a higher proportion in the South (48.2%) and Southeast (43.7%) regions, and with a lower proportion in the Northeast (27.1%) and North (28.9%) regions.) with the progressive increase in the diagnosis of syphilis in the first trimester of pregnancy (BRASIL, 2020). When performed only in the third trimester of pregnancy, the diagnosis is considered late and may be related to the late start of prenatal care, as well as the low effectiveness of prenatal care (CONCEIÇÃO; CÂMARA; PEREIRA; 2019).

Although the prenatal care of these pregnant women has not been evaluated, nor the performance of nursing, it is important to emphasize that prenatal care is an important conduct in the diagnosis, guidance and monitoring of the

pregnant woman in the detection of gestational syphilis, with a view to carrying out the tests. for diagnosis in the first trimester of pregnancy or as soon as the pregnant woman starts prenatal care, aiming at early and adequate prophylaxis of the disease, avoiding infection of the newborn (PEREIRA; SANTOS; GOMES; 2020).

The role of nursing is fundamental, as it is the profession that makes the first contact with the pregnant woman in the basic health unit, performing rapid tests that identify the disease, providing quality care, avoiding harm to the mother and the baby, it is necessary to receive it. in a welcoming way, carry out only necessary interventions, facilitate access by integrating all levels of health care, such as promotion, prevention and health care for pregnant women and newborns, in addition to providing guidance on the importance of correct treatment and its implications (NUNES, et al. 2017).

The age of the reported pregnant women ranged from 14 to 41 years, with an average age of 23 years, with a greater involvement of the young population, with 45% aged between 21 and 30 years and 42% being aged up to 20 years, as shown in Graph 2, which is corroborated by Bottura, et al (2019), which highlights between the years 2007 and 2016 the average age of pregnant women with syphilis in Brazil from 20 to 29 years and considerable involvement of adolescents.

Graph 2: Distribution of the number of cases of gestational syphilis by age group in the city of Cacoal-RO between 2016 and 2020.
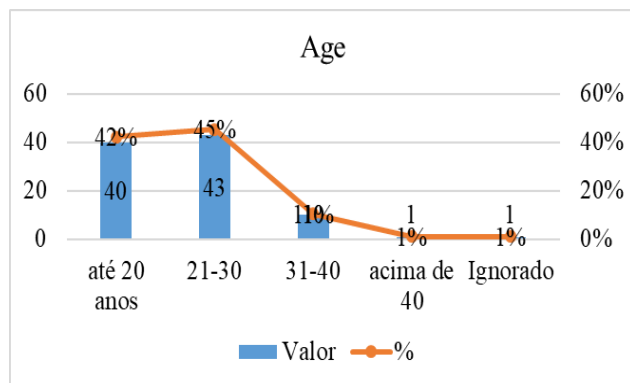
Source: GERA; FERNANDES; SILVA; SOARES, 2021.

This context can be explained because early sexual initiation is directly related to susceptibility to sexually transmitted infections due to the search for new experiences, difficulty in using condoms and a feeling of invulnerability, in addition to low education (PINTO et al, 2018).

When it comes to sexual health, young people are more exposed, especially due to the irregular and infrequent use

of condoms, thus contributing to the increase in infection rates. Some factors such as low level of education, the multiplicity of partners, low adherence to prevention measures and late access to prenatal care with insufficient numbers of consultations collaborate to increase the levels of sexually transmitted infections (STIs), including syphilis (WALTZ et al., 2021).

According to Graph 3, most patients have completed high school, comprising 33%, followed by incomplete high school with 25%, while only 2% have completed higher education, disagreeing with Mesquita (2012) who states that most of the cases of syphilis occur in pregnant women with a low level of education, which demonstrates an evolution in the level of education, since, according to Maeda et al (2018), in Cacoal between 2007 and 2016 the highest incidence of gestational syphilis was found in women with incomplete 5th to 8th grade education.

Graph 3: Distribution of the educational level of pregnant women affected by syphilis in the city of Cacoal-RO between 2016 and 2020.
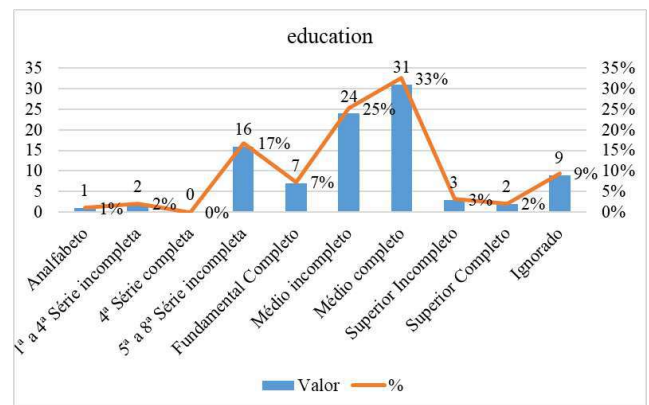
Source: GERA; FERNANDES; SILVA; SOARES, 2021.

The clinical classification is predominantly as tertiary syphilis, with 76% of the cases, as shown in Table 2, which shows a late diagnosis of syphilis, since it was not previously identified in the primary and secondary phases, since the lesions of the primary phase pass unnoticed by the patient. Whenever there is a report of a lesion in the genital region, current or prior to prenatal care, syphilis should be investigated, as well as in the presence of eruptions on the palms of the hands and soles of the feet suggestive of the secondary phase. Most pregnant women diagnosed with syphilis during prenatal care are asymptomatic and have no history of infection or treatment, and are therefore diagnosed in the latent phase (FEBRASGO, 2018).

Table 2: Distribution of the clinical classification of pregnant women affected by syphilis in the city of Cacoal-RO between 2016 and 2020.

Classificação Clínica	Valor	%
Primária	8	8%
Secundária	0	0%
Terciária	72	76%
Latente	15	16%
Total	**95**	**100%**

Source: GERA; FERNANDES; SILVA; SOARES, 2021.

The delay in diagnosing syphilis is directly related to the lack of knowledge of affected people about the disease and its clinical manifestations, fear, shame, tension, discomfort, guilt, impacts on marital life, pain during treatment and stigmas in the family and social, which leads the individual to hide the disease and not want to seek treatment (CAVALCANTE, et al, 2012).

On the other hand, the professional's knowledge about the management of this disease is fundamental in the elaboration of strategies that point ways to a quality care with correct treatment and avoiding late diagnosis, in addition to monitoring pregnant women, performs health education actions. for the awareness of the population, causing the identification of signs and symptoms of the disease and the search for help as soon as possible (RODRIGUES, et al. 2016).

The treponemal test (rapid test) was performed in 84% of the pregnant women, while the non-treponemal test (VDRL) was performed in 94%, in both the rate of reactive results was predominant, as shown in Graphs 4 and 5. It is important to emphasize that all pregnant women diagnosed with syphilis in the period in question underwent some test for the diagnosis of syphilis, whether treponemal or not, the rate of non-performance and/or ignored did not occur concomitantly in the two tests for the same pregnant woman.

Graph 4: Distribution of the results of treponemal tests performed on pregnant women with syphilis in the city of Cacoal-RO, 2016 and 2020.
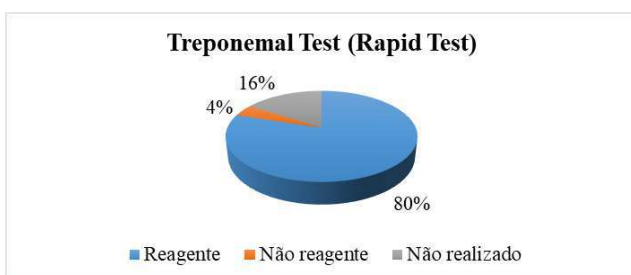
Source: GERA; FERNANDES; SILVA; SOARES, 2021.

According to Santos, et al (2017), the importance of the rapid test for syphilis is the rapid diagnosis, between 10 and 15 minutes, causing early treatment to be initiated in order to reduce transmission and minimize health problems, in addition to be recommended by the Ministry of Health to carry out the rapid test in the first trimester, preferably in the first prenatal consultation, its repetition in the third trimester and at childbirth (BRASIL, 2012).

Graph 5: Distribution of non-treponemal test results in pregnant women with syphilis in the city of Cacoal-RO, 2016 and 2020.
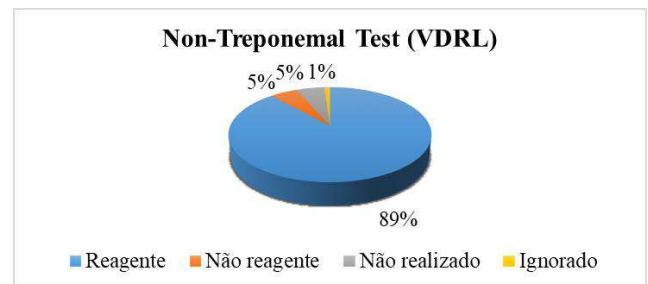
Source: GERA; FERNANDES; SILVA; SOARES, 2021.

The Ministry of Health recommends monitoring the pregnant woman's VDRL titration, if there is no fall or if there is an increase in the titration in relation to the last exam, the pregnant woman should be treated again and the partner's treatment verified, if this monitoring is not carried out. can result in inadequate treatment and bring serious damage to the pregnant woman and especially to the fetus (BRASIL, 2019).

Among the total number of pregnant women in the sample, when performing the non-treponemal test, it was observed that the titration 8 of VDRL/RPR was preponderant, totaling 18% of the cases, followed by 32 with 16% and the lowest occurrence was seen in the titration of 256, presenting only 1% of the sample, as shown in Table 3.

Table 3: Distribution of VDRL/RPR titration in pregnant women affected by syphilis in the city of Cacoal-RO between 2016 and 2020.

Titulação	Valor	%
1	9	9%
2	7	7%
4	8	8%
8	17	18%
16	12	13%
32	15	16%

64	11	12%
128	4	4%
256	1	1%
Ignorado	11	12%
Total	**95**	**100%**

Source: GERA; FERNANDES; SILVA; SOARES, 2021.

For the monitoring of reported cases, it is up to the medical professional or nurse to carry out consultations, requests for complementary exams, drug prescriptions and referrals, when necessary, according to protocols or technical regulations, the monitoring of pregnant women with syphilis must be monthly, evaluating the titration, possible reinfection and therapeutic failure indicating the need for new treatment, after delivery the woman should be followed up every three months until completing one year (POLLO & RENOVATO, 2020; HENNIGEN, et al, 2020).

IV.   FINAL CONSIDERATIONS

The analysis of the epidemiological profile of syphilis in pregnant women in the city of Cacoal was relevant for the study, as it made it possible to identify the increase in the number of cases over the years, the predominance in the young population with complete high school, early detection at the beginning of pre -natal care, however prevalently in the tertiary phase of the disease and the failure to perform the rapid test in part of the cases, although the Ministry of Health advocates the need for improvements in the effectiveness of prenatal care and to outline strategies for prevention, promotion and awareness in health.

Therefore, it is essential to address all aspects related to syphilis during the prenatal consultation, from the identification of risk factors, carrying out the rapid test, especially in the first consultation, to diagnosis and treatment, facilitating the pregnant woman's access to services. of health, integrating levels of care such as promotion, prevention and assistance to pregnant women and newborns, in addition to providing guidance on the use of condoms, attendance at prenatal consultations, adherence to measures prescribed by health professionals and the serious risks of syphilis for pregnant women and newborns.

ACKNOWLEDGEMENTS

REFERENCES

[1] AVELLEIRA, J. C. R.; BOTTINO, G.; Educação Médica Continuada. Sífilis: diagnóstico, tratamento e controle An Bras Dermatol, v. 81, n. 2, p. 111–137, 2006.

[2] BOTTURA B. R., *et al*. Perfil epidemiológico da sífilis gestacional e congênita no Brasil - período de 2007 a 2016. Arq Med Hosp Fac Cienc Med Santa Casa São Paulo. 2019;

[3] BRASIL, Ministério da saúde. Protocolo Clínico e Diretrizes Terapêuticas (PCDT). Atenção Integral às Pessoas com Infecções Sexualmente Transmissíveis (IST). 2a ed. Definição e etiologia da sífilis. Brasília (DF): Editora 2015. p. 89 a 92.

[4] BRASIL, Ministério da Saúde. Protocolo Clínico e Diretrizes Terapêuticas para Prevenção da Transmissão Vertical do HIV, Sífilis e Hepatites Virais. Departamento de Doenças de Condições Crônicas e Infecções Sexualmente Transmissíveis. – Brasília: Ministério da Saúde, 2019. p. 157 a 173.

[5] BRASIL, Ministério da saúde. Protocolo clínico e diretrizes terapêuticas para atenção integral às pessoas com infecção sexualmente transmissíveis (IST). Sífilis adquirida. 1a ed. Brasília (DF) 2019. p. 55 a 99.

[6] BRASIL, Ministério da saúde. Sífilis Estratégias para Diagnóstico no Brasil. Ministério da Saúde Secretaria de Vigilância em Saúde Departamento de DST, Aids e Hepatites Virais. Brasília: 2010

[7] BRASIL. Ministério Da Saúde, Boletim Epidemiológico de Sífilis. Secretaria de Vigilância em Saúde. Ano VI – n 01. 2020. Disponível em: www.gov.br/saude/pt-br/assuntos/media/pdf/2020/outubro/29/BoletimSfilis2020especial.pdf

[8] BRASIL. Ministério da Saúde. Atenção ao pré-natal de baixo risco. Cadernos de Atenção Básica, nº 32. Brasília: Editora do Ministério da Saúde, 2012.

[9] CAVALCANTE, A. E. S. *et al.* Diagnóstico e Tratamento da Sífilis: uma Investigação com Mulheres Assistidas na Atenção Básica em Sobral, Ceará. DST - Jornal Brasileiro de Doenças Sexualmente Transmissíveis, 2012.

[10] COFEN, Conselho Federal de Enfermagem. 2017. Mesa destaca papel da enfermagem no combate à sífilis congênita. Disponível em: www.cofen.gov.br/mesa-destaca-papel-da-enfermagem-no-combate-a-sifilis-congenita_58089.html.

[11] COFEN, Conselho Federal de Enfermagem. Nota técnica Cofen/ctln nº 03/2017. Brasília: 14 de junho de 2017

[12] CONCEIÇÃO, H. N.; CÂMARA, J. T.; PEREIRA, B. M.; Análise epidemiológica e espacial dos casos de sífilis gestacional e congênita. Saúde em Debate, v. 43, n. 123. 2019.

[13] FEBRASGO – Federação Brasileira das Associações de Ginecologia e Obstetrícia. Sífilis na Gravidez. 2018. Disponível em: https://febrasgo.org.br/pt/noticias/item/700-sifilis-na-gravidez

[14] HENNIGEN, A. W. *et al*. Programa de Pós-Graduação em Epidemiologia. TeleCondutas: Sífilis, versão digital. Porto Alegre. 2020.

[15] MAEDA, A. T. N. *et al.* Perfil Clínico e Epidemiológico das Gestantes com Sífilis e Sífilis Congênita no Município de Cacoal, Rondônia, Brasil, 2007 a 2016. Revista Eletrônica FACIMEDIT, v7, n1. 2018

[16] MESQUITA, *et al.* Perfil epidemiológico dos casos de Sífilis em Gestante no município de Sobral, Ceará, de 2006 a 2010. Revista Sanare, Sobral, vol.11, Ed. 1. Pág 16, 2012.

[17] NUNES, J. T. *et al.* Sífilis na gestação: perspectivas e condutas do enfermeiro. Revista de Enfermagem UFPE online, v. 11, n. 12, p. 4875-4884, dez. 2017.

[18] PEREIRA, B. B.; SANTOS, C. P.; GOMES, G.C.; Realização de testes rápidos de sífilis em gestantes por enfermeiros da atenção básica. Rev. Enferm. UFSM – REUFSM. Santa Maria, RS, v. 10, e82, p. 1-13, 2020.

[19] PINTO, *et al.* Fatores associados às infecções sexualmente transmissíveis: inquérito populacional no município de São Paulo, Brasil. Ciência e saúde coletiva, 2018.

[20] *POLLO, D.; RENOVATO R. D.;* Enfermagem e o tratamento medicamentoso da sífilis sob a ótica da Teoria Sócio-Humanista. Revista enfermagem UERJ, Rio de Janeiro, 2020; 28:e51482.

[21] RODRIGUES, A. R. M. *et al.* Atuação de enfermeiros no acompanhamento da sífilis na atenção primária. *Rev. enfermagem UFPE on line. 2016.*

[22] SANTOS, F. P. *et al.* Sífilis na gestação: A importância do diagnóstico precoce. Universidade Tiradentes. ANAIS 2017.

[23] SINAN – Sistema de Informação de Agravos de Notificação. Sífilis em Gestante. Disponível em: https://portalsinan.saude.gov.br/sifilis-em-gestante. 2021.

[24] WALTZ, M. B. *et al.* Sífilis gestacional segundo a idade das mães: ocorrências no município do Rio de Janeiro entre 2008 e 2018. J Manag Prim Health Care13:e 03, 2021.

Marijuana use and the risk of schizophrenia

Jade Ferreira Geraldes Iglesias[1], Jhonas Geraldo Peixoto Flauzino[2], Ana Luísa Carreira da Silveira[3], Ana Paula Dupuy Hermes[4], Dilter José Picin Correa de Oliveira[5], Enzo Masgrau de Oliveira Sanchotene[6], Gabriela Póvoas Pinto Ambar[7], Gabriel Ramos Canato[8], Isadora Ribeiro Rossi[9], Marcela Curvêllo Beltrão[10], Monaí Barbosa Oliveira[11], Natalia Maria Schincariol[12], Pedro Pompeo Boechat Araujo[13]

[1]Estudante de Medicina na São Leopoldo Mandic, em Campinas, SP

[2]Especialista em Neurociências, Pontifícia Universidade do Rio Grande do Sul, PUCRS

[3]Estudante de Medicina na São Leopoldo Mandic, em Campinas, SP

[4]Estudante de Medicina no Centro Universitário do Planalto Central Aparecido dos Santos, UNICEPLAC, Brasília, DF

[5]Estudante de Medicina na Universidade Municipal de São Caetano do Sul, em São Paulo.

[6]Estudante de Medicina na São Leopoldo Mandic, em Campinas, SP

[7]Estudante de Medicina na Universidade da Cidade de São Paulo

[8]Estudante de Medicina na Faculdade de Medicina de São José do Rio Preto – FACERES, São José do Rio Preto, SP

[9]Estudante de Medicina na São Leopoldo Mandic, em Campinas, SP

[10]Estudante de Medicina no Centro Universitário Tiradentes – UNIT, em Maceió, AL.

[11]Estudante de Medicina na Universidade Municipal de São Caetano do Sul, em São Paulo

[12]Estudante de Medicina na Universidade Municipal de São Caetano do Sul, em São Paulo

[13]Estudante de Medicina na São Leopoldo Mandic, em Campinas, SP

Abstract— To review the literature on the association between cannabis use as a triggering factor for schizophrenia in individuals with a predisposition to psychosis who used cannabis and to verify the relationship with the pathogenesis.

I. INTRODUCTION

Schizophrenia is classified in the Diagnostic and Statistical Manual of Mental Disorders - DSM-5 (APA, 2014) within the Spectrum that can have a variation within a limit of commitment and intensity. Thus, schizophrenia is defined through multiple symptoms such as delusions, grossly disorganized or catatonic behavior, hallucinations, and negative symptoms. In addition, moments of symptom reduction are interspersed, with apathy, social isolation and difficulties in expressing emotions.

Cannabis has psychoactive substances such as cannabidiol (CBD) and tetrahydrocannabidinol (THC), which generate a direct influence on the Central Nervous System (CNS), being classified as disturbing it. Its acute use can generate in the person a state similar to that of the psychotic, such as affective blunting, agitation, confusion in thoughts and hallucinations. Some authors defend that these symptoms are restricted to cannabis psychosis, that is, symptoms that occur only in the specific use of the drug. Other authors defend the direct influence of the substance on the development of schizophrenia, being considered one

of the risk factors for this disorder. The onset of schizophrenia occurs in youth and the use of cannabis is more intense between the ages of 15 and 20, coincidentally, being an additional point for analyzing the manifestation of symptoms (FITAS, 2012).

Among the various studies carried out in the area of chemical dependence and the relationship with the advent of schizophrenia, some authors believe that schizophrenia could be triggered by substance abuse, at least in subjects who have a predisposition, while others believe that patients with schizophrenia would use drugs to avoid the discomfort of disease symptoms or pharmacological treatment (HAMBRECHT; HAFNER, 2000). The hypothesis is unanimous that the comorbidity can generate a worsening of the prognosis and cause difficulty in the treatment, which can lead the schizophrenic subject to suicidal ideation.

OBJECTIVE

To review the literature on the association between cannabis use as a triggering factor for schizophrenia in individuals with a predisposition to psychosis who used cannabis and to verify the relationship with the pathogenesis.

II.   METHOD

The methodology used was bibliographic research in the SciELO, Virtual Health Library (VHL) and Pubmed databases on the topic in question. As inclusion criteria, studies published in Portuguese, English and Spanish in the last fifteen years were used, with the following descriptors: schizophrenia and cannabis. The exclusion criteria used were articles published for more than fifteen years, which were in languages other than Portuguese, English and Spanish, and which were not in accordance with the topic in question.

SCHIZOPHRENIA

Schizophrenia affects just under 1% of the population at some point in their lives. A systematic review showed that incidence rates ranged from 7.7 to 43.0 per 100,000, a fivefold difference. A survey carried out by Kirkbride et al. (----) evaluated the incidence of psychosis in three English cities as part of the large AESOP (Etiology and Ethnicity of Schizophrenia and Other Psychoses) study.

The peak incidence for schizophrenia in males was between 20 and 24 years, but 29 to 32 years in females. Schizophrenia in females appears on a flatter curve later than in males. Thus, this study confirms earlier evidence of an earlier age of onset of schizophrenia in males.

The risk factors for the disorder are diverse and divided into two main groups: biological and social. First-degree biological relatives have a 10 times greater risk of developing the disease than the general population. Studies have also indicated other risk factors such as pregnancy and childbirth complications, exposure to influenza during various epidemics of the disease, maternal starvation during pregnancy, Rhesus factor incompatibility, and an excess of winter births in the etiology of the disorder.

Given the early development of the disease, the financial expense is significant and long-lasting. It is estimated that the financial cost of the disease in the United States is greater than that of all types of cancer combined. A relevant fact, with regard to the social sphere, indicates that 15 to 45% of North Americans living on the streets have a diagnosis of schizophrenia. (KAPLAN, 2017).

The pathological mechanism of schizophrenia is not fully understood and current antipsychotics are characterized by severe limitations: these treatments are effective for only about half of patients and involve serious neurological and metabolic side effects, in addition to being able to lead to sexual dysfunction or agranulocytosis. ; KONDEJ; KACZOR; 2018).

THE INTERFERENCE CAUSED BY CANNABIS IN THE APPEARANCE OF THE PATHOLOGY

By collecting information, it was observed that there is a relationship between the etiopathogenesis of schizophrenia and the use of Cannabis, in which one of the authors studied emphasizes the greater probability of developing the pathology in people who daily use the substance with higher concentration. of THC (JUNIOR, 2019). Tetrahydrocannabionl, THC, is considered a psychoactive substance located in cannabus-type plants. This substance can increase the subject's anxiety levels, as well as affect their ability to learn, develop psychotic symptoms, cause tachycardia and sedation effects (BAU; PARISE; AVIZ, 2021).

This substance is undergoing studies, not being proven or fully defined all the symptoms that the use of cannabis can generate, however, when there is an increase in the levels of the substance in the body, the mental effects can be accentuated (JUNIOR, 2019).

Schizophrenia is treated as a pathology that results from or has the ability to intensify due to the use of cannabis, however, it occurs in predisposed people (BAU; PARISE; AVIZ, 2021).

The use of marijuana interferes with the development of the pathology and causes difficulty in treatment, which causes neurological changes in the person. According to Oliveira and Moreira (2007) apud Bau, Parise and Aviz (2021), cannabis is seen as a disturber of the Central Nervous System (CNS), generating in the person the

lack of spatial orientation, changes in any of the five senses, memory and causing you to become dependent on the substance. This is all due to the compounds identified in cannabis, generating a feeling of well-being in the individual.

RISK BEHAVIORS OF INDIVIDUALS WHO USE CANNABIS

The symptoms of schizophrenia together with the effects of the drug can generate mental confusion in the subjects, considering the appearance of behaviors that put these people at risk. As it is a disorder that has different phases, the symptoms can be both positive and negative, it is understood that risk behaviors can be presented in two moments, however, manifested in different circunstance (BAU; PARISE; AVIZ, 2021).

Among the various characteristics that schizophrenia has, negative symptoms are identified. At this stage, the subject tends to isolate himself from his support network and from society, which favors the development of depressive conditions. Despite this, depression can occur at all stages of the disease (MOGADOOURO et al., 2009 apud BAU; PARISE; AVIZ, 2021). It is observed in the analyzed articles that, regarding the possibilities of suicide in individuals with schizophrenia, it is common to happen in depressive symptoms. It was noted that there is a contradiction between one of the articles that brings the perspective that the patient with schizophrenia does not necessarily use the drug due to chemical dependence, however, for the relief of their own symptoms, even in the search to reduce the discomfort of the side effects of the drugs. (TRINADE; SANTOS; OLIVEIRA, 2019).

It was observed, on the other hand, through another article, that the use of cannabis may be related to the attempt to reduce negative symptoms and may also be the cause (OLIVEIRA; MOREIRA, 2007 apud BAU; PARISE; AVIZ, 2021). Research has shown that high levels of CB1 receptors in the CNS, including the anterior cingulate cortex, have been described in schizophrenic people (ZAVITSANOU; GARRICK; HUANG, 2004 apud BAU; PARISE; AVIZ, 2021). According to Oliveira and Moreira (2007) apud Bau, Parise and Aviz (2021), the anterior cingulate cortex is fundamental for cognition, especially with regard to attention and motivacion. The changes that marijuana generates in the CNS are related to the negative symptoms of schizophrenia.

Thus, it was observed that schizophrenic people who use cannabis or other substances to relieve negative symptoms, and those who manifest such symptoms by using the drug frequently, tend to be more likely to present risk behaviors, which can cause suicide. The existence of depressive symptoms is the fundamental cause of reintegration in schizophrenia and is more closely related to mortality and morbidity (MOGADOOURO et al., 2009 apud BAU; PARISE; AVIZ, 2021). Therefore, the patient who presents a depressive condition in addition to the diagnosis of schizophrenia and makes the conciliation with the use of cannabis, may have high possibilities of suicide due to feelings of hopelessness in association with risk behaviors, leading to an overdose, for example.

The use of drugs in general (marijuana, cocaine, crack) can induce the patient to have an increase in symptoms, such as delusions, fear, hallucinations and a feeling of persecution. In addition to having been found that drug use generates a feeling of self-sufficiency and self-confidence in these subjects (TRINTADE; SANTOS, OLIVEIRA, 2019).

Taking into account the behaviors and symptoms, it can be taken into account that the individual with schizophrenia, when using drugs, increases the possibilities of developing suicidal ideation, based on the assumption that in a moment of hallucination in which the subject imagines that he is being chased, he runs the risk of crossing a street without noticing if a vehicle is coming, throwing himself from somewhere that is high in the quest to escape from the person he is chasing, or even feeling self-confident to commit some illicit act, putting his life endangered (BAU; PARISE; AVIZ, 2021).

It has been proven that the abusive use of marijuana can worsen psychotic symptoms in patients with schizophrenia (OLIVEIRA; MOREIRA, 2007 apud BAU; PARISE; AVIZ, 2021). Even so, some changes were identified regarding how cannabis works effectively in the person's CNS. Some studies point out that the substance intensifies and affects positive symptoms, while others show the existence of functional interactions between cannabinoids and dopamine, that is, drugs that cause dopaminergic D2 receptor blockade reduce the positive symptoms of the disease (OLIVEIRA; MOREIRA, 2007 apud BAU; PARISE; AVIZ, 2021).

Among the consequences that drug use has on the subject, it is possible to find, through one of the studies, that they sufre fatal accidents more frequently, with the probability that a part of the accidents is due to suicides that have not been explained. Even though there is no specific information about the risk behaviors that an individual with schizophrenia

who uses cannabis can develop, it is confirmed that the drug can interfere with the treatment of these people. Thus, when treatment is not taken seriously, the consequences can be fatal (BAU; PARISE; AVIZ, 2021).

RELATIONSHIP BETWEEN CANNABIS USE AND SCHIZOPHRENIA

Some studies suggest that exposure to substances such as cannabis accounts for the increased prevalence of schizophrenia, in a causal relationship, that is, substance abuse would trigger schizophrenia, at least in predisposed individuals (MUESER et al., 1990).

Andreasson et al. (1987) carried out a study in which the hypothesis of a case-control causal model was investigated, in which 50,000 young people were followed up over a period of 15 years. This study suggested a positive and dose-dependent correlacion between early initiation of marijuana use and later diagnosis of schizophrenia in young men. Zammit et al. (2002), after a review of this study, found that for subjects who used marijuana alone, the dose-response relationship remained significant with a 1.5-fold increased risk. For people who had used marijuana more than 50 times, the risk rose to 3.1 times.

After the year 2000, the causal model gained strength (ARSENEAULT et al., 2004; SMIT; BOLIER; CUIJPERS, 2004), probably due to advances in the neurobiology of the endocannabinoid system. From that year on, systematic reviews of the epidemiological studies published until then began to assess the strength of the evidence for the predominance of the causal model.

In 1993, a Swedish study investigated 112 patients diagnosed with schizophrenia and marijuana use. In 69% of patients, marijuana abuse had occurred at least one year before the onset of psychotic symptoms. The disease preceded use in only 11% of cases (ALLEBECK; ADAMSSON; ENGSTROM, 1993). In 1994, a Dutch study showed that in 23 of the 24 cases studied, marijuana use had preceded the onset of the first psychotic symptoms by at least one year (LINSZEN; DINGEMANS; LENIOR, 1994).

A Dutch study followed 4045 subjects without psychosis and 59 subjects with psychotic symptomatology, assessed at baseline, through the first and third years. After adjusting for confounders, cannabis users at baseline were approximately three times more likely to manifest psychotic symptoms at follow-up. A dose-response relationship was found, with an OR of 6.8 (95% CI: 1.8-25.9) associated with the highest level of cannabis use.

The relationship between cannabis use and psychotic symptoms was more evident in cases with more severe symptoms. Cannabis-using individuals with psychotic symptoms at baseline had a higher risk of developing schizophrenia compared to non-using individuals. The attributable risk, that is, the percentage of cases that would be preventable if consumption were eliminated, was estimated at 13% for psychotic symptoms and 50% for psychotic disorders requiring psychiatric treatment.

A German study evaluated the relationship between cannabis use and psychotic symptoms in individuals with a predisposition to psychosis, who used cannabis for the first time in adolescence. In this study, 2437 individuals from the general population, aged between 14 and 24 years, with and without risk factors for psychosis, were followed for four years. In view of this study, there was an increase in the risk of psychosis depending on the dose, in individuals exposed to cannabis, with an OR of 1.53 (95% CI: 1.1-2.1) in individuals with consumption greater than five times at the beginning of the study. However, predisposition to psychosis was not found to be a predictive factor for cannabis use, which suggests that consumption leads to psychotic symptoms and not the other way around.

Semple, Mcintosh, and Lawrie (2005) performed a systematic review of the literature and included in the meta-analysis only those studies that clearly examined the association between marijuana use and schizophrenia or schizophrenic psychosis, but not with psychotic symptoms. These authors found that marijuana use was a risk factor and tripled the chance of developing schizophrenia.

Arseneault et al. (2004) showed that marijuana use doubled the risk for schizophrenia and estimated that the abolition of marijuana use would bring about an approximately 8% reduction in the incidence of schizophrenia.

Henquet et al. (2005) gathered seven prospective studies published between 2002 and 2005 that examined the association between marijuana use and the development of psychosis and submitted them to a meta-analysis study. The result revealed that there was a positive association between the two factors with a relative risk of around 2. Although the authors acknowledged that this value was not that high, they argue that, as marijuana use is quite prevalent in the young population, which is the group at greatest risk for developing psychosis, the data became quite relevant.

It is understood that the neurodevelopmental characteristic during adolescence may be vulnerable to the effects of cannabis consumption. Consumption aggravates psychotic symptoms in individuals at risk for schizophrenia, possibly inducing dysfunctions in the most relevant neurotransmitter systems, such as GABAergic and dopaminergic transmission (PAROLARO, 2010). Another 2000 epidemiological study in a German-influenced region of 1,500,000 people found that thirteen percent of 232 patients diagnosed with schizoid disorder had a history of cannabis abuse, which was twice the rate of matched normal controls. (HAMBRECHT; HÄFNER, 2000)

Despite studies, the correlation between cannabis use in adolescence and later development of schizophrenia is not conclusive. The pathogenic process is complex, it is likely that it depends on the existence of certain genes, on their activation or inactivation, on their interactions that can be influenced by non-genetic environmental factors.

III.   CONSIDERATIONS

Schizophrenia is a multifactorial disorder, reflecting the interaction between vulnerability and contributing environmental factors. Although the factors that make the brain at the time of maturation "vulnerable" to substances such as THC are still unknown, it is reasonable to consider this substance as part, an integral "knot" of a complex interative of pathophysiological factors. In it, changing any part of the system can lead to malfunction of the entire array. The disturbance is not found in one or several "nodes", but possibly in the interaction between them.

REFERENCES

[1] Andréasson S, Engström A, Allebeck P, Rydberg U. CANNABIS AND SCHIZOPHRENIA A Longitudinal Study of Swedish Conscripts. The Lancet. 1987;330(8574):1483-1486. doi:10.1016/s0140-6736(87)92620-1

[2] Allebeck P, Adamsson C, Engström A. Cannabis and schizophrenia: a longitudinal study of cases treated in Stockholm County. Acta Psychiatrica Scandinavica. 1993;88(1):21-24. doi:10.1111/j.1600-0447.1993.tb03408.x

[3] Arseneault L, Cannon M, Witton J, Murray RM. Causal association between cannabis and psychosis: examination of the evidence. British Journal of Psychiatry. 2004;184(2):110-117. doi:10.1192/bjp.184.2.110

[4] BAU, Letícia; PARISE, Thayná de Aquino; AVIZ, Adilson. **A relação entre comportamentos de risco e o uso de cannabis em pacientes esquizofrênicos**. Trabalho de Conclusão de Curso (Curso de Psicologia). Sociedade educacional de Santa Catarina. 2021.

[5] Linszen DH, Dingemans PM, Lenior ME. Cannabis Abuse and the Course of Recent-Onset Schizophrenic Disorders. Archives of General Psychiatry. 1994;51(4):273. doi:10.1001/archpsyc.1994.03950040017002

[6] Hambrecht M, Häfner H. Cannabis, Vulnerability, and the Onset of Schizophrenia: An Epidemiological Perspective. Australian & New Zealand Journal of Psychiatry. 2000;34(3):468-475. doi:10.1080/j.1440-1614.2000.00736.x

[7] Henquet C, Krabbendam L, Spauwen J et al. Prospective cohort study of cannabis use, predisposition for psychosis, and psychotic symptoms in young people. BMJ. 2005;330(7481):11. doi:10.1136/bmj.38267.664086.63

[8] Kaplan and Sadock's comprehensive textbook of psychiatry. Volumen 1 - 10. edición. Lippincott Williams & Wilkins; 2017

[9] Kirkbride JB, Fearon P, Morgan C et al. Heterogeneity in Incidence Rates of Schizophrenia and Other Psychotic Syndromes. Archives of General Psychiatry. 2006;63(3):250. doi:10.1001/archpsyc.63.3.250

[10] JUNIOR, Janio. **Uso da Cannabis sativa e sua relação com a etiopatogênese da esquizofrenia**. Salvador: Universidade Católica do Salvador, 2019.

[11] Kahn RS, Davis KL. New developments in dopamine and schizophrenia. In Bloom FE and Kupfer DJ, editors. Psycopharmacology: The Fourth Generation of Progress. New York: Raven Press; 1995. p. 1193-1203

[12] Smit F, Bolier L, Cuijpers P. Cannabis use and the risk of later schizophrenia: a review. Addiction. 2004;99(4):425-430. doi:10.1111/j.1360-0443.2004.00683.x

[13] Semple DM, McIntosh AM, Lawrie SM. Cannabis as a risk factor for psychosis: systematic review. Journal of Psychopharmacology. 2005;19(2):187-194. doi:10.1177/0269881105049040

[14] Stępnicki P, Kondej M, Kaczor AA. Current Concepts and Treatments of Schizophrenia. Molecules. 2018;23(8):2087. doi:10.3390/molecules23082087

[15] Parolaro D, Realini N, Vigano D, Guidali C, Rubino T. The endocannabinoid system and psychiatric disorders. Experimental Neurology. 2010;224(1):3-14. doi:10.1016/j.expneurol.2010

[16] Mueser KT, Yarnold PR, Levinson DF, Singh H, Bellack AS, Kee K et al. Prevalence of Substance Abuse in Schizophrenia: Demographic and Clinical Correlates. Schizophrenia Bulletin. 1990;16(1):31-56. doi:10.1093/schbul/16.1.31

[17] Radhakrishnan R, Wilkinson ST and D'Souza DC. Gone to pot – a review of the association between cannabis and psychosis. Front. Psychiatry. 2014; 5:54. doi: 10.3389/fpsyt.2014.00054

[18] Zammit S, Allebeck P, Andreasson S, Lundberg I, Lewis G. Self reported cannabis use as a risk factor for schizophrenia in Swedish conscripts of 1969: historical cohort study. BMJ. 2002;325(7374):1199. doi:10.1136/bmj.325.7374.1199

[19] TRINDADE, Barbara; SANTOS, ME. Walquiria; OLIVEIRA, Dra. Maria. A Esquizofrenia Associada a Dependência Química. **Revista JRG de Estudos Acadêmicos**, Brasília, v.2, n.5, p. 57-70, ago/dez. 2019.

Knowledge of management of health waste in COVID-19 for environmental impact

Pollyana da Conceição Andrade Silva [1], Paola Souto Campos[2]

[1]Student of the Postgraduate Program Master in Engineering, Process Management, Systems and Environmental (PPEMSE) the Institute of Technology and Education Galileo of the Amazon – ITEGAM. Avenue Joaquim Nabuco No 1950. Center. ZIP CODE: 69.020-030. Manaus-AM, Brazil.
Email: polly_0422@hotmail.com

[2] Professor and researcher of the Professional Master's in Engineering, Process Management, System and Environmental at the Instituto de Tecnologia e Educação Galileo da Amazônia – ITEGAM, Brazil.
Email: pscampos@gmail.com

Abstract— The pandemic due to COVID-19 has been shaping the healthcare landscape, mainly due to the amount of Health Service Waste (RSS) that is being produced. Understanding how these SSR are managed and how health professionals are involved in this process can provide a better understanding of how this knowledge directly impacts the better management of the SSR itself, as well as the reduction of environmental impacts from this flow. The objective of the study is to evaluate the knowledge of health professionals on waste management in time of COVID-19. An exploratory, descriptive, cross-sectional, observational study was conducted with 55 health professionals, working in a public hospital in Manaus – Amazonas - Brazil. Were included subjects over 18 years old, working in an institution that dealt with confirmed cases of COVID-19. The instruments used in the data collection were: Questionnaire defining the profile of the participants; Questionnaire evaluating basic knowledge about waste management of health services. The results indicated that the institution of interest has a protocol for the management of residues contaminated by COVID-19 as reported by 50 participants (90.9%), but most do not know what the Health Services Waste Management Plan (56.4%) is, not received training on SRHS (69.1%), not knowing how to classify without difficulty which are the Health Service Residues (54.5%), even performing invasive procedures (87.3%). Even with the increase in demand for health services during the COVID-19 pandemic, training and knowledge on how to manage the waste from these services did not follow the same growth.

I. INTRODUCTION

The pandemic by COVID-19 has been shaping the waste generation scenario, mainly by the amount produced of this waste in health services (SSR), which are composed mainly of personal protective equipment (PPE) produced with single-use plastics (Capoor; Parida, 2021; Hantoko *et al*, 2021; Sharma *et al*, 2020).

Due to the content of the SSR and its potential impact on the environment and on the service where it is generated, the concern about how this waste is already managed is part of the routine of health services, and

increased even more during the pandemic by COVID-19, focusing now on ensuring safe and sustainable management (Chowdhury *et al*, 2022). In Wuhan, China's first pandemic epicenter, one of the strategies to manage over 6,000 tons of SSR per day was to ensure proper management with instructions and training to optimize disposal (Singh *et al*, 2020). On the other hand, the lack of adequate knowledge about SSR management can generate local damage, such as the occurrence of biological accidents and contamination of co-workers and even patients, in addition to long-term impacts on the environment in which this waste is disposed of, such as loss of local species and depletion of resources (Rizan; Reed; Bhutta, 2021; López-Feldman *et al*, 2020).

The training on the SSR Management Plan is one of the processes implemented in health institutions that aim to reduce such impacts, however, what is the actual knowledge that has been absorbed by health professionals in relation to this process? And how is this knowledge being acquired/reinforced during the COVID-19 pandemic?

This study aimed to evaluate the knowledge of health professionals on waste management in times of COVID-19 pandemic aiming at the environmental impact.

II.   LITERATURE REVIEW

2.1. Waste classification

In general, the classification of waste types depends on their origin and characteristics. As to the origin, they can be categorized as residues of hospital origin or health services (SSR), industrial or municipal solid waste (SNS). Regarding the characteristics, they can be inert, hazardous or not (Rosa Filho; Rosa; Sena, 2016).

Thus, it is noted that the presence of pathogens in the waste is what in fact differentiates whether the waste originates in health services or not. A different but complementary definition is the one informed in the resolution of the National Council for the Environment, through resolution 358/2005, which states that "health services residues apply to all services related to human or animal health care" (Brasil; CONAMA, 2005).

2.2. Residues and COVID-19 Pandemic

With the pandemic due to COVID-19, the increase in the number of residues, not only from healthcare services, but also from municipal/domestic solid waste, dramatically worsens the waste management landscape (Yousefi *et al*, 2021).

One of the factors that contributed to this increase in waste production was the new habits acquired by society,

which began to have a constant concern for hygiene during this pandemic period. Recent data reveal that in Brazil, improper disposal of masks has been identified in several cities (Urban; Nakada, 2021).

Similarly, hospital overcrowding has directly impacted the exorbitant production of a greater amount of waste. Hospitals in Wuhan, the first epicenter of COVID-19, recorded a jump from 40 to 240 tons of SSR per day. The situation was so serious that to get around it was necessary to create a new plant to treat this waste (Sangkham, 2020). In Brazil, besides the increase in SSR production, it was observed that 35% of hospital residues was not properly treated, impacting negatively on the environment (Urban; Nakada, 2021).

2.3. Residues management and environmental impact

One cannot ignore the direct relationship between knowledge about SSR management and the environmental impact arising from the lack of this knowledge, such as pollution of water, soil, and even in the air (Manzoor; Sharma, 2019). Zand and Heir (2021) report that some hospitals in Tehran, Iran, for example, modified their SSR management policy to meet the high demand during the COVID-19 pandemic, but ignored the environmental impacts caused by the new strategies adopted, such as the disposal of SSR along with MSW, without any specific treatment before final disposal. Therefore, even if the healthcare professional who deals directly with the SSR disposes of them properly, the problem can happen when the healthcare service management does not use an adequate SSR management plan (Zand; Heir, 2021).

The SSR management guidelines reinforce the importance that the health professional has in this whole process. Understanding how professionals are being trained and what knowledge they have at this point can impact the professional and environmental environment in the short and long term (Jalal *et al*, 2021).

III.   MATERIALS AND METHODS

According to the definition of Merchán-Hamann and Tauil (2021), this research is observational (because there is no manipulation of direct interventions over the investigated ones), sectional (collected in a single moment in time), exploratory and descriptive (describes the characteristics of the study variables, establishing no causal relationship between them).

The population of interest of the study consisted of 55 health professionals, working in a public hospital in Manaus - Amazonas. For the study, individuals met the following inclusion criteria: being a health professional; being over 18 years old; accepting to participate in the

study and signing the informed consent form; work in a health institution that deals with confirmed cases of COVID-19.

Health professionals who were not working

specifically in the hospital of interest were excluded. Figure 1 exemplifies the flow chart for conducting the study.
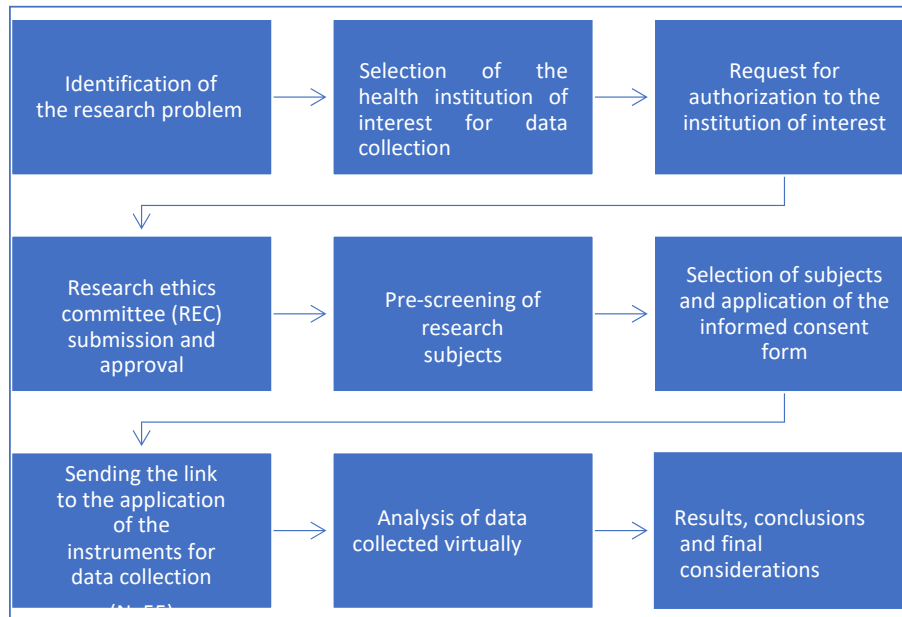
Fig. 1: Flow chart of the study

For data collection in this study, forms were used with virtual application, aiming at practicality and ensuring social distance. For this, all the recommendations of the "Circular Letter no. 1/2021-CONEP/SECNS/MS of March 3rd, 2021" were followed, from the collection of data, guarantee of confidentiality and security, as well as the content of the documents processed.

All biosafety protocols and standards were followed by the responsible researcher to avoid any risk of contamination on the part of the researcher and the research subjects, according to the Health Measures Plan.

No data collection step or approach to the subjects took place without the previous approval of the project by the Research Ethics Committee, under CAAE: 51785221.9.0000.5016.

Consent to participate in the research was acquired virtually, after pre-screening with the heads of unit, according to the standard protocol of the selected institution. The pre-screening consisted of selecting individuals who met the study criteria (health professionals, over 18 years old, and working in a sector that works directly with COVID-19).

All individuals who during the pre-screening met the research criteria were invited by the researcher (and not by the manager, in order not to influence their judgment) to voluntarily participate in the study. The electronic forms were then sent out via link.

The instruments used are described in Figure 2.

The data were analyzed using GraphPad Prism Software, version 22. Initially, analysis was performed to define the normality distribution of the data, then parametric comparisons and correlations were performed to achieve the study objectives.

The results were grouped into mean and standard deviation and represented in descriptive frequency tables. This study followed the ethical precepts of resolution 196/96 of the Ministry of Health, which aims at autonomy, non-maleficence, beneficence, and justice, among other rights of the research participant, by signing the ICF.
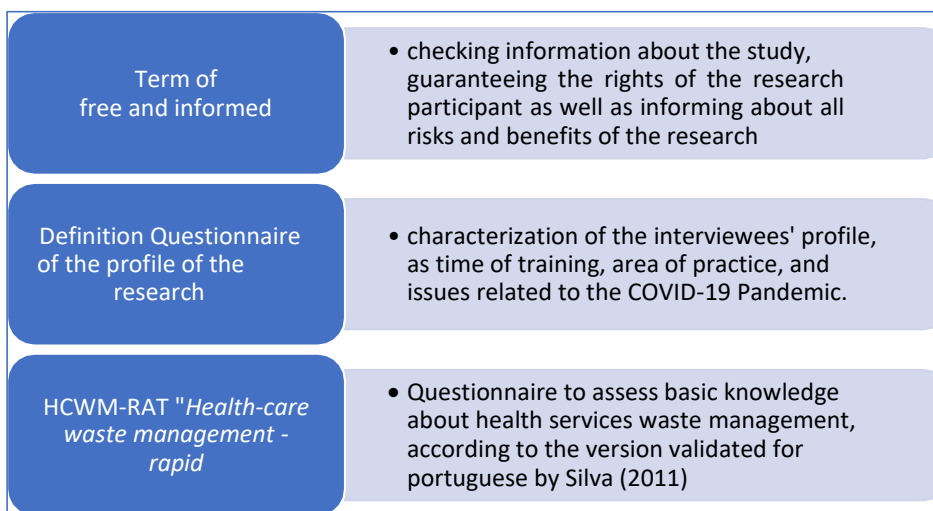
Fig. 2: Data collection instruments

IV.   RESULTS AND DISCUSSIONS

4.1. Profile of the interviewees

A total of 55 health professionals were interviewed, with an average age of 37 years, and 75% were female.

Table 1 shows that most of the interviewees had graduated from a technical nursing course (38.2%); 21 (38.2%) had a specialization course as a minimum; 21 (38.2%) had between 6 and 10 years of experience in the health area and 18 (32.7%) had between 6 and 10 years of experience in a hospital environment; 29 (52.7%) worked in the medical clinic sector.

Tab. 1: Characteristics of the population of health professionals interviewed

Features	N (%)
Area of Concentration	
Other	1 (1,8)
Nurse	18 (32,7)
Pharmacist	2 (3,6)
Physiotherapist	9 (16,4)
Physician	3 (5,5)
Nutritionist	1 (1,8)
Nursing Technician	21 (38,2)
Education (last completed course)	
High school/technical education/professional education	15 (27,3)
Higher education complete	10 (18,2)
Specialization	21 (38,2)
Master's Degree	9 (16,4)

Time of professional activity in the health area	
Not applicable	1 (1,8)
Between 01 and 5 years	10 (18,2)
Between 11 and 15 years old	16 (29,1)
Between 6 and 10 years old	21 (38,2)
More than 15 years	7 (12,7)
Time working in a hospital environment	
Not applicable	1 (1,8)
Between 01 and 5 years	13 (23,6)
Between 11 and 15 years old	15 (27,3)
Between 6 and 10 years old	18 (32,7)
More than 15 years	8 (14,5)
In which sector(s) of the hospital do you work?	
Outpatient, Other	1 (1,8)
Surgical Center, Outpatient, Other	1 (1,8)
Surgical Clinics	2 (3,6)
General Medical Practice	29 (52,7)
Internal Medicine, Outpatient Clinic	1 (1,8)
Medical Clinic, Surgical Clinic, Intensive Care Unit	1 (1,8)
Medical Clinic, Surgical Clinic, Intensive Care Unit, Surgery Center	1 (1,8)
Other	3 (5,5)
Intensive Care Unit	16 (29,1)

4.2. Aspects about the COVID-19 pandemic

In Table 2 it can be seen that 98.2% of the interviewed population had been vaccinated against COVID-19, however 90.9% had confirmed infection with COVID-19. The severity of the acquired infection was not questioned. The institution where the professionals interviewed work has encouraged vaccination in the opinion of 52 (94.5%), even though 28 (50.9%) reported that they are not vaccinated regularly.

Table. 2: Aspects related to the COVID-19 pandemic questioned to the interviewed population of health professionals

Aspects about COVID-19	N (%)
You had Covid-19	
No	5 (9,1)
Yes	50 (90,9)
Have you been vaccinated against Covid-19?	
Not applicable	1 (1,8)
Yes	54 (98,2)
Were you encouraged by the institution you work for to get vaccinated against Covid-19?	
No	3 (5,5)
Yes	52 (94,5)
Are the professionals of the institution you work for regularly immunized/vaccinated?	
No	28 (50,9)
I don't know	17 (30,9)
Yes	10 (18,2)

Similar results were described in the study by Parikh et al, (2021) who found high rates of COVID-19 contamination among their professionals, even with classical preventive measures. The authors adopted different strategies to circumvent the situation, including the proper use and disposal of PPE.

Vaccination against COVID-19 in healthcare workers achieved high levels of acceptability both in the present study and reported by other authors (Papagiannis *et al*, 2021; Rosiello *et al*, 2021).

4.3. SSR management knowledge

The information about the Health Services Waste Management Basic Knowledge Assessment Questionnaire is described in Table 3.

It was verified in general that the institution has a protocol for management of waste contaminated by

COVID-19 as reported by 50 participants (90.9%), however most did not know what the Health Service Waste Management Plan is (56.4%), nor received training on HSWM (69.1%).s Waste Management Plan (56.4%), nor received training on SWM (69.1%), not knowing how to classify without difficulty which are the Health Service Waste (54.5%), even performing invasive procedures with risk of contamination (87.3%).

Table. 3: Questionnaire to assess basic knowledge about health services waste management

Items of the "Health Services Residues Management Basic Knowledge Assessment Questionnaire"	No N (%)	I don't know N (%)	Yes N (%)
Does your institution have a protocol for handling Covid-19-contaminated waste?	1 (1,8)	4 (7,3)	50 (90,9)
Is the sector you work in always full of patients?	5 (9,1)	0 (0,0)	50 (90,9)
Do you know what the Health Services Residues Management Plan is?	31 (56,4)	0 (0,0)	24 (43,6)
The institution you work makes available to employees for consultation and withdrawal of questions about handling contaminated materials the Health Services Waste Management Plan?	29 (52,7)	23 (41,8)	3 (5,5)
Have you ever taken any training made available by the institution you work for on Health Services Waste Management Plan?	38 (69,1)	0 (0,0)	17 (30,9)
Do you know how to classify without difficulty which are the Health Service Residues?	30 (54,5)	0 (0,0)	25 (45,5)
Do you have direct contact with the patients?	5 (9,1)	0 (0,0)	50 (90,9)
Do you perform invasive procedures on the patients you see?	7 (12,7)	0 (0,0)	48 (87,3)
Do the procedures you perform generate garbage or contaminated residues?	4 (7,3)	0 (0,0)	51 (92,7)
Have you ever had an accident with sharp objects?	38 (69,1)	0 (0,0)	17 (30,9)

Are needles and syringes disposed of together?	23 (41,8)	4 (7,3)	28 (50,9)
Do you receive equipment for handling the contaminated products?	2 (3,6)	0 (0,0)	53 (96,4)
Are there suitable containers for disposal of biological material?	1 (1,8)	1 (1,8)	53 (96,4)
Are there suitable containers for cutting material disposal?	0 (0,0)	0 (0,0)	55 (100)
In the sector you work, has there been a lack of suitable containers for the disposal of sharp drills?	28 (50,9)	2 (3,6)	24 (43,6)
Is there a specific colour-coding system for disposing of waste from healthcare services?	31 (56,4)	4 (7,3)	20 (36,4)
Do you think that the current practices for collecting and transporting health care waste provide sufficient safety?	6 (10,9)	15 (27,3)	34 (61,8)
Are there written instructions about regulations /waste management plans for health services?	47 (85,5)	3 (5,5)	4 (7,3)

It is evident that even in times of COVID-19 pandemic, the trainings necessary to have knowledge about Residues Management in Health Services in the investigated institution are still a challenge. Most of those interviewed said they did not have enough knowledge about the subject and did not receive recurrent training or have access to materials for consultation.

In contrast to this result, a study in Malaysia revealed that local policies integrate SSR management and environmental protection. The public hospitals evaluated in this study used not only the policies indicated, but also added their own strategies to ensure the correct management of waste, such as the application of a management policy, training of employees on this policy, separation of waste types still in the hospital using their own labels and use of specific PPE for the team handling the COVID-19 infected waste (Agamuthu; Barasarathi, 2021). Therefore, in addition to local training, ensuring that environmental laws are enforced is fundamental and feasible.

The availability of appropriate material for sharps disposal was confirmed by all the interviewees in this study, as well as the existence of appropriate containers for disposal of biological material (96.4%), as reported in table 3. This finding is positively relevant, because it reveals that even with the lack of adequate training, the institution is concerned with the execution of the Health Services Waste Management Plan.

A recent study has shown that such attitudes are key to alleviating the problem of landfills, as on-site SSR treatment and temporary storage reduce the burden of such waste, helps reduce virus transmission and facilitates recycling work, effects that have a positive impact on the environmental preservation and safety of health professionals (Das *et al*, 2021).

It should not be forgotten that the city of Manaus in Brazil, the place of interest of this study, was the scene of one of the most critical episodes of Brazilian public health during the COVID-19 pandemic period (Orellana *et al*, 2020) and it is essential to stress that during periods of health crisis, ensuring the safety of professionals and patients is essential.

In general, several approaches are recommended to circumvent the problem of SSR management, such as the need to know the status quo, characterization of the problem and the involvement of environmental departments in the supervision of health institutions, that acting together, can have a more holistic view of the situation and have greater chances of success in the implementation of effective PGRSS (Du *et al*, 2021; Das *et al*, 2021; Sarkodie; Owusu, 2021).

Therefore, the identification of the problem is one of the pillars for the construction of a more tangible solution, as carried out in this study, identifying which actions are being taken at the cutting edge linked to health services to then understand the possible consequences on the edge of the environment.

V. CONCLUSION

With the present research it was identified that the knowledge of healthcare professionals about residues management in times of COVID-19 pandemic still needs attention.

Most of the professionals reported that they do not have sufficient knowledge, and/or did not receive adequate training, even though the institution is providing the necessary tools to ensure the final disposal of waste health services. Even reporting that they have frequent contact with contaminated waste, more than half of the professionals reported that they do not know how to

identify without difficulty the types of waste, which consequently can impact on the inadequate disposal and, therefore, on environmental impact resulting from the dumping of contaminated material in inappropriate places. As a contribution, this study returned the results to the management of the research site and suggested strategies for improving knowledge about SSR management, such as frequent trainings focused on the main difficulties reported during the interviews. In addition, at the end of data collection, the professionals received access to additional material on the subject, aiming at self-training, as well as materials that highlighted the impact of their actions on the environment.

We conclude that even with the increase in demand for health services and SSRs during the COVID-19 pandemic, the training and knowledge about how to manage such waste did not follow the same growth, thus, the increase in the production of SSRs can negatively impact the environment if the necessary measures are not known by all actors involved in this process.

ACKNOWLEDGEMENTS

REFERENCES

[1] Agamuthu, P., & Barasarathi, J. (2021). Clinical waste management under COVID-19 scenario in Malaysia. *Waste Management & Research*, 39(1_suppl), 18-26.

[2] Brasil. Conselho Nacional do Meio Ambiente. Resolução 358, de 29 de abril de 2005. Dispõe sobre o tratamento e a disposição final dos resíduos dos serviços de saúde e dá outras providências. (2005). *Diário Oficial da União*, 4 mai.

[3] Capoor, M. R., & Parida, A. (2021). Current perspectives of biomedical waste management in context of COVID-19". *Indian Journal of Medical Microbiology*, 39(2), 171-178.

[4] Chowdhury, T., Chowdhury, H., Rahman, M. S., Hossain, N., Ahmed, A., & Sait, S. M. (2022). Estimation of the healthcare waste generation during COVID-19 pandemic in Bangladesh. *Science of The Total Environment*, 811, 152295.

[5] Das, A. K., Islam, M. N., Billah, M. M., & Sarker, A. (2021). COVID-19 pandemic and healthcare solid waste management strategy–A mini-review. *Science of the Total Environment*, 778, 146220.

[6] Du, Q., Zhang, D., Hu, W., Li, X., Xia, Q., Wen, T., & Jia, H. (2021). Nosocomial infection of COVID-19: A new challenge for healthcare professionals. *International Journal of Molecular Medicine*, 47(4), 1-1.

[7] Hantoko, D., Li, X., Pariatamby, A., Yoshikawa, K., Horttanainen, M., & Yan, M. (2021). Challenges and practices on waste management and disposal during COVID-19 pandemic. *Journal of Environmental Management*, 286, 112140.

[8] Jalal, S. M., Akhter, F., Abdelhafez, A. I., & Alrajeh, A. M. (2021, June). Assessment of knowledge, practice and attitude about biomedical waste management among healthcare professionals during COVID-19 crises in Al-Ahsa. In *Healthcare* (Vol. 9, No. 6, p. 747). Multidisciplinary Digital Publishing Institute.

[9] López-Feldman, A., Chávez, C., Vélez, M. A., Bejarano, H., Chimeli, A. B., Féres, J., ... & Viteri, C. (2020). Environmental impacts and policy responses to Covid-19: a view from Latin America. *Environmental & resource economics,* 1.

[10] Manzoor, J., & Sharma, M. (2019). Impact of biomedical waste on environment and human health. *Environmental Claims Journal*, 31(4), 311-334.

[11] Merchán-Hamann, E., & Tauil, P. L. (2021). Proposta de classificação dos diferentes tipos de estudos epidemiológicos descritivos. *Epidemiologia e Serviços de Saúde*, 30, e2018126.

[12] Orellana, J. D. Y., Cunha, G. M. D., Marrero, L., Horta, B. L., & Leite, I. D. C. (2020). Explosão da mortalidade no epicentro amazônico da epidemia de COVID-19. *Cadernos de Saúde Pública*, 36.

[13] Papagiannis, D., Rachiotis, G., Malli, F., Papathanasiou, I. V., Kotsiou, O., Fradelos, E. C., ... & Gourgoulianis, K. I. (2021). Acceptability of COVID-19 vaccination among Greek health professionals. *Vaccines*, 9(3), 200.

[14] Parikh, P., Mehta, P., Bansal, S., Aggarwal, S., Patel, A., Batra, A., & Sahoo, R. K. (2020). Protecting health-care professionals and workers (other than COVID-19 management facilities) from contamination during COVID-19 pandemic (March 26, 2020–India). *Indian Journal of Medical Sciences*, 72(1), 3.

[15] Rizan, C., Reed, M., & Bhutta, M. F. (2021). Environmental impact of personal protective equipment distributed for use by health and social care services in England in the first six months of the COVID-19 pandemic. *Journal of the Royal Society of Medicine*, 114(5), 250-263.

[16] Rosa Filho, E.S., Rosa, R., Sena, N. D. S. (2016). Atuação do enfermeiro frente ao gerenciamento de resíduos sólidos de serviço de saúde. 64 f. - Enfermagem, *Faculdade Paraense de Ensino*.

[17] Rosiello, D. F., Anwar, S., Yufika, A., Adam, R. Y., Ismaeil, M. I., Ismail, A. Y., ... & Sallam, M. (2021). Acceptance of COVID-19 vaccination at different hypothetical efficacy and safety levels in ten countries in Asia, Africa, and South America. *Narra J,* 1(3).

[18] Sangkham, S. (2020). Face mask and medical waste disposal during the novel COVID-19 pandemic in Asia. *Case Studies in Chemical and Environmental Engineering*, 2, 100052.

[19] Sarkodie, S. A., & Owusu, P. A. (2021). Global assessment of environment, health and economic impact of the novel coronavirus (COVID-19). *Environment, Development and Sustainability*, 23(4), 5005-5015.

[20] Sharma, H. B., Vanapalli, K. R., Cheela, V. S., Ranjan, V. P., Jaglan, A. K., Dubey, B., ... & Bhattacharya, J. (2020). Challenges, opportunities, and innovations for effective solid waste management during and post COVID-19 pandemic. *Resources, conservation and recycling*, 162, 105052.

[21] Silva, E. N. C. D. (2011). *Gerenciamento de resíduos de serviços de saúde: adaptação transcultural e validação do instrumento healt-care wast management-rapid assessment tool'para a língua portuguesa no Brasil (Doctoral dissertation).*

[22] Singh, N., Tang, Y., Zhang, Z., & Zheng, C. (2020). COVID-19 waste management: effective and successful measures in Wuhan, China. *Resources, conservation, and recycling*, 163, 105071.

[23] Urban, R. C., & Nakada, L. Y. K. (2021). COVID-19 pandemic: Solid waste and environmental impacts in Brazil. *Science of the Total Environment,* 755, 142471.

[24] Yousefi, M., Oskoei, V., Jonidi Jafari, A., Farzadkia, M., Hasham Firooz, M., Abdollahinejad, B., & Torkashvand, J. (2021). Municipal solid waste management during COVID-19 pandemic: effects and repercussions. *Environmental Science and Pollution Research,* 28(25), 32200-32209.

[25] Zand, A. D., & Heir, A. V. (2021). Environmental impacts of new Coronavirus outbreak in Iran with an emphasis on waste management sector. *Journal of Material Cycles and Waste Management,* 23(1), 240-247.

Project based learning STEM to enhance secondary school students' comprehension on projectile motion

Mutia Delina[1], B H Iswanto[2], S Ditania[3]

[1]Physics Department, Faculty of Mathematics and Natural Sciences, Universitas Negeri Jakarta, Indonesia
[2]Master Program of Educational Physics, Faculty of Mathematics and Natural Sciences, Universitas Negeri Jakarta, Indonesia
[3]Physics Education Department, Faculty of Mathematics and Natural Sciences, Universitas Negeri Jakarta, Indonesia
E-mail: mutia_delina@unj.ac.id

Abstract— At the beginning of 2020, the Covid-19 pandemic has influenced learning activity where students and teachers have to adapt from face-to-face learning to online learning. This study aims to overcome the issue by developing a learning media with Project-based learning STEM on projectile motion. The media which accommodated the catapult project was developed for secondary schools on google sites. In this research, the media was developed by conducting the Research and Development (RnD) method with the ADDIE model, consisting of five steps: analyze, design, develop, implement, and evaluate. Furthermore, the media was validated by experts and then implemented to the students. Finally, the validation and implementation results were analyzed with four points of the Likert scale. The validation results showed that the average score of the material aspect was 3.8. Meanwhile, the media aspect was 3.3. After the revision, the media was implemented to the students. The average of implementation cores showed that the material aspect was 3.6, the media aspect was 3.6, and the benefit aspect was 3.5. Both validation and implementation results showed that the media was excellent. Therefore, the project-based learning STEM with a catapult project can be applied as a supplemented media for the projectile motion learning process and applied in online learning during the covid-19 pandemic.

I. INTRODUCTION

The Corona Virus Disease 2019 (Covid-19) has influenced the world since the beginning of 2020. Later on, the World Health Organization (WHO) announced that Covid-19 was a pandemic [1]. This situation does globally impact the economy and the educational sector[2].Consequently, the students cannot study at school to avoid the virus spreading. However, on the other hand, the learning activities must keep going. Therefore, the teacher needs to convert the learning activities[3]from face-to-face learning to online learning[4].In addition, appropriate learning

media and model is also needed to support the online learning process during the pandemic Covid-19.

In the 21st century, digital learning media such as websites is more often applied[5]. Therefore, students can study and comprehend the learning material anytime and anywhere through the website. Along with the media, the learning model is also developed rapidly today. For example, the combination of Science, Technology, Engineering, and Mathematics as STEM learning models to enhance students' skills[6], and replace "teacher center" learning with project-based learning[7][8]. Project-based learning applies projects as a learning process[9]and set

"students center" in the learning process [10].Therefore, students can complete the task independently with design, problem-solving, and decision-making skills [11].

Several studies combined project-based learning with STEM to obtain a better result in the learning activity. For example, a project-based learning STEM module was developed to support students in accomplishing a biology project[12]. Besides module, project-based learning STEM websites and video conferences were also conducted to enhance organizational and communication skills [13][14]. In another research, project-based learning STEM was also conducted to enhance the students' comprehension of the engineering design process[15].

Based on those previous research, we combined project based-learning and STEM to enhance student comprehension of physics material, especially the projectile motion, during the online learning. The combination of project-based learning and STEM at Indonesian secondary school has not been applied yet. It was shown by physics teachers' interviews at the 107 Jakarta secondary school, where the learning process was still "teacher-centered." Besides, the questionnaire result of 9th-grade students at 107 Jakarta secondary schools showed that the student comprehension on four projectile motion questions was 64%, 58%, 64%, and 70%. These results indicated that students' fundamental knowledge and comprehension were low. Therefore, this study developed project-based learning STEM media to enhance students' comprehension of projectile motion material. In addition, project-based learning STEM which has five steps: 1) Reflection; 2) Research; 3) Discovery; 4) Applications; 5) Communication[16]is in line with the 2013 curriculum in Indonesia[17].

II.   METHODOLOGY

This study conducted the Research and Development (RnD) method with the ADDIE model, consisting of 5 stages: analyze, design, develop, implement, and evaluate. The cycle of the ADDIE model is shown in figure 1 [18].

The first stage was analyzed. Here, an assessment need and literature review were conducted to identify the teachers' and students' problems in the learning process during the pandemic. The need analysis was obtained from teachers' interviews and students' questionnaires. Meanwhile, the literature review was attained from several references. Then, the second stage was designed. After identifying the problems, the learning media was designed by setting the learning objectives, stages, materials, assignments, guidance, and validation instruments. Next, the stage was developed. Here, the learning media was built on google sites. The fourth stage is implementation.

In this stage, the learning media was validated by experts and then implemented to the students in the learning process.
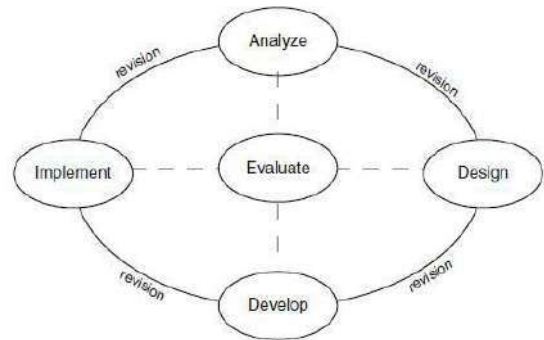
Fig.1. The cycle of the ADDIE model

The validators were from the Physics Education and Physics department at Universitas Negeri Jakarta. Finally, the media was evaluated and improved in the last stage based on the validation and implementation results. Here, the results were analyzed by four points of the Likert Scale. The average scores were obtained from the following formula.

$$\bar{x} = \frac{\sum x}{n} \qquad (1)$$

where, $\bar{x}$is the average score,$\sum x$ is the total scores and$n$ is the number of questions. The product quality could be qualified based on the following classification [19].

Table 1. The score range classification

No	Score Range	Criteria
1	$3.25 < \bar{x} \leq 4.0$	Excellent
2	$2.5 < \bar{x} \leq 3.25$	Good
3	$1.75 < \bar{x} \leq 2.5$	Fair
4	$1.0 < \bar{x} \leq 1.75$	Poor

Table 1 showed the score range from 1.0 to 4.0. Thus, the learning media could be proceeded to the implementation stage, once the $\bar{x}$was larger than 2.5. Meanwhile, if the $\bar{x}$was lower than 2.5, then the media should be revised and revalidated.

III.   RESULTS AND DISCUSSION

Project-based learning STEM media on the projectile motion for secondary schools has been developed. The developed media was a website built on googles sites. Here, the media title was a catapult project which can be accessed on the following link https://sites.google.com/view/media-proyek-ketapel.

Fig.2. The homepage

page, the learning activities page, the course material page, the project page, and references. The guidelines page showed the media application. Meanwhile, the introduction page displayed the competencies, learning objectives, and learning stages. Furthermore, the learning activity page showed the learning activities complete with video. In addition, the course material page displayed theory for projectile motion. Besides, the project page displayed the catapult project to enhance the comprehension of projectile motion. The learning activities page displays the students' core activities. Finally, the references showed some references of projectile motion. The details were shown in figure 3 (a) and (b).

The homepage showed the title and menu. On this page, users can go to the guidelines page, the introduction
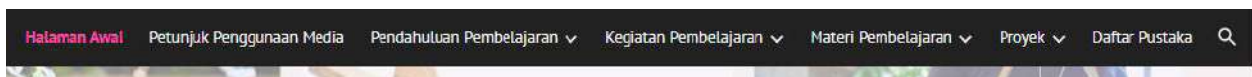
(a)
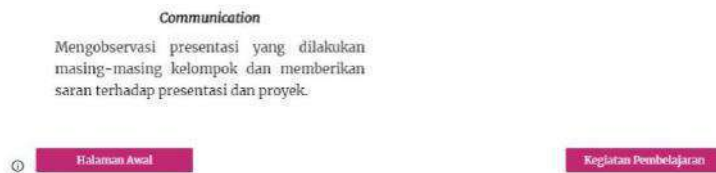
(b)

Fig.3. (a) The main menu, (b) The sub menu's button

Fig.4. Menu of learning activities

Figure 4 showed the three learning activities: kegiatan belajar 1 to 3.The learning activities are arranged based on five process stages of project-based learning STEM. In general, learning activities lead students to create the catapult project and do the presentation. Finally, the students present the project by integrating STEM as shown in figure 5.
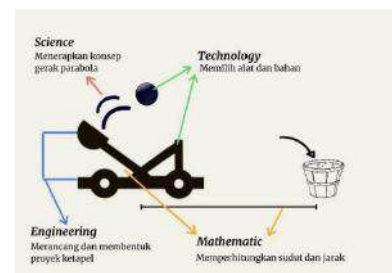
Fig.5. Example of students' project design

Moreover, before the learning media was implemented, the experts should validate it in material and media aspects. The material aspect consists of content, language, and presentation. Meanwhile, the media aspect consists of design, user-friendly and visual communication. The validation results showed in the following table.

Table 2. The validation result of learning media by the experts

Aspects	Indicator	Score	Average	Criteria
Material	1. Contents	3.8	3.8	Excellent
	2. Language	4		
	3. Presentation	3.5		
Media	1. Design	3.3	3.3	Excellent
	2. User friendly	3.4		
	3. Visual communication	3.2		

Table 2 shows that the material and media validation results' average score was 3.8 and 3.32, respectively. Based on the criteria in table 1, the scores met the excellent category. Therefore the media can be applied for project-based learning STEM as an essential component in the learning process[20]. Besides, the media can help the students to comprehend the projectile motion in the form of a project. Finally, even though the results are excellent, the validator recommended revising the typographical error in the media.

After the media revised, researcher implements the media to see how the response of students having studied with the project-based learning media. Students are given a questionnaire that consisted of 18 questions with aspect of material, media, and benefit. The questionnaire is filled 28 students in grade 10 secondary school. The results of responses by students shown in table 3.

Table 3. The students' response on project-based learning STEM

Aspects	Indicator	Score	Average	Criteria
Material	1. Learning material	3.6	3.6	Excellent
	2. Assignment	3.5		
	3. Resume	3.6		
	4. Presentation	3.6		
	5. Picture and video	3.6		
Media	1. Language	3.7	3.6	Excellent
	2. Layout	3.6		
	3. Typographical	3.7		
	4. Picture and video quality	3.7		
	5. Learning media interest	3.4		
	6. User friendly	3.7		
Benefit	1. Convenience	3.5	3.5	Excellent
	2. Interest	3.4		
	3. Motivation	3.5		

Table 3 showed results of students' responses which consist of material, media, and benefits aspects. The material aspect consisted of learning material, assignment, resume, presentation, picture, and video. At the same time, the media aspect consisted of language, layout, typography, picture and video quality, learning media interest, and user friendly. Finally, the benefit aspect consisted of convenience, interest, and motivation. The

results were 3.6, 3.6, and 3.5 for material, media, and benefits aspects which were excellent.

IV. CONCLUSION

In the covid-19 pandemic, the learning process has changed from face-to-face to online learning. Digital media (google site) have been developed to enhance student comprehension in online learning. Here is project-based learning STEM media on the projectile motion for secondary school students. Several experts have been validated the media to evaluate it. The validation results showed that the media is excellent because the material and media aspect's average score was 3.8 and 3.3, respectively. Besides validation, the students' response was also excellent for material, media, and benefit criteria, with an average score of 3.6. Both validation and implementation results showed that the media was excellent. Therefore, the project-based learning STEM with a catapult project can be applied as a supplemented media for the projectile motion learning process and applied in online learning during the covid-19 pandemic.

ACKNOWLEDGEMENT

REFERENCES

[1] World Health Organization, "Listings of WHO's response to COVID-19," 2020. https://www.who.int/news/item/29-06-2020-covidtimeline.

[2] S. Dhawan, "Online Learning: A Panacea in the Time of COVID-19 Crisis," J. Educ. Technol. Syst., vol. 49, no. 1, pp. 5–22, 2020, doi: 10.1177/0047239520934018.

[3] J. B. Rieley, "Corona Virus and its impact on higher education," ResearchGate, 2020. https://www.researchgate.net/post/Corona_Virus_and_its_impact_on_higher_education (accessed Aug. 31, 2021).

[4] A. El Masri and E. Sabzalieva, "Dealing with disruption, rethinking recovery: Policy responses to the COVID-19 pandemic in higher education," Policy Des. Pract., vol. 3, no. 3, pp. 312–333, 2020, doi: 10.1080/25741292.2020.1813359.

[5] E. D. T. Puspitasari, H. D. Surjono, and A. D. Minghat, "Utilizing web based learning as 21st century learning media for vocational education," Int. J. Eng. Technol., vol. 7, no. 4, pp. 157–160, 2018, doi: 10.14419/ijet.v7i4.33.23522.

[6] T. Wynn and J. Harris, "Toward A Stem + Arts Curriculum: Creating the Teacher Team," Art Educ., vol. 65, no. 5, pp. 42–47, 2015, doi: https://doi.org/10.1080/00043125.2012.11519191.

[7] N. Mustafa, Z. Ismail, Z. Tasir, and M. N. H. Mohamad Said, "A meta-analysis on effective strategies for integrated STEM education," Adv. Sci. Lett., vol. 22, no. 12, pp. 4225–4288, 2016, doi: 10.1166/asl.2016.8111.

[8] J. M. Breiner, S. S. Harkness, C. C. Johnson, and C. M. Koehler, "What Is STEM? A Discussion About Conceptions of STEM in Education and Partnerships," Sch. Sci. Math., vol. 112, no. 1, pp. 3–11, 2012, doi: 10.1111/j.1949-8594.2011.00109.x.

[9] S. S. Sumarti, "Project Based Learning Model Development on Buffer Solution Materials with Soft Skill Entrepreneur Oriented," Int. J. Eng. Sci., vol. 4, no. 3, pp. 5–10, 2015.

[10] S. Aldabbus, "PROJECT-BASED LEARNING : IMPLEMENTATION & CHALLENGES," no. March, 2018.

[11] K. H. Tseng, C. C. Chang, S. J. Lou, and W. P. Chen, "Attitudes towards science, technology, engineering and mathematics (STEM) in a project-based learning (PjBL) environment," Int. J. Technol. Des. Educ., vol. 23, no. 1, pp. 87–102, 2013, doi: 10.1007/s10798-011-9160-x.

[12] D. Susanti, V. Fitriani, and L. Y. Sari, "Validity of module based on project based learning in media biology subject," J. Phys. Conf. Ser., vol. 1521, no. 4, 2020, doi: 10.1088/1742-6596/1521/4/042012.

[13] Chatwattana, PinantaPrachyanun Nilsook, "A_Web_based_Learning_System_using_Projec.pdf," pp. 4–22, 2017.

[14] J. Fitzsimons and R. Turner, "Integrating project-based learning into an undergraduate programme using Web 2.0 and videoconferencing," J. Appl. Res. High. Educ., vol. 5, no. 1, pp. 129–140, Apr. 2013, doi: 10.1108/17581181311310324.

[15] K.-Y. Lin, H.-S. Hsiao, Y.-S. Chang, Y.-H. Chien, and Y.-T. Wu, "The Effectiveness of Using 3D Printing Technology in STEM Project-Based Learning Activities," EURASIA J. Math. Sci. Technol. Educ., vol. 14, no. 12, Sep. 2018, doi: 10.29333/ejmste/97189.

[16] D. Laboy-Rush, "Integrated STEM Education through Project-Based Learning," Learning.com, 2015. https://studentsatthecenterhub.org/resource/integrated-stem-education-through-project-based-learning/ (accessed Feb. 12, 2021).

[17] Toto, "STEM-based Science Learning Design in the 2013 Curriculum," J. Phys. Conf. Ser., vol. 1233, no. 1, 2019, doi: 10.1088/1742-6596/1233/1/012094.

[18] R. M. Branch, Instructional Design: The ADDIE Approach. Boston, MA: Springer US, 2009.

[19] M. H. Haloua et al., "Cosmetic Outcome Assessment following Breast-Conserving Therapy: A Comparison between BCCT.core Software and Panel Evaluation," Int. J. Breast Cancer, vol. 2014, no. November, pp. 1–7, 2014, doi: 10.1155/2014/716860.

[20] D. Susanti, L. Y. Sari, and V. Fitriani, "Curriculum Analysis of Biological Learning Media Module Development Based on Project Based Learning (PjBL)," J. Penelit. Pendidik. IPA, vol. 6, no. 2, p. 157, 2020, doi: 10.29303/jppipa.v6i2.302.

Influence of vitamin D deficiency on intestinal dysbiosis: A systematic review

Daniela Machado Bezerra[1], Reinaldo da Silva Bezerra[2], Ricardo De Bonis[3]

[1]Doctoral student Universidad de la Integración de las Américas, CDE, Paraguay.
Email:danielamachadobezerra@hotmail.com
[2]Doctoral student at the University of Integration of the Americas, CDE, Paraguay
Email:reinaldobezerra@ufpi.edu.br
[3]Post-Doctor Universidad Iberoamerica, ASU, Paraguay Professor at the Universidad de la Integración de las Américas, CDE, Paraguay
Email: ricardo@institutoiiep.com.br

Abstract— The intestinal microbiota influences important local and systemic processes for the organism, having in its composition probiotic bacteria that assist in the beneficial processes and common bacteria, which often cause infections. The aim of this article is to analyze the existence of a relationship between the prevalence of pathogenic bacteria and intestinal inflammation when plasma levels are deficient in vitamin D. For this, the literature review was carried out with a systematic search in order to capture the current information. on the topic, in order to contribute to the clinical direction. As a result of the analysis, it was found that vitamin D sufficiency favors the presence of probiotics and intestinal barrier integrity, and that deficiency is associated with the prevalence of pathobionts and intestinal inflammation.

I. INTRODUCTION

The gut microbiota is established as an organ of the body, influencing local and systemic processes such as nutrition, vitamin supply, maturation of mucosal immunity, and gut-brain communication (Weiss & Hennet, 2017). Thus, it needs an adequate and stable cellular composition, which in this case consists of 30-400 trillion microorganisms, including bacteria (mainly bacteria of the phyla Bacteroidetes, Firmicutes, Actinobacteria and, to a lesser extent, Proteobacteria), fungi and viruses that colonize the human intestine (de Oliveira et al., 2017).

The intestinal tract is sterile at birth, being colonized and shaped by lifelong exposures such as delivery (especially in vaginal delivery, by direct contact with the mother's fecal microbiota), genetic factors, diet, antibiotic use, gestational age and microorganisms from the maternal digestive tract,reaching adult composition at approximately 3 years of age (Yatsunenko et al., 2012). In this sense,

alterations in the immune system and in the factors previously exposed can lead to Dysbiosis, a state of imbalance between the number of protective and aggressive bacteria, favoring a metabolic endotoxemia and a chronic inflammatory state, due to the increase in intestinal permeability, which results in an ascending passage. of lipopolysaccharide (LPS) to the systemic circulation (dos Santos Moraes et al., 2017)

Fecal calprotectin, a marker of intestinal inflammation, has been shown to be inversely related to serum vitamin D (VD) concentration in Crohn's disease and Inflammatory Bowel Disease, raising questions about the existence of a bidirectional relationship between vitamin D and inflammation and microbiota. intestinal tract (Naderpoor et al., 2019). Sigh et al., (2020) further described the potential role of vitamin D as a modifier of the gut microbiota in healthy individuals by finding that following VD supplementation there was an increase in the overall diversity of the gut microbiota and, in particular, an

increase in abundance. relative abundance of Bacteroidetes (bacteria related to beneficial effects in the body) and decreased relative abundance of Firmicutes (bacteria often associated with infections).

Vitamin D, despite its name, is considered a steroid hormone that is part of the secosteroid group, derived from 7-dehydrocholesterol (7-DHC), having 1α,25-dihydroxy-vitamin D or calcitriol as an active metabolite; as precursors vitamin D2 or ergosterol, vitamin D3 or cholecalciferol, 25-hydroxyvitamin D [25(OH)D] or calcidiol, and some degradation products. Most vitamin D is synthesized endogenously in the deep layers of the epidermis, as follows: exposure of the skin to ultraviolet rays (UVB) allows the process of photochemical cleavage of the cutaneous precursor of vitamin D, 7-dehydrocholesterol, giving rise to pre-vitamin D3, which undergoes a temperature-dependent molecular rearrangement resulting in the formation of vitamin D3 or cholecalciferol (Marques et al., 2010). Limiting factors for the production of vitamin D are considered to be non-exposure to ultraviolet rays, the use of sunscreens and the degree of skin pigmentation, since black skin has lower penetration of UVB rays (Melmed et al., 2015). A small part can still be obtained through the diet, vitamin D3 (cholecalciferol) is of animal origin and is present in tuna, cod, sardines and salmon; Vitamin D2 (ergosterol) is of plant origin and is also found in edible fungi such as fresh and dried shitake mushrooms (Claudio Gonçalves de Castro, 2011). vitamin D3 (cholecalciferol) is of animal origin and is present in tuna, cod, sardines and salmon; Vitamin D2 (ergosterol) is of plant origin and is also found in edible fungi such as fresh and dried shitake mushrooms (Claudio Gonçalves de Castro, 2011). vitamin D3 (cholecalciferol) is of animal origin and is present in tuna, cod, sardines and salmon; Vitamin D2 (ergosterol) is of plant origin and is also found in edible fungi such as fresh and dried shitake mushrooms (Claudio Gonçalves de Castro, 2011).

In the blood, cholecalciferol and ergosterol are transported to the liver mainly by the vitamin D binding protein, or transcalciferrin, and a small part by albumin, where they are hydroxylated by a cytochrome P450-like enzyme at carbon 25 to form calcidiol (25-OH- Vitamin D) which is the depot form of vitamin D. Finally, calcidiol is transported by DBP to the kidneys where new hydroxylation occurs by the action of the enzyme 1-alpha-hydroxylase, forming calcitriol (1,25-OH-vitamin D), which is the metabolically active form of vitamin D (Científico & De Paula, 2016).

Vitamin D binds to vitamin D receptors (VDRs) and thus can exert its biological functions, as they regulate the transcription of DNA into RNA, similar to other members of the nuclear receptor family. For a long time, the role of vitamin D was solely attributed to the regulation of osteomineral physiology, especially calcium metabolism. However, VDRs are expressed by several cell types, including osteoblasts, osteoclasts, hematopoietic cells, epidermal cells, pancreatic cells, small intestinal epithelium, in addition to being widely expressed in most immune cells, including monocytes, macrophages, dendritic cells. , NK cells and T and B lymphocytes (Marques et al., 2010). The anti-inflammatory effects of vitamin D have been studied extensively in different conditions of subacute, acute, and chronic inflammation, such as obesity, diabetes, and inflammatory bowel disease. In this sense, this study aimed to review the literature in order to gather updated information regarding the relationship between impaired levels of Vitamin D and the consequences of this on intestinal dysbiosis, in order to contribute to clinical guidance.

II. METHODOLOGY

The present study is a systematic literature review, a qualitative-quantitative research (Estrela, 2018; Pereira et al., 2018). For its elaboration, methodological steps were followed in this sequence: (I) elaboration of the research question; (II) search for scientific evidence; (III) selection of articles; (IV) data extraction; (V) assessment of methodological quality; (VI) data synthesis; (VII) assessment of evidence levels; and (VIII) writing and publishing the results.

The search for scientific records was based on the guiding question: "Do low levels of vitamin D favor the development of intestinal dysbiosis?", formulated using the strategy of the acronym PICO (Population, Intervention, Comparison, Outcome), which in turn time was defined based on the objectives of the present study as:

P: Patients and animals with vitamin

D deficient plasma levels.

I: Vitamin D supplementation.

C: Vitamin D-restricted diet. O: Intestinal dysbiosis.

In order to capture articles that presented in their study designs a correlation between intestinal dysbiosis and vitamin D deficiency. Health Sciences (LILACS), PubMed and Scientific Electronic Library Online (Scielo), using as descriptors the terms "Dysbiosis", "Vitamin D deficiency" and "Gintestinal microbiome", identified in the Health Sciences Descriptors (DECS). The research was carried out with descriptors in English on Pubmed and in Portuguese and Spanish on Scielo and LILACS. The search for articles was carried out in each of the databases

following the following steps: initially the search was performed using the three descriptors separately and then, in combination of two and three terms, using the Boolean operator "and". Studies performed in humans and animals, which had good methodological reliability and addressed the relationship between vitamin D and intestinal

dysbiosis, were included. The exclusion criteria for the study were articles with a publication time of more than 15 years, articles with incompatible samples, literature reviews and systematic reviews. Thus, 18 articles were found suitable to be addressed, as shown in Figure 1.
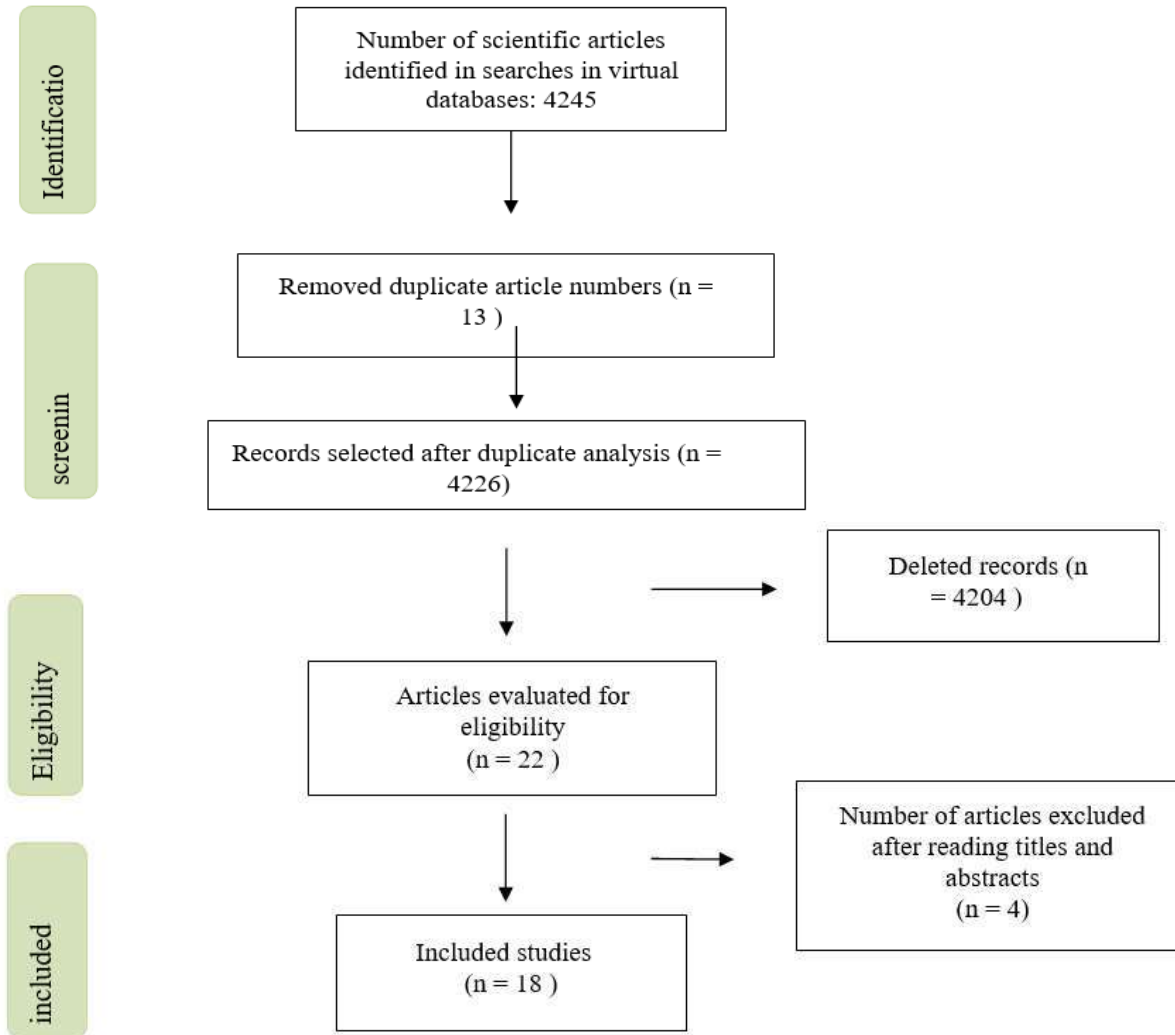
Fig.1. Flowchart of methodological steps for selecting studies.

III.   RESULTS AND DISCUSSION

Initially, 4245 articles were obtained: 4234 from PubMed, 5 from Scielo and 6 from Lilacs. After considering the exclusion criteria and analyzing the titles, 22 articles remained from PubMed, 0 from Scielo and 0 from Lilacs: 22 in total, which were selected for full reading of the abstracts. When the abstract proved to be relevant to the research objective, the work was read in full. Finally, 18 texts from PubMed, 0 from Scielo and 0 from Lilacs were selected, reducing the corpus to 18 scientific articles, as shown in Table 1.

The 18 articles were divided as follows: ten studies

performed in humans and eight in animals, eight of which were controlled clinical trials, two uncontrolled clinical trials, six randomized and controlled clinical trials, and two in vivo experimental studies, as shown in the Table two.

Table 1.Number of articles per database.

Basis of data	found	selected
PubMe d	4234 articles	18 articles
Scielo	5 articles	no article
lilacs	6 articles	no article

Source: Authors (2021).

Table 2. Distribution of articles according to authors/year of publication, design, level of evidence and main results.

Title of work	Author/Y ear	Outline	Level of evidenc e	main results
1 The effect of vitamin D on intestinal inflammation and fecal microbiota in patients with ulcerative colitis	Garg et al., 2018	controlled clinical trial	Level III – well- designed clinical trials, without randomiza tion	Vitamin D replacement at a dose of 40,000 IU weekly for 8 weeks reduced markers of intestinal inflammation such as fecal calprotectin in patients with active UC with vitamin D deficiency. This was associated with an increase in Enterobacteriacae, but overall there was no significant changes in the diversity of the microbiota.
two The effect of daily consumption of different doses of fortified Lavash bread versus plain bread on serum vitamin D status, body composition, metabolic and inflammatory biomarkers, and gut microbiota in apparently healthy adults: study protocol of a randomized clinical trial	Tangest ani; Kurosh; Shab- Bidar., 2019	Double- blind, randomize d, controlled clinical trial	Level II - evidence derived from at least one randomiz ed clinical trial	Using bread, a food consumed daily by diverse populations, fortified with vitamin D, in order to improve serum vitamin D levels and determine the effect of vitamin D on body composition, metabolic and inflammatory biomarkers and intestinal microbiota in apparently healthy adults
3 Weekly bolus vitamin D3 supplementation affects gut and airway microbiota in adults with cystic fibrosis: a double-blind, randomized, placebo-controlled clinical trial	Kanher eet al., 2018	Randomiz ed controlled clinical trial	Level II - evidence derived from at least one trial randomiz ed clinical	After 12 weeks, there was a difference in the microbiota of subjects who were randomized to take 50,000 IU of vitamin A once a week. D3 compared to subjects randomized to placebo. The gammaproteobacteria, potentially pathogenic species, were enriched in vitamin D deficiency, in addition to the increase of Bacteroides in the airway microbiota. *Lactococcus,*bacteria associated with Health intestinal tract, were enriched in the presence of vitamin D3.

#	Title	Author	Type	Level	Results
4	Correlation between vitamin D status and gut microbiota in patients with inflammatory bowel disease	Chen et al., 2020	controlled clinical trial	Level III - clinical trials well outlined, Without randomizati on	There was no difference in the alpha and beta diversity of the microbiota between the sufficient, deficient and insufficient groups of 25(OH)D. However, the abundance of Proteobacteria was higher in the vitamin D deficient group (<30nmol/L) and Actnomycete was higher in the sufficient group of vitamin D (>50nmol/L).
5	Effect of vitamin D supplementation on the fecal microbiota: a randomized clinical trial	Naderp oor et al., 2019	Parallel group, double- blind, randomized , controlled clinical trial	Level II - evidence derived from at least one randomiz ed clinical trial	Participants with a BMI >25kg/m² and no comorbidities received a loading dose of 100,000 international units (IU) of oral cholecalciferol followed by 4000 IU/day (four capsules) for 16 weeks or matching placebo. An increase in abundance was found of Lachnospira and Coprococcus and a decrease in the abundance of Blautia, *Clostridiaceae* and Ruminococcus in individuals with higher serum concentrations of 25(OH)D.
6	Effect and mechanism of vitamin D on colorectal cancer development based on intestinal flora disorder	Zhou et al., 2020	Randomiz ed, controlled clinical trial	Level II - evidence derived from at least one randomiz ed clinical trial	Vitamin D deficiency worsened the deterioration of inflammation and intestinal cancer in mice with colorectal cancer, while the overall condition of the mice improved after vitamin D supplementation (with 1500 or 3000 IU vitamin D3/kg). Vitamin D has a regulatory effect on intestinal probiotics and aids in the integrity of the colonic barrier, which is mediated by Akkermansia muciniphila through the expression of acylglycerols.
7	Vitamin D- restricted high-fat diet downregulates the expression of intestinal alkaline phosphatase isozymes in ovariectomized rats	nakaoka et al., 2018	Experiment al in vivo, controlled and non-randomized	Level III – well- designed clinical trials, without randomiza tion	Vitamin D-restricted high-fat diet down-regulated mRNA expressions ofisozymesIntestinal alkaline phosphatase (IAP) in the duodenum of menopausal animal models. IAP controls bacterial endotoxin-induced inflammation by dephosphorylating thelipopolysaccharide, beinga defense factor of the intestinal mucosa.
8	Vitamin D deficiency alters the gut microbiome, reducing the production of vitamin B in the gut. The resulting lack of pantothenic acid negatively affects the immune system, producing a "pro- inflammatory" state associated with atherosclerosis and autoimmunity.	Gomin ak, 2016	Uncontroll ed clinical trial	Level III – well- designed clinical trials, without randomiza tion	Participants with neurological complaints, sleep problems and symptoms of irritable bowel syndrome (IBS) after supplementation with minimum recommended doses of the 8 B vitamins for three months, plus individual doses of vitamin D in order to maintain blood levels of 60- 80ng/ml on an ongoing basis, most achieved complete resolution of all IBS symptoms by the end of three months. Vitamin D supplementation was maintained and doses of B vitamins were withdrawn. There was also improvement in some sleep and pain complaints.

9 Vitamin D administration leads to a change in intestinal bacterial composition in patients with Crohn's disease, but not in healthy controls.	Shaffler et al., 2018	controlled clinical trial	Level III – well- designed clinical trials, without randomiza tion	After administration of 20,000IU cholecalciferol for 4 weeks every other day, patients with Chron's Disease had high abundance of some species such as Alistipes, Barnesiella, Roseburia, Anaerotruncus, Subdoligranulum and a Ruminococacaee. Although microbial communities changed significantly, a further increase in vitamin D level was associated with a reversal of this effect, causing a decrease in bacterial richness. However, there were no changes in healthy control patients.
10 The potential role of vitamin D supplementatio n as a gut microbiota modifier in healthy individuals	Singh, 2020	Uncontroll ed clinical trial	Level III – well-designed clinical trials, without randomizati on	Vitamin D supplementation increased the overall diversity of the gut microbiota and, in particular, increased the relative abundance of Bacteroidetes and decreased the relative abundance of Firmicutes. There was also an increase in *phyla Verrucomicrobia* and Actinobacteria. In this sense, it also favored an enterotype dominated by Bacteroides over Prevotella, the latter being considered an intestinal pathobiont.
11 Vitamin D signaling through the induction of panetitic cell defensins maintains the gut microbiota and improves metabolic disorders and hepatic steatosis in animal models	Su et al., 2016	Randomiz ed clinical trial	Level II - evidence derived from at least one randomiz ed clinical trial	Mice fed a high-fat diet + vitamin D (HFD) or a control diet without vitamin D (VDD) developed moderate hepatic steatosis. In contrast, HFD + VDD mice developed severe hepatic steatosis. The degree of steatosis was associated with 25-OH deficiency DV3, as well as the degree of systemic inflammation and the integrity of the ileal mucosal lining. There was growth of H. Hepaticus in the vitamin D deficient groups and suppression of A. Muciniphila.
12 Vitamin D regulates the gut microbiome and protects mice from sodium dextran sulfate- induced colitis Vitamin D regulates the gut microbiome and protects mice from dext sodium sulfate-induced colitis	Ooi et al., 2013	controlled clinical trial	Level III – well- designed clinical trials, without randomiza tion	The data suggest that in the absence of the VDR or the ability to produce 1,25(OH)2D3, dysregulated gut inflammation results in an environment that supports the expansion of bacteria in the phylum Proteobacteria. Expanding phylum Proteobacteria (including members of the Helicobacteraceae family) competes with beneficial members of phyla Firmicutes and Deferribacters. In this way, epithelial integrity is impaired, dysbiosis, increased inflammation and more severe experimental colitis occur.

13 Impact of vitamin D deficit on the rat intestinal microbiome Impact of vitamin D deficit on the rat intestinal microbiome	Robles- Vera et al., 2019	Randomiz ed, controlled clinical trial	Level II - evidence derived from at least one randomiz ed clinical trial	The animals were allocated into two groups, one with a standard diet plus 1,500 IU/kg of cholecalciferol and one with a personalized diet free of vitamin D, for seven weeks. there was an increase in the Enterobacteriaceae family with significant increases in their genera associated Escherichia , Candidatus blochmannia and Enterobacter , an increase in Prevotellaceae and its genus Prevotella and a decrease in the family Odoribacteraceae and its genus Butyricimonas in the vitamin D free group. α and β diversity.
14 Vitamin D deficiency predisposes to barrier dysfunction induced by adherent invasive Escherichia coli and experimental colonic injury	Assa et al., 2015	controlled clinical trial	Level III – well- designed clinical trials, without randomiza tion	1,25(OH)2D3 attenuated paracellular permeability induced by adherent invasive Escherichia coli infection and redistribution of junction proteins. Vitamin D deficiency predisposes to changes in barrier function, thus creating an environment that promotes colonization of intestinal tract pathogens and subsequent exacerbation of the inflammatory response.
15 Lack of vitamin D receptor causes dysbiosis and alters murine gut microbiome functions	Jin et al., 2015	In vivo experiment al study	Level III – well- designed clinical trials, without randomiza tion	At the taxonomic level, the Lactobacillales-a-Lactobacillus lineage was dwarfed in fecal samples from Vdr $^{-/-}$. In Vdr -/- mice, Lactobacillus was depleted in feces compared to cecal feces, while Tannerella, *odoribacter*, they are enriched.
16 New role of the receiverof vitamin D in maintenance of barrier integrity of the intestinal mucosa	Kong et al., 2008	controlled clinical trial	Level III – well- designed clinical trials, without randomiza tion	Mice that had VDR (VDR +/+) were resistant to induced colitis, while those that did not (VDR -/-) developed severe diarrhea, rectal bleeding, body weight loss, and death after 2 weeks. The study found severe damage to the gut epithelial junctions in mice that lacked VDR expression.
17 Impaired 25-hydroxylation of vitamin D in liver injury suppresses intestinal Paneth cell defensins, leading to intestinal dysbiosis and hepatic fibrogenesis	Wu et al., 2020	controlled clinical trial	Level III – well- designed clinical trials, without randomiza tion	Liver damage and fibrosis are associated with vitamin D (VD) deficiency due to decreased hepatic 25-hydroxylation of VD in the liver. Insufficiency of RV signaling can impair innate intestinal immunity and integrity, including downregulation of Paneth cell functions, leading to increased bacterial translocation to endotoxemia and intestinal dysbiosis, which can consequently promote hepatic fibrogenesis. The increase in intestinal permeability in liver injury and fibrosis was improved by repeated administration of DEFA5, which consequently also reduced plasma endotoxin. Bacteriodetes at the phylum level were decreased in mice with liver damage.

18 Vitamin D deficiency promotes epithelial barrier dysfunction and intestinal inflammation	Assa et al., 2014	controlled clinical trial	Level III – well- designed clinical trials, without randomiza tion	Mice were divided into 4 groups, two infected by C. Rodentium (one group deficient and the other sufficient in vitamin D) and two uninfected (one deficient and the other efficient in vitamin D). *THE*C. rodentium infection in animals increased intestinal permeability and crypt hyperplasia in the vitamin D sufficient group, however, the increase was significantly greater in the vitamin D deficient group. Vitamin D deficiency resulted in higher levels of pro- inflammatory and anti-inflammatory cytokines in both vitamin D-deficient study groups (without and with infection) compared with animals with sufficient vitamin D. In the group of mice infected with vitamin D deficiency, there was an increase in the abundance of Actinobacteria and Gammaproteobacteria.

Source: Authors (2021).

3.1 Influence of vitamin D on the composition of the gastrointestinal microbiota

All records analyzed showed an increase in phyla, families, genera or species of beneficial/probiotic bacteria and a decrease in pathogenic bacteria in cases of vitamin D supplementation, or the reverse, in cases of deficient levels of vitamin D or changes in the receptor of vitamin D (VDR), as in the study by Kanhere et al. (2018), where after patients were supplemented with 50,000 IU of vitamin D3 for 12 weeks, there was an enrichment of Lactococcus, bacteria associated with intestinal health, corroborating reports of a study carried out by Jin et al. (2015), who showed a decrease in Lactobacillus in fecal samples from mice lacking vitamin D receptor (Vdr - / -).

In addition, 95% of the records chosen to compose the present review, which analyzed microbial diversity, did not report significant changes in it, as in the study by Robles-Vera et al. (2019), who found that a diet free of vitamin D for seven weeks did not significantly alter microbial diversity and richness when compared to a standard diet. However, he reported that there was an increase in the Enterobacteriaceae family and its genera Escherichia, Enterobacter , and Candidatus blochmannia species, which are part of the Gammaproteobacteria class and often cause infections in the gastrointestinal, urinary and respiratory tracts; in addition to the opportunistic bacterium Prevotella, often found in infections. Likewise, Naderpoor et al. In addition to favoring an enterotype dominated by Bacteroides over Prevotella, the latter being considered an intestinal pathobiont (Singh et al., 2020). Thus, regardless of the microbial diversity percentile, both studies indicate

that vitamin D deficiency may favor an appropriate environment for the establishment of opportunistic pathogens, which cause dysfunctions in the intestinal barrier, promoting bacterial translocation of the pathogen, infection and systemic inflammation.

3.2 Vitamin D levels and impacts on intestinal inflammation

In the present review, 50% of the articles obtained results about the effects of vitamin D or its deficiency on intestinal inflammation. Overall, vitamin D deficient groups (generally levels <30nmol/L) had higher levels of pro-inflammatory and anti-inflammatory cytokines when compared to vitamin D sufficient groups (generally levels >50nmol/L). Like Zhou et al. (2020), where vitamin D deficiency in mice with colorectal cancer increased the deterioration of cancer-caused inflammation, compared with the control group. However, the general condition of the mice improved after vitamin D supplementation (with 1500 or 3000 IU vitamin D3/kg). Similar to the study by Su et al. (2016), who associated worse degrees of steatosis with plasma 25-OH VD3 deficiency, as well as the degree of systemic inflammation and the integrity of the ileal mucosal lining. Furthermore, growth of H. hepaticus was observed in vitamin D deficient groups and suppression of Akkermansia muciniphila. According to the analyses, vitamin D has a regulatory effect on intestinal probiotics, such as Akkermansia muciniphila, a bacterium that improves intestinal permeability by increasing the thickness of the mucus layer of the intestinal mucosa, helping to maintain the integrity of the colonic barrier. Therefore, when suppressed, epithelial integrity is

impaired. Vitamin D has a regulatory effect on intestinal probiotics, such as Akkermansia muciniphila, a bacterium that improves intestinal permeability by increasing the thickness of the mucus layer of the intestinal mucosa, helping to maintain the integrity of the colonic barrier. Therefore, when suppressed, epithelial integrity is impaired. Vitamin D has a regulatory effect on intestinal probiotics, such as Akkermansia muciniphila, a bacterium that improves intestinal permeability by increasing the thickness of the mucus layer of the intestinal mucosa, helping to maintain the integrity of the colonic barrier. Therefore, when suppressed, epithelial integrity is impaired.

Nakaoka et al. (2018) described a different mechanism when finding that a high-fat diet with vitamin D restriction down-regulated the mRNA expressions ofisozymesIntestinal alkaline phosphatase (IAP) in the duodenum of menopausal animal models. IAP controls bacterial endotoxin-induced inflammation by dephosphorylating thelipopolysaccharide, beinga defense factor of the intestinal mucosa. Associated with this, according to Ooi et al. (2013) Vitamin D and VDR prevent Th1, Th17 and the production of inflammatory cytokines in the gastrointestinal tract, reducing inflammation in the gut and controlling dysbiosis. In this sense, in the absence or low expression of the VDR or in the deficiency of producing 1,25 (OH) 2 D 3, dysregulated inflammation of the intestine results in an environment that supports the expansion of bacteria in the phylum Proteobacteria. Expanding phylum Proteobacteria (including members of the Helicobacteraceae family) competes with beneficial members of phyla Firmicutes and Deferribacters. As in the study by Chen et al. (2020), where Proteobacteria was higher in the vitamin D deficient group (<30nmol/L). Thus,

3.3 Vitamin D supplementation as an intestinal protective factor

Kong et al. (2008) when using in vitro culture systems obtained an increase in the levels of tight junction proteins ZO-1, claudin-1, claudin-2 and adherent binding protein E-cadherin after 24 hours of treatment with 1,25(OH) 2 D3. In the study by Ooi et al. (2013), mice that failed to produce 1,25(OH)D (Cyp KO) had substantially less E-cadherin expression than control mice. The analyzed data suggest that vitamin D and VDR may participate in the preservation and integrity of the intestinal barrier by increasing the level of key proteins for the tight junction of the intestine.

The lack of vitamin D receptors altered the function of intestinal epithelial cells (Paneth cells), reducing the production of defensins and lysozyme, antimicrobials that

cause changes in the cell wall of pathogenic bacteria, producing their lysis. Thus, VDR defects can impair the immunity and innate integrity of the intestinal barrier, favoring the inflammatory effects and modifications of the intestinal microbiota (Wu et al., 2020). However, 1,25(OH)2D3 supplementation attenuated the paracellular permeability induced by adherent invasive Escherichia coli infection and redistribution of junction proteins (Assa et al., 2015). Similar to the study by Garg et al. (2018), where vitamin D replacement at a dose of 40,000 IU weekly for 8 weeks reduced markers of intestinal inflammation,

IV.   CONCLUSION

Based on the analysis of the manuscripts that composed this systematic review, the data report that sufficient levels of vitamin D favor the presence of beneficial bacteria/probiotics (e.g. Lactobacillus, Croococcus, Bacteroidetes and Akkermansia muciniphila) and insufficient levels are associated with the establishment of pathobionts in the intestinal environment (eg, Prevotella, Escherichia, Candidatus blochmannia and Enterobacter). In addition, a trend towards elevated levels of inflammatory cytokines and decreased intestinal permeability in vitamin D deficient levels was demonstrated. However, patients who supplemented with vitamin D had improved intestinal barrier integrity, decreased inflammatory markers, and resolution of intestinal symptoms. Therefore, given the available data, maintaining sufficient serum levels of vitamin D (>50nmol/L) favors intestinal health, enabling an enterotype dominated by probiotics, decreasing inflammatory markers, protecting the integrity of the intestinal barrier, and preventing and treating intestinal and systemic inflammation. However, this review found that not only the presence or deficiency of vitamin D interfered with the results obtained, but also its metabolism; availability; previous infections and pathologies; presence, expression and signaling of the VDR. For a better definition of supplementation doses and adequate plasma levels of vitamin D, greater investments are needed in randomized clinical studies in humans, with standardization of doses and periodicity.

REFERENCES

[1] ASSA, A., Et al (2014). Vitamin D deficiency promotes epithelial barrier dysfunction and intestinal inflammation. The Journal of infectious diseases, 210(8), 1296-1305.

[2] ASSA, A., Et al (2015). Vitamin D deficiency predisposes to barrier dysfunction induced by adherent invasive Escherichia coli and experimental colonic injury. Inflammatory bowel diseases, 21(2), 297-306.

[3] CASTRO, L. (2011). The vitamin D endocrine system The vitamin D endocrine system. In Arq Bras Endocrinol Metab.

55.

[4] CHEN, D., Et al (2020). Correlation between Vitamin D Status and Gut Microbiota in Patients with Inflammatory Bowel Disease. Zhongguo yi xue ke xue Yuan xue bao. Acta Academiae Medicinae Sinicae, 42(6), 740-748.

[5] SCIENTIFIC, Council; DE PAULA, Leila Cristina Pedroso. Hypovitaminosis D in pediatrics: recommendations for diagnosis, treatment and prevention.

[6] DE ANDRADE, Mirella Vidal Félix et al. Influence of vitamin D deficiency on intestinal dysbiosis: A systematic review. Research, Society and Development, v. 10, no. 9, p. e24610916596-e24610916596, 2021.

[7] DE OLIVEIRA, Gislane Lelis Vilela et al. Intestinal dysbiosis and applications of probiotics in autoimmune diseases. Immunology, vol. 152, no. 1, p. 1-12, 2017.

[8] DOS SANTOS MORAES, Marcia et al. Functional effects of probiotics with emphasis on the role of kefir in the treatment of intestinal dysbiosis. UNILUS Teaching and Research, v. 14, no. 37, p. 144-156, 2018.

[9] STAR, Charles. Scientific methodology: science, teaching, research. Medical Arts, 2018.

[10] GARG, Mayur et al. The effect of vitamin D on intestinal inflammation and fecal microbiota in patients with ulcerative colitis. Journal of Crohn's and Colitis, v. 12, no. 8, p. 963-972, 2018.

[11] GOMINAK, SC Vitamin D deficiency alters the gut microbiome by reducing the production of vitamin B in the gut. The resulting lack of pantothenic acid negatively affects the immune system, producing a "pro-inflammatory" state associated with atherosclerosis and autoimmunity. Medical hypotheses, v. 94, p. 103-107, 2016.

[12] JIN, Dapeng et al. The lack of vitamin D receptor causes dysbiosis and alters the functions of the murine gut microbiome. Clinical Therapeutics, vol. 37, no. 5, p. 996-1009. e7, 2015.

[13] KONG, Juan et al. Novel role of the vitamin D receptor in maintaining intestinal mucosal barrier integrity. American Journal of Physiology-Gastrointestinal and Liver Physiology, v. 294, no. 1, p. G208-G216, 2008.

[14] MARQUES, Cláudia Diniz Lopes et al. The importance of vitamin D levels in autoimmune diseases. Brazilian Journal of Rheumatology, v. 50, p. 67-80, 2010.

[15] NADERPOOR, Negar et al. Effect of vitamin D supplementation on the fecal microbiota: a randomized clinical trial. Nutrients, v. 11, no. 12, p. 2888, 2019.

[16] NAKAOKA, Kanae et al. A high-fat diet with vitamin D restriction negatively regulates the expression of intestinal alkaline phosphatase isoenzymes in ovariectomized rats. Research in nutrition, vol. 53, p. 23-31, 2018.

[17] OOI, JH, et al (2013). Vitamin D regulates the gut microbiome and protects mice from dextran sodium sulfate-induced colitis. The Journal of Nutrition, 143(10), 1679-1686.

[18] PEREIRA, Adriana Soares et al. Scientific research methodology. 2018

[19] ROBLES-VERA, Iñaki et al. Impact of vitamin D deficit on the intestinal microbiome of rats. Nutrients, v. 11, no. 11, p. 2564, 2019.

[20] SCHÄFFLER, H., et al (2018). Vitamin D administration leads to a change in intestinal bacterial composition in patients with Crohn's disease, but not in control controls. Journal of Digestive Disease, 19(4), 225-234.

[21] SINGH, Parul et al. The potential role of vitamin D supplementation as a modifier of the gut microbiota in healthy individuals. Scientific reports, v. 10, no. 1, p. 1-14, 2020.

[22] Su, D., et al (2016). Induction of vitamin D production through cell defensins maintains the intestinal microbiota and improves animal models of vitamin D reproduction and steatosis. Borders in physiology, 7, 498.

[23] WEISS, G. Adrienne; HENNET, Thierry. Mechanisms and consequences of intestinal dysbiosis. Cellular and Molecular Life Sciences, v. 74, no. 16, p. 2959-2977, 2017.

[24] WU, P., et al (2020). Impaired 25-hydroxylation of vitamin D in liver injury suppresses intestinal Paneth cell defensins, leading to intestinal dysbiosis and hepatic fibrogenesis. American Journal of Physiology-Gastrointestinal and Liver Physiology, 319 (6), G685-G695.

[25] YATSUNENKO, Tanya et al. Human gut microbiome seen through age and geography. nature, v. 486, no. 7402, pg. 222-227, 2012.

[26] ZHOU, Xueyan et al. Effect and mechanism of vitamin D on colorectal cancer development based on intestinal flora disorder. Journal of gastroenterology and hepatology, v. 35, no. 6, p. 1023-1031, 2020.

Intestinal microbiota in anxiety and depression

Caroline Krabbe Erthal[1], Jhonas Geraldo Peixoto Flauzino[2], Alexia Allis Rocha Lima[3], Ana Paula Dupuy Hermes[4], Ana Luiza Alves Fonseca Pellissaro[5], Beatriz Ramos Canato[6], Catarina Castro dos Santos[7], Enzo Masgrau de Oliveira Sanchotene[8], Giovanna Biângulo Lacerda Chaves[9], Kamila Giovana Lacerda Villas Bôas Dechichi[10], Marcela Lara Albuquerque Ranulfo[11], Natalia Maria Schincariol[12], Pedro Pompeo Boechat Araujo[13], Susana Gfoni da Silveira[14], Victor Ryan Ferrão Chaves[15]

[1]Estuda Medicina na Faculdade Meridional – IMED, Passo Fundo, RS
[2]Especialista em Neurociências, pela Pontifícia Universidade Católica do Rio Grande do Sul (PUCRS). Jhonasflauzino@cardiol.br
[3]Estudante de Medicina na São Leopoldo Mandic, em Campinas, SP.
[4]Estudante de Medicina no Centro Universitário do Planalto Central Aparecido dos Santos, UNICEPLAC, Brasília, DF
[5]Estudante de Medicina na Universidade José do Rosário Vellano – UNIFENAS, Belo Horizonte, MG
[6]Estuda Medicina na Unilago, em São José do Rio Preto, em SP.
[7]Estudante de Medicina na Universidade José do Rosário Vellano – UNIFENAS, Belo Horizonte, MG.
[8]Estudante de Medicina na São Leopoldo Mandic, em Campinas, SP
[9]Estudante de Medicina no Centro Universitário Unieuro – UNIEURO, Brasília, DF
[10]Estudante de Medicina na Universidade José do Rosário Vellano – UNIFENAS, Belo Horizonte, MG
[11]Estudante de Medicina na universidade Cidade de S. Paulo – UNICID, São Paulo
[12]Estudante de Medicina na Universidade Municipal de São Caetano do Sul, em São Paulo
[13]Estudante de Medicina na São Leopoldo Mandic, em Campinas, SP
[14]Estudante de Medicina na Faculdade São Leopoldo Mandic, em Campinas, São Paulo
[15]Estudante de Medicina na Universidade José do Rosário Vellano – UNIFENAS, Belo Horizonte, MG

Abstract— *The overall purpose of this study is to review clinical studies involving probiotic supplementation and its effects on mental health in subjects with anxiety and depression. Probiotic supplementation is able to provide benefits on both qualitative and quantitative mental health parameters in anxiety and mood. Even with the limitation of studies regarding the use of probiotics in improving anxiety and depression in humans, most studies have identified positive results, in healthy or unhealthy people. One of the most commonly used probiotics is the genus Bifidobacterium. It has been shown to be efficient in inflammatory disorders, and it has been suggested that this probiotic may have antidepressant properties, since the balance between anti- and pro-inflammatory cytokines plays a relevant role in depression.*

I. INTRODUCTION

Anxiety is considered a universal human experience and defined as a persistent feeling of impending doom, apprehension and fear, or restlessness and tension. It is considered pathological when the condition that triggers it is disproportionate, or when there is no specific object that is directed, causing direct interference in the individual's quality of life.

Depression can affect individuals at any stage of life and, although recurrence is higher in middle ages, there has been a growth in adolescence and early adulthood. The disorders can vary according to severity, ranging from mild to very severe, occurring several times sporadically,

however, it can be chronic or recurrent, and women are more vulnerable to depressive states due to hormonal fluctuations that are especially exposed in the fertile period

Anxiety and depression are considered mental disorders with higher prevalence in several countries due to the consequences to human health, with the recommendation of interventional measures. A healthy diet and the consumption of probiotics can be a natural and practical option for the treatment of disorders.

Therefore, this study is justified by the fact that it searches for evidence in the scientific literature, suggesting that the use of probiotic bacteria helps in mental health, by modulating the diversity of the intestinal microbiota, the production of neurotransmitters and the balance of clinical biomarkers with association with the Central Nervous System (CNS).

The hypothesis is that consuming probiotics can improve the clinical parameters of both anxiety and depression in adult subjects.The general objective of this study is to review clinical studies involving probiotic supplementation and its effects on the mental health of subjects with anxiety and depression. In addition, it has as specific objectives to understand the strains of microorganisms in relation to improving parameters related to anxiety and depression; and study what depression, anxiety and gut microbiota are.

II.   INTESTINAL MICROBIAL

The word microbial refers to all microorganisms and the group of genetic variety of viruses, bacteria, protozoa and fungi distributed in various parts of the individual's body (HUMAN MICROBIOME PROJECT CONSORTIUM, 2012).

In 2001, the term microbiome was first used by physician Joshua Lederberg (URSELL et al., 2012) who defined it as "the ecological community of commensal, symbiotic and pathogenic microorganisms that literally share our space. body" (LEDERBERG; MCCRAY, 2001, p. 22).
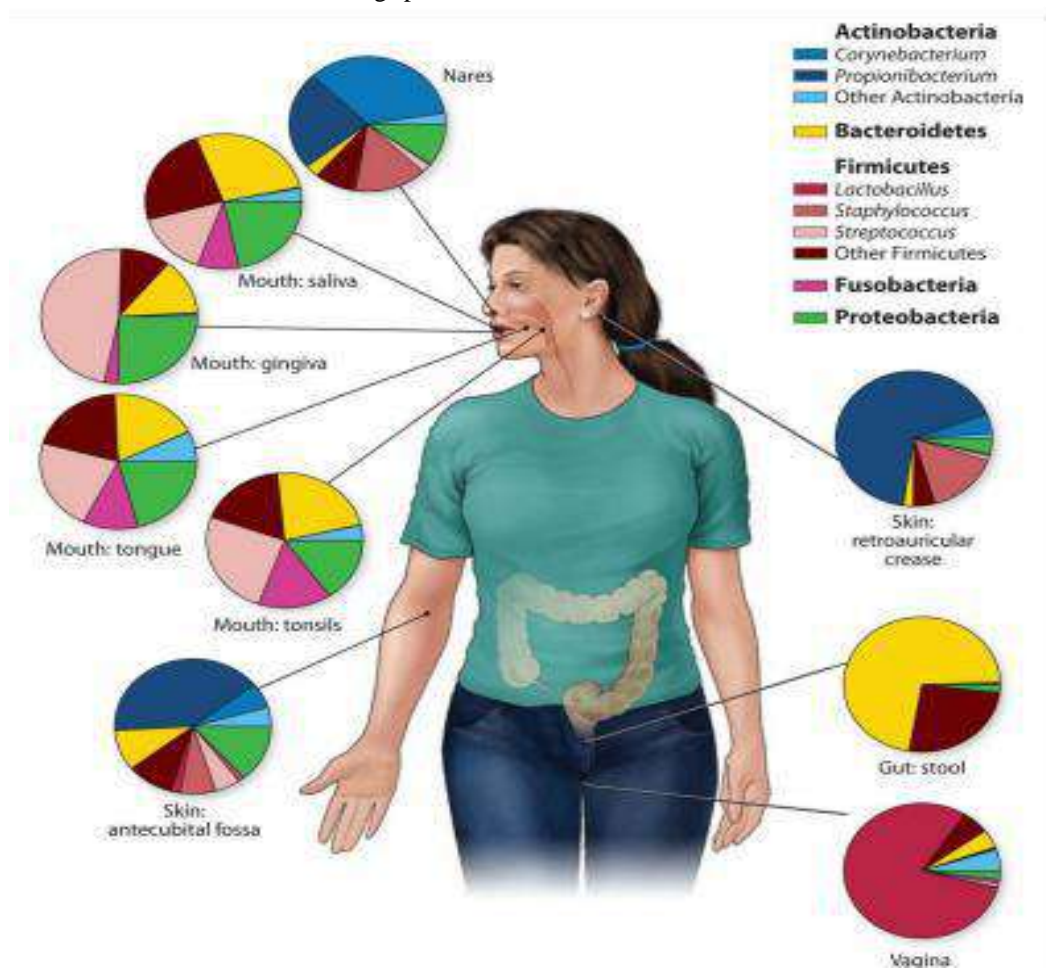
Fig.1: Microbioma humano e a sua diversidade na região corporal

Reference: Grice e Segre (2012)

The intestinal microbiota forms a set of microorganisms that are present in the human body (LEY; PETERSON; GORDON, 2006). A person's body harbors a large population of microorganisms, mainly bacteria, which are distributed in the nasal cavity, stomach, urogenital tract, mouth, skin, pharynx and intestine (TURNBAUGH et al., 2007). The diversity and wide variability of bacterial composition are different in each subject, and can be conceptualized by a genetic part (MORAES et al., 2014) and the other part by individual and environmental, such as eating habits, age and birth (childbirth). cesarean or normal) (HUMAN MICROBIOME PROJECT CONSORTIUM, 2012; NELSON et al., 2015; PENDERS et al., 2006).

Organisms that inhabit the internal and external surface of the body are dependent on conditions such as pH, availability of nutrients, temperature and humidity to ensure their survival (RIBEIRO et al., 2014). Figure 2 shows the microbial variety and its abundance.
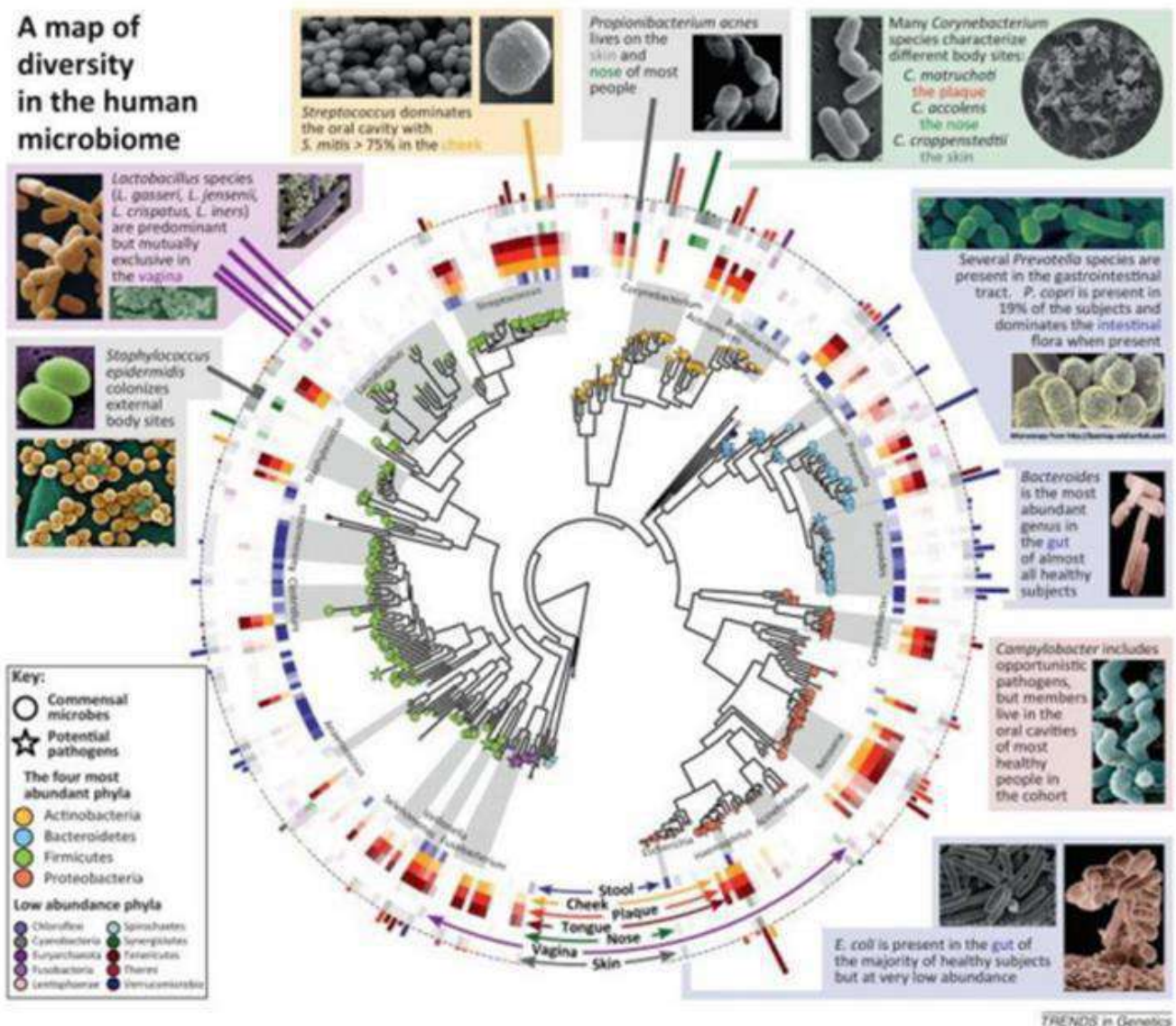
Fig.2: Mapa da diversidade microbiana. Na parte central é representada pela árvore filogenética dos micro-organismos mais abundantes no microbioma humano. As barras laterais, exteriores ao círculo, são proporcionais à taxa de abundância na região corporal predominante.

Reference: KHODOR; SHATAT, 2016

The gastrointestinal tract (GIT), preferably in the intestine, is a place rich in microorganisms, with around

1014 bacteria, that is, ten times higher than the number of human cells (EVRENSEL; CEYLAN, 2015; TURNBAUGH). et al., 2007).

A higher bacterial concentration is presented by the large intestine, most of which are resident in the distal colon with 1011 -1012 cells/g of intestine (LEY; PETERSON; GORDON, 2006; WHITMAN; COLEMAN; WIEBE, 1998).

What is known is that the intestinal microbiome provides about 150 times more genes than the human genome itself (QIN et al., 2010), bringing the elucidation of how relevant it is to characterize the microbiome, bringing potentiation to the knowledge of the human organism.

The TGI is extremely dynamic and it contains allochthonous or autochthonous bacteria. The autochthonous microorganisms colonize the host, carrying out the formation of populations with a significant size in a certain region of the intestine, without producing diseases under normal circumstances. Allochthonous, on the other hand, can be acquired through food ingestion, remaining for a limited time in the ecosystem (LEY; PETERSON; GORDON, 2006; WALTER, 2008). However, it is often difficult to differentiate whether the micro-organism is autochthonous even to the host (BERG, 1996).

Under healthy circumstances, there is a balance between the host and the microorganisms. Its presence can benefit the health of the host by collaborating with the digestion of food, the production of molecules that can decrease inflammation, the production of short-chain grazoa acids and the development of the immune system (MOOS et al., 2016). An example is that, in the digestion of dietary fiber, bacterial strains are needed in which some carry out the production of vitamin K (BROWN et al., 2012) and others produce some B vitamins, such as vitamin B6, B12 and folic acid (BIESALSKI, 2016). It still affects the physiological properties of the individual, such as, for example, controlling intestinal epithelial proliferation, protecting against pathogens and cellular differentiation (BACKHED, 2005).

The lack of balance in the microbiota with pathogenic bacteria is defined as dysbiosis, and has been associated with the compromise of the host's health, since it is associated with several diseases, such as neurological disorders, inflammatory bowel disease, cancer, malnutrition and obesity (CLARKE et al., 2012).

2.1. ANXIETY

Anxiety is considered a vague and unpleasant feeling of apprehension, fear, whose characterization is given by the tension or discomfort that derives from something strange or unknown, from the anticipation of fear

(ALLEN; LEONARD; SWEDO, 1995; SWEDO et al., 1994).).

According to DSM-5, anxiety disorders encompass related behavioral disorders and disorders that share characteristics of anxiety and excessive fear. These disorders have included selective mutism, separation anxiety disorder, specific phobia, panic disorder, social anxiety disorder (SAD), agoraphobia, medication/substance-induced anxiety disorder, generalized anxiety disorder (GAD), and anxiety disorder. as a result of a medical condition. Anxiety and fear overlap, however, have differentiation, since fear is considered the response to a perceived or real threat, while anxiety is seen as the anticipation of a future threat (APA, 2013).

According to Metzler, Mahoney and Freedy (2016) highlight that the main physical symptoms of anxiety are chest tightness or pain, muscle tension, gastrointestinal disorders and headache. They still show an increase in the levels of use of medical services, a reduction in productivity and a lower quality of life.

In addition to psychosocial implications, there are also physiological factors of the disease. The neural pathways that process visceral pain signals also regulate the response to gastrointestinal function, mood, anxiety and stress (GRUNDY et al., 2006).

In the Central Nervous System, the main mediators of the symptoms of anxiety disorders seem to be serotonin, γ-aminobutyric acid (GABA), neropinephrine and dopamine (FREITAS-FERRARI et al., 2010).

There may also be involvement of the neurotransmitter corticotropin-releasing hormone (CHR) (ROY-BYRNE et al., 2008), resulting in excessive sympathetic activation, disruption of the HPA axis and modification of the inflammatory response, leaving patients predisposed to increased risks. for the development of the disease (DONG et al., 2015).

Not much is known about the relationship between eating and anxiety (YANNAKOULIA et al., 2008). However, anxiety is related to chronic stress (COHEN, 2000) and, as a result, exposure to stressful conditions can lead to the development of eating disorders (TORRES; NOWSON, 2007).

An example is the excessive workload, test stress and exposure to chronic stressors, which cause the induction of an increase in the consumption of caloric foods (CHAPUT; TREMBLAY, 2007).

2.2. DEPRESSION

Depression is also known as depressive disorder and is considered a frequent condition associated with lack of functional capacity and impairment of the

person's physical health (CUNHA; BASTOS; DUCA, 2012). This disorder is characterized by the set of disorders associated with social, family, psychological and genetic factors (STOPA et al., 2015).

According to the World Health Organization (WHO, 2016), at least 350 million individuals are affected by depression. Symptoms of depression are negative thoughts about oneself and others, changes in appetite, feelings of deep sadness, lack of interest in social activities, lack and/or loss of confidence and even suicide (CUNHA; BASTOS; DUCA, 2012).

Dejection and sadness are considered emotional symptoms most commonly presented in cases of depression. The person feels sad, being torn apart, often bursts into tears, and may contemplate suicide. A lack of satisfaction with life still occurs frequently. The gestures that once generated satisfaction seem insignificant and sad. Most patients with depression say they no longer enjoy previous activities, and many say they lose affection and interest in people (ATKINSIN et al., 2002).

Atkinson et al. (2002) state that cognitive symptoms have involved low self-esteem, negative thoughts and feelings of guilt for failures. People doubt your ability to do anything to improve your life.

With regard to physical symptoms, sleep disturbances, loss of energy, change in appetite and fatigue are presented. The person is focused on the interior and not on external events, may worry about health and exaggerate discomfort and minor pain (ATKINSON et al., 2002).

2.3. PROBIOTICS

The Food and Agriculture Organization of the United Nations (FAO) together with the World Health Organization, in 2001, define the definition of probiotics as live microorganisms that, when administered at appropriate levels, provide benefits to the host health (FAO; WHO, 2001). This concept excludes metabolic and microbial components (ISHIBASHI; YAMAZAKI, 2001).

The main determinants of the definition have included the fact that the probiotic bacteria need to be administered live and undergo a controlled evaluation to document the benefits to the host where they are not necessarily human beings (SANDERS, 2009).

Most probiotics are sold as drugs (sachets or capsules) or food, and it is essential to consider their safety (Ishibashi & Yamazaki, 2017). The safety factors for use in humans are:

strains should preferably be of human origin; need to be isolated from the human TGI; have a history of non-pathogenic or

associated GI disease; not cause deconjugation of bile salts and must not carry transmissible antibiotic resistance genes (DIAS, 2017, p. 24).

Knowledge about the intestinal microbiota and interactions enabled the increase of new strategies for the stimulation and maintenance of resident bacteria (FOOKS; FULLER; GIBSON, 1999).

Healthy people suffer damage due to environmental and physiological factors, in which they achieve normal intestinal functioning and the balance of the intestinal microbiota (PARVEZ et al., 2006).

Therefore, the introduction of probiotics through food is recommended as a beneficial agent capable of improving/balancing the microbiota, acting in the modulation of the intestinal mucosa immune system and protecting against inflammation in the intestine (O'BRIEN et al., 1999; SHI et al., 2016).

Dian et al. (2013) emphasize that "psychobiotics" are considered living organisms that, when ingested in sufficient quantities, are beneficial to the health of people with mental illness. According to Wang et al. (2016) it was reported that probiotics influence the Central Nervous System, modifying the composition of the intestinal microbiota, directly or not, increasing the number of studies in the last ten years.

Even though evidence is presented in the literature that the brain-gut axis can impair intestinal function, it is suggested that the intestine also brings changes in the Central Nervous System (DESBONNET et al., 2008).

Memory agility and psychiatric disorders are altered with the use of probiotics (WANG et al., 2016). Directly, probiotics can modify the biochemistry of the CNS, reaching concentrations of the neurotrophic factor that derives from the brain, dopamine, serotonin and GABA, influencing behavior (LIU, et al., 2016).

One of the most used probiotics is from the genus Bifidobacterium. It has been shown to be efficient in inflammatory disorders, such as Irritable Bowel Syndrome, where treatment with bifidobacteria is able to ament the existing balance between anti-inflammatory and pro-inflammatory cytokines. Thus, it is suggested that this probiotic may have antidepressant properties, since the balance between anti- and pro-inflammatory cytokines plays a relevant role in depression. (O'MAHONY et al., 2005).

Desbonnet et al. (2010) carried out a study in which a probiotic with Bifidobacterium infantis was administered to rats with maternal separation and observed a reduction in

the levels of norepinephrine in the brain, an increase in mRNA (messenger RNA) levels of HLC and peripheral pro-inflammatory secret. of IL-6. The probiotic performed the reversal of behavior problems, normalizing the levels of noradrenaline in the brain and in the immune system, which suggests the use of Bifidobacterium infantil as a therapeutic application in neural processes.

Another study also analyzed the ability of bacteria of the Bifidobacterium and Lactobacillus genera to produce GABA, given that its dysfunction generates symptoms of anxiety and depression. The result was that the production of GABA was more efficient with Bifidobacterium dentium and Lactobacillus brevis among the strains that were tested, although variation in the production of GABA in bifidobacteria was presented between the types (BARRETT et al., 2012).

Probiotic supplementation is able to provide benefits on both qualitative and quantitative parameters of mental health, anxiety and mood. Even with the limitation of studies regarding the use of probiotics to improve anxiety and depression in humans, most studies identified positive results, in healthy or not (DIAS, 2017).

The microorganisms most used in the composition of the probiotic were Bifidobacterium longum, Lactobacillus acidophilus and Lactobacillus casei, in sachet or capsule, together with other strains. Lactobacillus and Bifidobacterium are seen as beneficial bacteria and demonstrate improvement in gut immune barrier, reduction in pro-inflammatory cytokine production and promotion of balanced microbiota (INOUE; SHIMOJO, 2015).

Administration of these probiotics is able to decrease gastrointestinal symptoms in people with IBS (Whorwell et al. 2006). However, there is still a need to carry out additional studies to evaluate the strains individually to identify which ones generate benefits for mental health (WALLACE; MILEV, 2017).

In general, the studies showed that the use of probiotic supplements with Bifidobacterium and Lactobacillus is efficient in mental health, causing balance of neurochemical and metabolic biomarkers. Ingestion of probiotics for 4 or 8 weeks appears to be sufficient to generate satisfactory results, even though the optimal intervention time to observe specific effects is still unknown (WALLACE; MILEV, 2017).

III. CONCLUSION

With the exploration and recognition of the human intestinal microbiome, new treatments to modify the intestinal bacterial concentration beneficial to the health of the individual have been carried out with the use of probiotic supplements, changing symptoms of anxiety and depression.

Most of the research regarding the communication between the brain and the gut and the existing benefits of probiotics in modifying the chemical imbalance in the brain and in behavior is done in animals. However, human studies have confirmed the benefits of probiotic supplementation in people with mental illness.

REFERENCES

[1] ATKINSON, L. R.; et al. **Introdução à Psicologia de Hilgard**. Tradução Bueno, D.; 13. Ed. Porto Alegre: Artmed, 2002. p. 562-563.

[2] ALLEN, A. J.; LEONARD, H.; SWEDO, S. E. Current Knowledge of Medications for the Treatment of Childhood Anxiety Disorders. **Journal Of The American Academy Of Child & Adolescent Psychiatry**, [s.l.], v. 34, n. 8, p.976-986, 1995.

[3] APA. Diagnostic and Statistical Manual of Mental Disorders: fifth edition. **American Psychiatric Association**, England, 2013.

[4] BÄCKHED, F. et al. **Host-Bacterial Mutualism in the Human Intestine**. Science, [s.l.], v. 307, n. 5717, p.1915-1920, 25 mar. 2005.

[5] BARRETT, E. et al. γ-Aminobutyric acid production by culturable bacteria from the human intestine. **Journal of Applied Microbiology**, [s.l.], v. 113, n. 2, p.1384-1386, 15 jun. 2012.

[6] BERG, R. D. **The indigenous gastrointestinal microflora**. Trends In Microbiology, [s.l.], v. 4, n. 11, p.430-435, nov. 1996

[7] BIESALSKI, H. K. Nutrition meets the microbiome: micronutrients and the microbiota. **Annals Of The New York Academy Of Sciences**, [s.l.], v. 1372, n. 1, p.53-64, maio 2016.

[8] BROWN, K. et al. **Diet-Induced Dysbiosis of the Intestinal Microbiota and the Effects on Immunity and Disease**. Nutrients, [s.l.], v. 4, n. 8, p.1095-1119, 21 ago. 2012.

[9] CHAPUT, J. P.; TREMBLAY, A. Acute effects of knowledge-based work on feeding behavior and energy intake. **Physiology & Behavior**, [s.l.], v. 90, n. 1, p.66-72, jan. 2007.

[10] CLARKE, S. F. et al. The gut microbiota and its relationship to diet and obesity: new insights. **Gut Microbes**, [s.l.], v. 3, n. 3, p.186-202, maio 2012.

[11] COHEN, J. I. Stress and mental health: a biobehavioral perspective. **Issues Ment Health Nurs**, [s.i], n. 2, p.185-202, mar. 2000.

[12] CUNHA, R. V.; BASTOS, G. A. N.; DUCA, G. F. Prevalência de depressão e fatores associados em comunidade de baixa renda de Porto Alegre, Rio Grande do Sul. **Revista Brasileira de Epidemiologia**, São Paulo, v. 15, n. 2, p.346-54, jun. 2012.

[13] DESBONNET, L. et al. Effects of the probiotic Bifidobacterium infantis in the maternal separation model of

depression. **Neuroscience**, [s.l.], v. 170, n. 4, p.1179-1188, nov. 2010.

[14] DIAS, P.D.C. **Efeito da suplementação de probióticos na depressão e ansiedade**: Uma revisão sistemática. Trabalho de Conclusão de Curso (Bacharelado em Nutrição). Universidade Federal do Rio Grande do Sul. Porto Alegre, 2017.

[15] DINAN, T.G., et al. Psychobiotics: A novel class of psychotropic. **Biological Psychiatry**, v. 74, n. 10, p. 720–726, 2013

[16] DONG, Y. et al. Managing Anxiety in the Medically Ill. **Psychiatric Times**, [s.l], p.1-6, jan. 2015.

[17] EVRENSEL, A.; CEYLAN, M. E. The Gut-Brain Axis: The Missing Link in Depression. **Clinical Psychopharmacology And Neuroscience**, [s.l.], v. 13, n. 3, p.239-244, 31 dez. 2015.

[18] FAO; WHO. **Health and Nutrition Properties of Probiotics in food including Powder Milk with Live Lactic Acid Bacteria**. p. 1–4, 2001.]

[19] FOOKS, L. J.; FULLER, R.; GIBSON, G. R. Prebiotics, probiotics and human gut microbiology. **International Dairy Journal**, [s.l.], v. 9, n. 1, p.53-61, jan. 1999.

[20] FREITAS-FERRARI, M. C. et al. Neuroimaging in social anxiety disorder: a systematic review of the literature. **Progress In Neuropsychcology And Biological Psychiatryopharma**, [s.l.], v. 34, n. 4, p.565-580, maio 2010.

[21] GRICE, E. A.; SEGRE, J. A. The Human Microbiome: Our Second Genome. **Annual Review Of Genomics And Human Genetics**, [s.l.], v. 13, p.151-170, 2012

[22] GRUNDY, D. et al. **Fundamentals of Neurogastroenterology**: Basic Science. Gastroenterology, [s.l.], v. 130, n. 5, p.1391-1411, abr. 2006.

[23] HUMAN MICROBIOME PROJECT CONSORTIUM. **Structure, Function and Diversity of the Healthy Human Microbiome**. Nature, v. 486, n. 7402, p. 207–214, 2012.

[24] Inoue, Y., Shimojo, N. Microbiome/microbiota and allergies. **Seminars in Immunopathology**, 37(1): 57–64, 2015

[25] ISHIBASHI, N.; YAMAZAKI, S. Probiotics and safety. **American Journal Of Clinical Nutrition**, [s.l], v. 73, p.465-470, jul. 2001.

[26] KHODOR, S. A.; SHATAT, I. F. Gut microbiome and kidney disease: a bidirectional relationship. **Pediatric Nephrology**, [s.l.], v. 32, n. 6, p.921-931, 29 abr. 2016.

[27] LEDERBERG, J.; MCCRAY A. T. **'Ome sweet 'omics** - a genealogical treasury of words. Scientist, v. 15, 2001.

[28] LEY, R. E.; PETERSON, D. A.; GORDON, J. I. **Ecological and Evolutionary Forces Shaping Microbial Diversity in the Human Intestine**. Cell, [s.l.], v. 124, n. 4, p.837-848, fev. 2006.

[29] LIU, Y. W. et al. Psychotropic effects of Lactobacillus plantarum PS128 in early lifestressed and naïve adult mice. **Brain Research**, [s.l.], v. 1631, p.1-12, jan. 2016.

[30] METZLER, D. H.; MAHONEY, D.; FREEDY, J. R. Anxiety Disorders in Primary Care. **Primary Care: Clinics in Office Practice**, [s.l.], v. 43, n. 2, p.245-261, jun. 2016.

[31] MOOS, W. H. et al. **Microbiota and Neurological Disorders**: A Gut Feeling. Bioresearch Open Access, [s.l.], v. 5, n. 1, p.137-145, 2016.

[32] MORAES, A. C. F. et al. Microbiota intestinal e risco cardiometabólico: mecanismos e modulação dietética. **Arquivos Brasileiros de Endocrinologia & Metabologia**, [s.l.], v. 58, n. 4, p.317-327, jun. 2014.

[33] NELSON, M. H. et al. Harnessing the Microbiome to Enhance Cancer Immunotherapy. **Journal Of Immunology Research**, [s.l.], v. 2015, p.1-12, 2015.

[34] O'BRIEN, J. et al. **Safety evaluation of probiotics**. Trends In Food Science & Technology, [s.l.], v. 10, n. 12, p.418-424, 1999.

[35] O'MAHONY, L. et al. **Lactobacillus and bifidobacterium in irritable bowel syndrome**: Symptom responses and relationship to cytokine profiles. Gastroenterology, [s.l.], v. 128, n. 3, p.541-551, mar. 2005.

[36] PARVEZ, S. et al. Probiotics and their fermented food products are beneficial for health. **Journal Of Applied Microbiology**, [s.l.], v. 100, n. 6, p.1171-1185, jun. 2006.

[37] PENDERS, J. et al. **Factors Influencing the Composition of the Intestinal Microbiota in Early Infancy**. Pediatrics, [s.l.], v. 118, n. 2, p.511-521, ago. 2006.

[38] QIN, J. et al. **A human gut microbial gene catalogue established by metagenomic sequencing**. Nature, [s.l.], v. 464, n. 7285, p.59-65, mar. 2010.

[39] RIBEIRO, A. A. et al. **Microbioma Humano**: Uma Interação Predominantemente Positiva?. Uningá Review, [s.l], v. 19, n. 1, p.38-43, 2014

[40] ROY-BYRNE, P. P. et al. **Anxiety disorders and comorbid medical illness**. General Hospital Psychiatry, [s.l.], v. 30, n. 3, p.208-225, maio 2008

[41] SANDERS, M. E**. How Do We Know When Something Called "Probiotic" Is Really a Probiotic?** A Guideline for Consumers and Health Care Professionals. Functional Food Reviews, [s.l], v. 1, n. 1, p. 3–12, 2009.

[42] SHI, L. H. et al. **Beneficial Properties of Probiotics**. Tropical Life Sciences Research, [s.l.], v. 27, n. 2, p.73-90, 2016.

[43] STOPA, S. R. et al. Prevalência do autorrelato de depressão no Brasil: resultados da Pesquisa Nacional de Saúde, 2013. **Epidemiologia e Serviços de Saúde**, [s.l.], v. 18, n. 2, p. 170-180, jun. 2015.

[44] SWEDO, S. E. et al. New developments in childhood affective and anxiety disorders. **Current Problems In Pediatrics**, [s.l.], v. 24, n. 1, p.12-38, jan. 1994.

[45] TORRES, S. J.; NOWSON, C. A**. Relationship between stress, eating behavior, and obesity**. Nutrition, [s.l.], v. 23, n. 11-12, p.887-894, nov. 2007.

[46] TURNBAUGH, P. J. et al. **The Human Microbiome Project**: exploring the microbial part of ourselves in a changing world. Nature, [s.l.], v. 449, n. 7164, p.804-810, out. 2007.

[47] URSELL, L. K. et al. **Defining the human microbiome**. Nutrition Reviews, [s.l.], v. 7, n. 1, p.38-44, ago. 2012.

[48] WALLACE, C. J. K.; MILEV, R. The effects of probiotics on depressive symptoms in humans: a systematic review. **Annals of General Psychiatry**, 16: 2–10, 2017.

[49] WALTER, J. Ecological Role of Lactobacilli in the Gastrointestinal Tract: Implications for Fundamental and

Biomedical Research. **Applied And Environmental Microbiology**, [s.l.], v. 74, n. 16, p.4985-4996, jun. 2008.

[50] WANG, H. et al. Effect of Probiotics on Central Nervous System Functions in Animals and Humans: A Systematic Review. **Journal Of Neurogastroenterology and Motility**, [s.l.], v. 22, n. 4, p.589-605, out. 2016

[51] WHITMAN, W. B.; COLEMAN, D. C.; WIEBE, W. J. Prokaryotes: the unseen majority. **Proceedings of the National Academy of Sciences**, [s.l.] v. 95, n. 12, p. 6578–6583, 1998.

[52] WHO. **Depression** [Internet]. n. 369, 2016. Disponível em: http://www.who.int/mediacentre/factsheets/fs369/en/. Acesso em: 19 abr. 2022.

[53] YANNAKOULIA, M. et al. **Eating habits in relations to anxiety symptoms among apparently healthy adults**. A pattern analysis from the ATTICA Study. Appetite, [s.l.], v. 51, n. 3, p.519-525, nov. 2008.

The Influence of the time and Temperature Binomium in the Process of Extraction of Bioactive Compounds from Guaraná (Paullinia cupana)

A Influência do Binômio Tempo e Temperatura no Processo de Extração de Compostos Bioativos do Guaraná (Paullinia cupana)

Alexandre Santos de Souza[1], Daiane Pereira Barbosa[2], Lara Bruna Brito Castro de Souza[3], Acsa Santos Batista[4], João Lucas Ferreira Gomes Lemos[5]

[1]Professor at IFNMG/Campus Salinas 39560-000 Salinas, MG.
[2]Master's student at UFLA/Campus Lavras 37200-900 Lavras, MG.
[3]Laboratory Technician of the IFNMG/Campus Salinas 39560-000 Salinas, MG.
[4]Doctoral studentat UESB/Campus Itapetinga 45031-900 Itapetinga, BA.
[5]Student of the Food Engineering course at IFNMG/Campus Salinas 39560-000 Salinas, MG.

Abstract — Guarana is a plant native to the state of Amazonas that found favorable soil and climate conditions for its development in southern Bahia. It is recognized worldwide for its medicinal and stimulant properties from the presence of alkaloids from the methylxanthine group, such as caffeine. The caffeine content in guarana can reach 6%, a content four times higher than arabica coffee, which makes it a useful raw material for the caffeine extraction process. Among the caffeine extraction processes, there is the method of extraction by chemical solvents, which, in addition to being expensive, are very harmful to the environment, so an alternative is the use of water as a solvent, which also has a good affinity in the process. extraction and does not harm the environment like chemical solvents. The objective of this project is to optimize the process of extracting caffeine from guarana seeds, using water as a solvent, through an experimental design. Chromatographic and microbiological analyzes will be carried out and the concentration of the extract will be performed with the highest yield by the spray drying method. Data evaluation will be performed using the Statistica software version 10, for analysis of variance with a 95% confidence interval. It is expected that, with this project, extracts rich in caffeine will be obtained and that it will be able to determine which variables influenced the caffeine extraction process, so that in this way they can be worked more deeply. Keywords: HPLC, Spray drying, Maltodextrin, Yield.

Resumo— O guaraná é uma planta nativa do estado do Amazonas que encontrou condições edafoclimáticas favoráveis para o seu

desenvolvimento no sul da Bahia. É reconhecida mundialmente pelas suas propriedades medicinais e estimulantes proveniente da presença de alcaloides do grupo das metilxantinas, como a cafeína. O teor de cafeína no guaraná pode chegar a 6%, teor quatro vezes maior que o café arábica, que, o torna uma matéria prima útil para o processo de extração de cafeína. Dentre os processos de extração de cafeína, tem se o método de extração por solventes químicos, que, além de caro, agridem muito o meio ambiente, assim, uma alternativa é a utilização da água como solvente, que também possui uma boa afinidade no processo de extração e não agride o meio ambiente como os solventes químicos. O objetivo deste projeto é otimizar o processo de extração de cafeína de sementes de guaraná, utilizando a água como solvente, por meio de um planejamento experimental. Será realizada análises cromatográficas, microbiológicas e a concentração do extrato com maior rendimento pelo método de secagem em Spray drying. A avaliação dos dados será realizada utilizando o software Statistica versão 10, para análise de variância com intervalo de confiança de 95%. Espera se que, com o presente projeto obtenha extratos ricos em cafeína e que consiga determinar quais foram as variáveis que influenciaram no processo de extração de cafeína, para que dessa forma sejam trabalhas mais profundamente.

I. INTRODUCTION

Guarana (Paullinia cupana) is a plant native to the state of Amazonas that is recognized worldwide for its medicinal and stimulant properties.This stimulant power comes from the presence of methyl xanthine-type alkaloids, with a greater predominance of caffeine (SANTOS, 2017).

Although guaraná is of Amazonian origin, this species found favorable soil and climate conditions for its development in southern Bahia due to rainfall, temperature, relative humidity and the production system adopted by the state (SANTOS, 2017).According to Conab (2019), Bahia was the state to conquer the first place in the guaraná production ranking in 2018, Amazonas occupies the second position, followed by Mato Grosso.

The guarana seed can present a percentage of approximately 6% of caffeine, a content four times higher than coffee, which shows its stimulant power (NOGUEIRA, 2017).

In addition to caffeine, the chemical composition of guarana is characterized by the presence of theophylline, theobromine, tannins, gallic acid, saponins, catechins, epicatechins, flavonoids, phenolic compounds, antioxidants, among other compounds in lower concentrations (PINTO, 2012).

For the pharmaceutical, food and cosmetic industries, caffeine is of extreme value, because, when consumed in a moderate way, this alkaloid acts in an antagonistic way to adenosine receptors, which provides an increase in the individual's state of alertness, promoting aimprovement in the association of ideas and intellectual activities, greater resistance to fatigue and increased well-being (SANTOS, 2017).

In the literature, it is possible to find several studies on caffeine extraction and concentration (NOGUEIRA, 2017).Among the methods employed are the use of organic solvents with the affinity of caffeine, which aims to extract this alkaloid.The solvents used are: 2 dichloromethane, ethyl acetate, benzene, chloroform, ether, alcohol, trichlorethylene, carbon tetrachloride, acetone, among others (SANTO, 2016).

However, for the industry, the use of these solvents results in a high value in the production line, because, in addition to having a high price and having the need to remove the solvent through distillation, these solvents harm the environment. (SANTO, 2016).

An alternative is the use of water in the caffeine extraction process, which also has a good affinity, has low value and does not harm the environment when compared to chemical solvents (LEITE, 2009).

During the caffeine extraction process, attention must be paid to several factors such as: extraction time and temperature, as these directly influence the final result. Thus, the study of these factors is necessary, so that it becomes possible to understand the system and the interactions between them, so that maximum yields are obtained during the extraction process (SANTO, 2016).

The present work aims to obtain and characterize extracts of guarana (Paullinia cupana) in powder form subjected to different temperatures and extraction times.

II.   MATERIALS AND METHODS

2.1 Plant material

The organic guarana seeds were supplied by Asscorp Alimentos LTDA acquired from the Onça project in the municipality of Taperoá, BA, a city located in the Territory of Citizenship of Baixo Sul da Bahia, from the 2019 harvest.original, stored in transparent polyethylene bags and packed in cardboard boxes.The guarana beans were sent to the company Moinhos Vieira, located in Rio de Janeiro, where they were ground to a particle size of 0.5 µm.The powder was stored in transparent polyethylene bags and packed in cardboard boxes and sent to the Instituto Federal do Norte de Minas Gerais-Salinascampus.

2.2 Preparation of extracts

Factorial experimental design

A 22 factorial design was adopted with triplicate at the central point.The central point was necessary for the calculation of the experimental error. In the factorial design, the influence of Time (72 and 12 hours) and Temperature (60 and 80 °C) was evaluated and at the central point, the time of 48 hours and the temperature of 70 °C were evaluated, as shown in Table 1The 22-factor design assays at different levels were performed in duplicates.Table 2 shows the tests performed in the present study.The sample weight of 50 g, stirring speed of 220 rpm, volume of 100 mL of water and granulometry of 0.5 µm were kept fixed.

Table 1: Actual values assigned to experimental design variables

Levels	Temperature (ºC)	Time(hours)
1	60	12
-1	80	72
PC	70	48

Source: From the Author.

Table 2: Experimental Design 22 with triplicate at the central point.

Treatment	Temperature (ºC)	Time (hours)
1	80	72
2	80	72
3	80	12
4	80	12
5	60	12
6	60	12
7	60	72
8	60	72
9	70	48
10	70	48
11	70	48

Source: From the Author.

2.3 Preparation of extracts

The preparation of aqueous extracts was carried out according to an experimental design as shown in Table 2. Sterile distilled water was used, autoclaved at 121 °C for 15 minutes.

50 grams of guarana powder were weighed on a Martes analytical balance, model BL 3200H and transferred to erlenmeyers and then 100 mL of distilled water was added and homogenization was carried out. The erlenmeyers were sealed with aluminum foil and masking tape and placed in a Nova Técnica brand water bath, model NT 232 Dubnoff, under agitation at 220 rpm. After that, a first filtration of the extract was carried out in Voil Fabric, then a second filtration was carried out, through the vacuum method.

After that, the extracts were transferred to falcon tubes and centrifuged (Centrifuga Mad Lab CT-5000) at 3000 rpm for 3 minutes. The extracts were stored in amber glass and the extract residues were dried in a conventional oven at a temperature of 55 to 60 °C until constant weight and stored in laminated Zip Lock bags. Both were taken to the BOD oven at 10 °C until the time of analysis.

2.4 Physicochemical analysis of guarana powder

The moisture content was determined by gravimetry in a conventional oven at 105 °C, until constant mass, according to Instituto Adolfo Lutz (2008).The determination of ash (fixed mineral residue) was performed by gravimetric method from the incineration at 550 ºC in the muffle for an average of 6 hours according to the Instituto Adolfo Lutz (2008).Crude protein determination was performed using the Kjeldahl method, according to Instituto Adolfo Lutz (2008).The lipid content was determined by the Soxhlet method, according to Instituto Adolfo Lutz (2008).All physicochemical analyzes were performed in triplicate.

Sample Preparation

For the preparation of the samples, an aliquot of 0.5 mL of the guarana extracts was removed and for the guarana powder and the residue of the extracts, 0.02 g of sample was used.5 mL of extracting solution (85% H_2O Milli-Q,

acidified with 0.3% acetic acid, and 15% Methanol) was added to falcon centrifuge tubes containing the samples.The tubes were taken to an ultrasonic bath (SoniClean 6) under agitation for 15 minutes, followed by a water bath at 60 °C for 10 minutes, and then centrifuged (3000 rpm for 15 minutes) for better separation.These extracts were used for the analysis of Caffeine, Theobromine, Catechin, Epicatechin Flavonoids, Phenolic Compounds and Antioxidants.

Total Phenolic Compounds (CFT)

For the determination of total phenolic compounds, the methodology used by Lee et al. (2003). An aliquot of 0.5 mL of sample was added to a test tube and 2.5 mL of 10% Folin Ciocalteau and 2.0 mL of 7.5% Sodium Carbonate solution were added, totaling 5.0 mL corresponding to each trial. The obtained solution was taken to a water bath at 40 °C for 15 minutes. After that, the samples were left to rest for 30 minutes under the protection of light. The reading was performed in a spectrophotometer (UV VIS SCAN model 0898UV2) in a quartz cuvette, at an absorbance of 750 nm. The blank was made by adding extractor solution in place of the sample. The analysis was performed in duplicate.

The calibration curve was obtained from the aqueous solution of Gallic Acid at concentrations between 10 and 100 µg AG.mL-1. The CFT content results were expressed as Gallic Acid equivalents (g AG.100g-1) and calculated using a curve constructed with concentrations of the standard. The R2 obtained was 0.993.

Total Flavonoids (FT)

The total flavonoid content was adapted by the method proposed by Zhishen, Mengcheng; Janming (1999). An aliquot of 0.5 mL of the extract, 2.5 mL of distilled water and 0.15 mL of 5% sodium nitrite (NaNO2) were added to test tubes, vortexed and left to rest for 6 minutes. Given the time, 0.3 mL of 10% aluminum chloride (AICI3) was added, stirred and left to stand for 5 minutes. After that, 1 mL of 1M sodium hydroxide (NaOH) was added and the remainder of water was added to 5 mL. The spectrophotometer reading (UV VIS SCAN model 0898UV2) in a quartz cuvette, at absorbance of 510 nm. The blank was performed by adding methanol in place of the sample. The analysis was performed in duplicate.

The calibration curve was obtained from the catechin solution at concentrations of 20 and 200 µg Ca.mL-1. Total flavonoid content results were expressed as Catechin equivalents (g Ca.100g-1). The R2 obtained was 0.976.

Antioxidant Analysis

The total antioxidant activity was determined using the DPPH method according to the methodology used by Brand-Williams;Cuvelier;Berset (1995), which consists in the capture of the DPPH radical (2,2-diphenyl-1-picryl-hydrazyl) by antioxidants contained in the sample, using the DPPH standard solution.

0,1 mL of sample and 3.9 mL of DPPH were added to test tubes, the solution was homogenized and after standing for 30 minutes under the protection of light, the reading was carried out in a quartz cuvette, using the spectrophotometer.(UV VIS SCAN model 0898UV2) with absorbance of 515 nm.The blank was performed with ethyl alcohol in place of the sample.The results for the DPPH assay were expressed in percentage of inhibition (%I) of DPPH present in the extracts capable of decreasing the initial concentration of DPPH in 30 minutes.The percentage of inhibition of the DPPH radical was calculated according to equation 1:

(Equation 1)   DPPH %E=Control - Sample sample x 100

Where:

Ac= DPPH absorbance

Aa= Sample absorbance

Quantification of Caffeine, Theobromine, Catechin and Epicatechin in High Performance Liquid Chromatography (HPLC)

The high performance liquid chromatography method was used to quantify caffeine and theobromine and major phenolic compounds in guarana samples ((+)-catechin and (-)-epicatechin), this method was based on the methodology used by Risner, (2008).) and Gonçalves (2016).

Samples were filtered with sterile 0.22 μm filters and stored in eppendorf until analysis.

A SHIMADZU DGU-20A5R High Performance Liquid Chromatograph was used, equipped with a manual injector, with an injection volume of 20 μm, a Shim-pack column PREP-ODS(H)KIT (H) (octadecylsilane) 250 mm x 4.6 mm and with an ultraviolet wavelength of 280nm at a flow rate of 0.5 mL/min.

The mobile phase composite gradient was established as: A (Methanol) and B (H2O Milli-Q with 0.3% Acetic Acid) with a total run time of 28 minutes and a temperature of 30 °C ± 2.

2.5 Statistical Analysis

The results obtained in the present study were statistically evaluated using the Analysis of Variance (ANOVA) methods, followed by a Tukey mean comparison test and Contrast Analysis.For this, the SISVAR 5.7 software was used.All statistical tests used had a 5% significance level ($p \leq 0.05$).

III.   RESULTS AND DISCUSSIONS

Physicochemical characterization of guarana poder

The results obtained from the physical-chemical characterization of guarana powder are shown in Table 3, below. This type of analysis mainly aims to analyze the quality of the raw material, as well as quantify the active principles present in it. According to Pellozo (2005), the high presence of humidity is a factor that can not only favor microbial contamination but also triggers enzymatic reactions culminating in the degradation of active principles. As for the ash content, it is an indication of the possibility of containing inorganic impurities in guarana powder.

The moisture and ash content of guarana powder was approximately 8.7% and 2.3%, respectively. According to the Ministry of Agriculture, Livestock and Supply (BRASIL, 1982), the moisture content should be a maximum of 12% and 2% ash. The National Commission of Norms and Standards for Food (CNNPA) of the Ministry of Health (BRASIL, 1978), says that the moisture content should be a maximum of 7% and the ash content 2%. However, the Brazilian Pharmacopoeia (2003) determines that the ash content should be a maximum of 3%.

As the guarana powder used in this experiment presented a moisture content below 12%, it is within the limits established by MAPA (BRASIL, 1982), however, it presented a higher content for ash.

As for the protein and lipid content, the values obtained were approximately 8.4% and 4.6%, respectively. These results were lower than those by Nazaré (1998), who analyzed guarana powder and obtained 13.69% of proteins and 5.57% of lipids. Martins (2010) also obtained a higher protein content (12.84%) in his study, however, the lipid content was lower (2.85%) than that obtained in the present research.

The stimulant and prolonged effect of guarana is attributed to the presence of a complex formed between methylxanthines and condensed tannins (PELLOZO, 2005). Pellozo (2005) also states that the total tannin content is attributed to the presence of substances that are composed of interconnected monomeric units of proanthocyanidins and/or prototannins (catechin and epicatechin).

The caffeine and theobromine content obtained was 3.902 g.100g-1 and 1.627 g.100g-1, respectively.The caffeine content was close to that found by Souza (2010) and Pereira (2011), but the theobromine content in this study was higher.However, the caffeine content was lower than that found by Nazaré (1998), who obtained a caffeine

content of 4.45% when analyzing the guarana powder sample.

Table 3: Physicochemical and chemical characterization of Guarana poder.

Determinations	Results
Humidity (%)	8,709 ± 0,291
Lipids (%)	4.462 ± 0.342
Protein (%)	8.432 ± 0.396
Gray (%)	2.274 ± 0.013
Caffeine (g.100g-1)	3.902 ± 0.186
Theobromine (g.100g-1)	1.627 ± 0.114
Epicatechin (g.100g-1)	2.008 ± 0.102
Catechin (g.100g-1)	0.146 ± 0.57
FT (gCa*.100g-1)	2.030 ± 0.347
CFT (gAG**.100g-1)	17.797 ± 1.751
%I DPPH ***	60,879 ± 2,542

Results of means ± standard deviation.

*Catechin;** Gallic Acid;*** Inhibition Percentage.

The content of epicatechin and catechin found in guarana powder was 2.008g.100g-1 and 0.146 g.100g-1, respectively.These values are lower than those found by Souza (2010), who obtained a catechin and epicatechin value of 0.87 g.100g-1 and 0.61 g.100g-1, respectively.

According to Gomes (2018), the antioxidant activity of guarana is associated with phenolic compounds such as tannins.Phenolic compounds are responsible for color, astringency, aroma, oxidative stability and are included in the category of free radical scavengers.These compounds are distributed in substances such as phenolic acids, flavonoids, among others.

The content of phenolic compounds was given as a percentage of %galic acid, the value obtained (Table 4) in the present study was 17.797 gAG.100g-1, about 178 mg AG.g-1, a value higher than that found by Pereira (2011), who obtained a content of 128.64 mg AG.g-1 and lower than the research carried out by Gomes (2018) who analyzed different batches of guarana powder, obtained an average content of 440 mg.AG.g-1 and 270 mg.AG.g1.

Flavonoids are considered a secondary group of the class of low molecular weight phenolic compounds, they can be presented as flavonols, flavones, flavanones, catechins, anthocyanins, isoflavones and chalcones. These compounds also have a direct action in the scavenging of free radicals, therefore presenting antioxidant activity.

In the present study, the TF content was given in catechin (g Ca). In this way, guarana powder showed about 20.30 mg Ca per gram of sample. In the work carried out by Gomes (2018), the flavonoid content was given in amount of catechol (CAT), the analyzed batches showed an average amount of 288.75 mg CAT.g-1 and 150.09 mg CAT.g-1.

As for the antioxidant activity of guarana powder, it was expressed in terms of DPPH Radical Inhibition Percentage (%I). The value obtained was approximately 61%I DPPH, a value below those obtained by Gomes (2018), who obtained averages of 79%I DPPH and 70%I DPPH.

Gomes (2018) states that the high antioxidant activity of guarana powder is mainly due to the amount of phenolic compounds present. Because of this, guarana powder has been the focus of some research, as it is a natural product and protects the body from damage caused by free radicals, preventing various diseases.

Experimental Design 22 with triplicate at the central point The statistical analysis of the data consisted of two stages. In the first stage, the statistics of the means obtained from the factorial design 22 were performed, that is, the first 8 trials were analyzed. Tukey's Test and Analysis of Variance (ANOVA) were applied to these data. In the second stage, the 11 factorial design trials were analyzed. In this step, in addition to the Analysis of Variance (ANOVA) and the Tukey Test, the Contrast Test was applied, which aims to evaluate the general average obtained by the 22 factorial design in relation to the central point (additional treatment). In both stages, the tests were performed with a significance level of 5% (p≤0.05).

The significance of the effects of temperature, time and the interaction between them for planning 22 was determined by analysis of variance, where, for each response of the significance of the effects, it was verified using the p values. P values less than or equal to 0.05 indicate that the variable is significant in the experimental domain studied, with a confidence level of 95%. Table 4 shows the mean square values obtained by the analysis of variance, it also shows the source of variation (FV) and degrees of freedom (GL) for the analysis of caffeine, theobromine, catechin and epicatechin in guarana extracts.

*Table 4: Analysis of variance of the results obtained from the 22 factorial design *Significant; **Not significant. Significance level of 5%*

FV	GL	Caffeine	Theobromine	Catechin	Epicatechin
Temperature (°C)	1	0,148513s*	0,044253s	0,000761s	0,003321ns
Time (hours)	1	0,000545ns**	0,009870ns	0,000008ns	0,000006ns
Temperature*Time	1	0,000365ns	0,018528ns	0,000450ns	0,002556ns
Error	4	0,001531	0,002376	0,000074	0,000567
Total corrected	7				

Through analysis of variance, it was observed that temperature was significant at a significance level of 5% (p≤0.05) for caffeine, theobromine and catechin, and not significant for epicatechin. Time was not significant for the compounds analyzed in Table 4. The same occurred when the interaction between temperature and time was performed.

In a study carried out by Paredes et al. (2016), the process of extracting caffeine from guarana seeds was evaluated, showing that the temperature had a greater influence on the extractive process when compared to the time used. The author also states that, in addition to these factors, the granulometry and the type of solvent influence the extraction process, since, in addition to caffeine, guarana has other substances such as: theophylline, theobromine, alkaloids, terpenes, tannins, flavonoids, saponins. , pigments, it is good to extract caffeine, and that studies of these factors are necessary, so that it is possible to understand the system and interactions to obtain maximum yields.

Table 4.1 shows the mean square values obtained by the analysis of variance, it also shows the source of variation (FV) and degrees of freedom (GL) in the analysis of flavonoids, phenolic compounds and %I DPPH of guarana extracts.

Table 4.1: Analysis of variance of the results obtained from the factorial design 22

FV	GL	%I DPPH	Flavonoids	Phenolic Compounds
Temperature (°C)	1	21,014645s*	0,026796s	0,138601ns
Time (hours)	1	42,007778s	0,003081s	0,029161ns
Temperature*Time	1	47,638561s	0,00023ns**	0,014028ns
Error	4	1,496649	0,000353	0,090844
Total corrected	7			

Significant;**Not significant.Significance level of 5% (p≤0.05).

When evaluating the I DPPH, temperature, time and the interaction between them, it proved to be significant. In relation to flavonoids, both time and temperature proved to be significant, however, it was not significant when the interaction between the two was effected. As for phenolic compounds, there was no significant difference in relation to the sources of variations analyzed. All data contained in Table 4.1 were evaluated at a significance level of 5% (p≤0.05).

In a research carried out by Schafranski et al. (2019), on extractions of bioactive compounds and antioxidant activity of black mulberry leaf extracts, demonstrated that both temperature and time significantly influenced the extraction of total phenolic content. In these extracts, flavonoids, flavonoids and ortho-diphenolics were also evaluated, as well as the antioxidant activity against the DPPH radical. A research carried out by Piovesan (2016), which evaluated extractive processes of bioactive compounds in blueberries, found that time and temperature were significant for the extraction of total phenolic compounds, while for flavonoids only the temperature was significant. And for DPPH, temperature and time were not significant.

When analyzing the means as a function of temperature, using the Tukey test (Table 5), it is noted that there was a significant difference at a significance level of 5% (p≤0.05) for caffeine, theobromine and catechin, in the however, there was no significant difference for epicatechin when the means obtained at 60 °C and 80 °C were evaluated. On the other hand, when the averages were evaluated as a function of time, all the analyzed compounds did not show a significant difference between the averages obtained at the time of 12 and 72 hours.

For the averages obtained as a function of temperature (Table 5) for %I DPPH and flavonoids, there was a significant difference between the samples at 60 °C and 80 °C at a significance level of 5% (p≤0.05), already in In relation to phenolic compounds, there was no difference between the means.

When the means were analyzed in relation to time (Table 5.1), it was observed that there was a difference between the means of flavonoids and % IDPPH at a significance level of 5% (p≤0.05), while phenolic compounds did not differ between yes.

Table 5: Tukey's test of means as a function of time and temperature

Variable	Treatment	Caffeine (g.100g-1)	Theobromine (g.100g-1)	Catechin (g.100g-1)	Epicatechin (g.100g-1)
Temperature (°C)	60	0,688±0,041a	0,215±0,109a	0,045±0,010a	0,116±0,034a
	80	0,416±0,025b	0,066±0,024b	0,025±0,011b	0,075±0,020a
Time (hours)	12	0,560±0,168a	0,176±0,146a	0,037±0,005a	0,095±0,010a
	72	0,544±0,152a	0,105±0,052a	0,033±0,021a	0,096±0,051a

Values obtained from means ± standard deviation.Values that have the same letters in the same column are similar at a significance level of p≤0.05, and those that have different letters are different from each other, according to Tukey's test.

Table 5.1: Tukey test result as a function of time and temperature Values obtained from means ± standard deviation.Values that have the same letters in the same column are similar at a significance level of p≤0.05, and those that have different letters are different from each other, according to Tukey's test.

Variable	Temperature	%I DPPH	Flavonoids (gCa.100g-1)	Phenolic Compounds (gAG.100g-1)
Temperature (°C)	60	88,897±0,182a	0,226±0,035a	1,271±0,0,346a
	80	85,655±5,643b	0,110±0,017b	1,007±0,124a
Time (hours)	12	89,568±0,965a	0,188±0,073a	1,199±0,110a
	72	84,985±4,893b	0,149±0,063b	1,079±0,399a

In the analysis of variance for the treatments used during the extraction process, it was shown to be significant for caffeine, theobromine, % IDPPH and flavonoids and not significant for catechin, epicatechin and phenolic compounds (Tables 6 and 6.1) at a significance level of 5%.(p≤0.05).

Table 6: Result of analysis of variance for 22 factorial design with triplicate at the central point.

FV	GL	Caffeine (g.100g-1)	Theobromine (g.100g-1)	Catechin (g.100g-1)	Epicatechin (g.100g-1)
Treatment	4	0,046211s	0,018749s	0,010875ns	0,003761ns
Error	6	0,003775	0,002397	0,008578	0,000940
Total corrected	10				

s = significant;ns= not significant

REFERENCES

[1] BRAND, W. W.; CUVELIER, M. E.; BERSET, C. Use of a free radical method to evaluate antioxidant activity. Lebensmittel Wissenschaft und Technologie – Food Science and Technology, London, v.28, n.1, p.25-30, 1995.

[2] BRASIL, Ministério de Agricultura, Pecuária e Abastecimento. Portaria n. 70, de março de 1982. Diário Oficial da União, Brasília, 1982.

[3] CONAB, Companhia Nacional de Abastecimento. Análise Mensal: Guaraná. Brasília, DF. 2019. 8 p.

[4] ANVISA. Agência Nacional de Vigilância Sanitária. Farmacopeia Brasileira. 5. ed. Brasília: ANVISA, 2010.

[5] GOMES, R. A. C. et al. Avaliação da atividade antioxidante do extrato metanólico dos galhos de Bambusa vulgaris (L.) - POACEAE. In: Perspectivas Experimentais e Clínicas, Inovações Biomédicas e Educação em Saúde (PECIBES) v. 4, n. 1, 10 set. 2018.

[6] INSTITUTO ADOLFO LUTZ. Métodos químicos e físicos para análise de alimentos 1. ed. São Paulo: IMESP, 2008.

[7] LEE, K. W. et al. Cocoa has more phenolic phytochemicals and a higher antioxidant capacity than teas and red wine. Journal of agricultural and food chemistry, v. 51, n. 25, p. 7292-7295, 2003.

[8] LEITE, C. L. Aceitação e preferência por cafés submetidos a diferentes métodos de extração de cafeína. 2009. 121 f. Dissertação (Mestrado em Nutrição em Saúde Pública) -

Curso de Nutrição em Saúde Pública, Universidade de São Paulo, São Paulo, 2009.

[9] Nazaré, R. F. R. Processamento de Guaraná em Pó Solúvel. 95. ed. Belém: EMBRAPA, 1998.

[10] NOGUEIRA, R. P; MARTINS, V. L.; CORRÊA, G. M. Quantificação de cafeína em cascas do fruto de guaraná coletadas no município de urucará-am. In: XI Semana Nacional de Ciência e Tecnologia ICET/UFAM E IFAM, 11, 2017, Itacoatiara. Anais [...]. Itacoatiara.

[11] PAREDES, S. A. H. et al. Obtenção de cafeína de sementes de guaraná por meio de extração sólido-líquido em batelada. In: Congresso Brasileiro de Engenharia Química, 21, 2016, Fortaleza. Anais [...] Fortaleza: COBEQ, 2016.

[12] PELLOZO, M. I. G. Desenvolvimento e caracterização tecnológica de extratos e do granulado de Paullinia cupana H.B.K. var. Sorbilis (mart.) Ducke (guaraná). 2005. 85 f. Dissertação (Mestrado em Farmácia), Universidade Estadual de Maringá, Maringá, 2005.

[13] PEREIRA, A. et al. Redução de compostos fenólicos de resíduos de lagares de azeite utilizando culturas de Coriolus versicolor. In: IV CONGRESSO IBÉRICO DE AGRO-ENGENHARIA. 2011, Évora. Anais [...]. Évora: Icaam, 2011.

[14] PINTO, P. M. Atividade antibacteriana das espécies Paullinia cupana kunth. e Ptychopetalum olacoides benth. 2012. 134 f. Dissertação (Mestrado em

Biotecnologia), Universidade Federal do Amazonas, Manaus, 2012.

[15] PIOVESAN, N. et al. Influência de diferentes parâmetros em métodos de extração de compostos bioativos de mirtilo (Vaccinium ashei Reade) e atividade antioxidante e antimicrobiana. 2016. Tese de Doutorado (Ciência e Tecnologia de Alimentos) - Universidade Federal de Santa Maria, Santa Maria, 2016.

[16] SANTO, A. T. E. Estudo sobre processos de extração e purificação de cafeína da erva-mate. 2016. 79 f. Dissertação (Mestrado em Engenharia Química), Pontifícia Universidade Católica do Rio Grande do Sul, Porto Alegre, 2016.

[17] SANTOS, H. M. Desenvolvimento de Método Analítico para a determinação de Macro e Microelementos em amostras de Guaraná (Paullinia Cupana) produzidas na região sul da Bahia. 2017. 90 f. Dissertação (Mestrado) - Curso de Química, Universidade Estadual de Santa Cruz, Ilhéus, 2017.

[18] SCHAFRANSKI, Kathlyn et al. Avaliação de compostos bioativos e atividade antioxidante de extratos de folhas de amoreira preta (Morus nigra L.) utilizando planejamento experimental. Química Nova, v. 42, p. 736-744, 2019.

[19] ZHISHEN, J.; MENGCHENG, T.; JIANMING, W. The determination of flavonoid contents in mulberry and their scavenging effects on superoxide radicals. Food chemistry, v. 64, n. 4, p. 555-559, 1999.

Education, Inclusion and Social Responsibility in Brazil

Educação, Inclusão e Responsabilidade Social no Brasil

Richardson Lemos de Oliveira, Leiliane Domingues da Silva, Bibiana Kaiser Dutra, Maiton Bernardelli, Evandro de Oliveira Brito, Davi Milan, Gislaine Schon, Jociene Martins Matheus Silva, Maria de Fátima dos Silva Santos, Jucicleide Gomes Acioli, João Batista Lucena

Abstract — In times of chaos motivated by mass illness and consequent social distancing, it is necessary to rethink the ways of (with) living. Under parameters of a harmonious coexistence between educational, moral, economic and political sectors, it is necessary to recognize that society is increasingly intertwined with the advancement of technology and the internet. Bakhtin had already mentioned about the dialogical contraposition of the subject in discourse, in the chapter Dialogue in Dostoevsky, when he said that "only in communication, in the interaction of man with man, "man in man" is revealed (emphasis by the author) for others or for yourself". (BAKHTIN, 2013, p. 292). In a scenario in which the potential of communication through platforms that enable interaction with the world in real time is evident, our objective is to analyze the importance of education and social responsibility for achieving success in technological areas. In this perspective, we investigate how this communicational ecosystem can be better undertaken and constituted by mixing principles such as rationality, alterity and responsibility.

Resumo— Em tempos de caos motivados por adoecimento em massa e consequente distanciamento social, é preciso repensar os modos de (com)viver. Sob parâmetros de uma convivência harmoniosa entre setores educacional, moral, econômico e político, é preciso reconhecer que a sociedade está cada vez mais interligada com o avanço da tecnologia e com a internet. Bakhtin já havia mencionado a respeito da contraposição dialógica do sujeito no discurso, no capítulo O diálogo em Dostoiévski, ao dizer que "somente na comunicação, na interação do homem com o homem revela-se "o homem no homem" (grifos do autor) para outros ou para si mesmo". (BAKHTIN, 2013, p. 292). Em um panorama em que se evidencia o potencial da comunicação por meio de plataformas que possibilitam a interação com o mundo em tempo real, nosso objetivo é o de analisar a importância da educação e da responsabilidade social para efetivação do sucesso em âmbitos tecnológicos. Nessa perspectiva, investigamos como esse ecossistema comunicacional pode ser melhor empreendido e constituído mesclando princípios como a racionalidade, a alteridade e a responsabilidade.

I.   INTRODUÇÃO

Em tempos de caos motivados por adoecimento em massa e consequente distanciamento social, é preciso repensar os modos de (com)viver, inclusive em setores de profissionalização. Sob parâmetros de uma convivência harmoniosa entre setores educacional, moral, econômico e político, é preciso reconhecer que a sociedade está cada vez mais interligada com o avanço da tecnologia e com a internet. Bakhtin já havia mencionado a respeito da contraposição dialógica do sujeito no discurso, no capítulo *O diálogo em Dostoiévski*, ao dizer que "somente na comunicação, na interação do homem com o homem revela-se "o homem no homem" (grifos do autor) para outros ou para si mesmo". (BAKHTIN, 2013, p. 292).

Em um panorama em que se evidencia o potencial da comunicação por meio de plataformas que possibilitam a interação com o mundo em tempo real, nosso objetivo é o de analisar a importância da educação e da responsabilidade social para efetivação do sucesso em âmbitos de profissionalização. Nessa perspectiva, investigamos como esse ecossistema comunicacional pode ser melhor empreendido e constituído mesclando princípios como a racionalidade, a alteridade e a responsabilidade.

Para tanto, apontaremos caminhos via linguagem responsável, no sentido de que a educação precisa estar vinculada a um panorama que insira os sujeitos em uma perspectiva inclusiva.

II.   A INCLUSÃO QUE SE FAZ POR MEIO DA LINGUAGEM RESPONSÁVEL

Atuar em busca de uma educação de qualidade, requer que compreendamos os diferentes espaçotemporalidades e atribuições necessárias as diversas dimensões que compõem a organização das instituições de ensino. Não falamos de um ensino individual, mas inseridos em uma coletividade, e principalmente nos últimos dois anos, em que a a população se viu em meio ao caos do coronavírus.

Vemos isso conforme explicita a Declaração de Salamanca (1994, p.8-9):

> [...] as crianças e jovens com necessidades educativas especiais devem ter acesso ás escolas regulares, que a elas devem se adequar [...] elas constituem meios mais capazes para combater as atitudes discriminatórias, construindo uma sociedade inclusiva e

atingindo a educação para todos.

A educação inclusiva vem como possibilidade de efetivar os nossos argumentos por entendermos os diferentes tipos de sujeito existentes, com suas fragilidades e competências. Desse modo, via linguagem, a educação inclusiva veio sendo redimensionada ao longo do tempo, e aqui propomos o ensino que seja feito por meio do gênero discursivo, especificamente o meme.

Diante o conceito de gênero discursivo explanado anteriormente, o meme pode ser considerado como gênero discursivo porque está ligado ao uso da linguagem em um dado campo da atividade humana e por efetuar-se em forma de enunciado concreto (BAKHTIN, 2016, p. 11-12). De acordo com Almeida e Santana (2018), esse tipo de enunciado está ligado a uma esfera virtual de comunicação humana, do mesmo modo como "configura-se em uma organização composicional, tema e estilo, o que o difere de outros gêneros dessa mesma esfera macro e de outras práticas comunicativas da linguagem" (ALMEIDA; SANTANA, 2018, p. 319). Desse modo, segundo Melo (2018), o meme pode ser considerado como um gênero discursivo, pois nele se abriga uma rede complexa de enunciados vivos, históricos e ideológicos. Constituídos de enunciados concretos, eles são formados pelas linguagens verbal e não verbal, contêm um conteúdo irônico, de crítica social e de sarcasmo. (MELO, 2018, p. 57).

Assim,

> O planeta vive tempos difíceis. A humanidade está a travar uma batalha que já condicionou a vida de milhões de pessoas. Em tempos de incerteza e receio, com muitos países a impor o isolamento social como medida de contenção, há quem revele uma das maiores virtudes da humanidade — o humor. O riso tem funcionado como uma ferramenta de adaptação que ajuda a passar o tempo e a aliviar a preocupação (FERREIRA, 2020, in Observador.com).

O meme que escolhemos para esta análise foi publicado no site do jornal Português "*Observador*", em 15 de março de 2020, e junto ao meme o site traz um texto escrito pela jornalista Marta Leite Ferreira, falando sobre o momento que o mundo vem vivenciando desde o início do mês de março por causa da pandemia causada pela

pandemia da Covid-19. Além de falar sobre algumas mudanças que os seres humanos vêm vivendo em muitos lugares do mundo por conta da pandemia, tais como, o isolamento social, maiores cuidados com a higiene das mãos, de superfícies e objetos, o uso obrigatório de máscaras, entre outros, a jornalista também fala, em seu texto, sobre a importância das pessoas tentarem sorrir um pouco, como forma de amenizar o momento de tensão por conta de muitos fatores negativos trazidos pela alta contaminação que o vírus oferece.

III.   UMA ANÁLISE QUE PRIME PELA INCLUSÃO E PELA RESPONSABILIDADE

Dessa forma, o site apresenta alguns memes com conteúdo de humor que tem como tema a situação e o comportamento das pessoas diante da pandemia. Dentre eles, destacamos o meme a seguir:

Figura 1:

Fonte: https://observador.pt/2020/03/15/rir-no-meio-de-uma-pandemia-estes-9-videos-e-memes-mostram-como/.
Acessado em: 23/05/2020

O enunciado anteposto circulou num determinado contexto real, situado em um momento sócio-histórico. Todo enunciado concreto, segundo Volóchinov (2017), é composto entre outros elementos de um **tema** que é "individual e irrepetível... a depender da situação histórica concreta a qual pertence em essência" (VOLOCHINOV, 2017,p.228), e composto de uma **significação** que são aspectos do enunciado "que são repetíveis e idênticos a si mesmo em todas as ocorrências... significações das palavras, das formas da sua ligação morfológica e sintática, da entonação, etc. (VOLOCHINOV, 2017, p.228-229). O enunciado do meme acima é composto por uma imagem e por uma sentença e só poderá ser plenamente compreendido se o analisarmos em sua totalidade.

Um interlocutor, ao ver esse enunciado, em um tempo futuro, poderá não entender a mensagem passada em seu sentido completo se não tiver conhecimento do contexto sócio-histórico vivenciado no período de circulação do mesmo. O tema do meme em análise é a pandemia causada pelo coronavírus, trazendo a doença popularmente conhecida como Covid-19, no início do ano de 2020, evidenciada no enunciado pelo decreto de obrigatoriedade do uso de máscaras, pelas pessoas, em muitos países pelo mundo, como forma de prevenção de contaminação pelo vírus. Segundo Almeida e Santana (2018), o meme possui uma estrutura com a apresentação de elementos verbais e extra-verbais. Nesse sentido, as palavras e imagens autorizam o acontecimento de relações dialógicas que os recursos verbais e extra-verbais engendram e, naturalmente, expressam valores ideológicos dos sujeitos autores. A linguagem é desenvolvida dentro de uma situação histórica e social em que os textos devem ser interpretados segundo esses fatores (ALMEIDA; SANTANA, 2018, p. 318).

Como podemos observar na composição imagética do enunciado, existe a figura de um cão falando com um homem que, provavelmente, é seu dono, enquanto o homem aparece com as mãos dentro dos bolsos da calça e usando um *colar Elizabetano* (objeto utilizado em alguns animais para impedir que o mesmo consiga coçar ou lamber/morder um local de seu corpo, após algum procedimento cirúrgico) cobrindo a boca e o nariz do mesmo.

O autor do meme usou a ironia para representar a inversão dos papéis do ser humano e do animal irracional, já que muitas autoridades de saúde confirmaram, na época, que animais de estimação não poderiam ser infectados pelo vírus e, mesmo que contraíssem a doença, também não passariam para os seres humanos. Por esse motivo, o cão aparece falando, aparentando estar "despreocupado" com sua própria proteção, mas mostrando "preocupação" com a proteção do homem, justificando em sua fala o motivo pelo qual o homem precisava usar o colar elizabetano, servindo para impedi-lo de tocar a face com as mãos para protegê-lo do contágio pela Covid-19.

Podemos ver, ainda, a presença da significação do enunciado na frase *"É pro seu bem. Vc não pode tocar no seu rosto"*. Essa sentença formada por palavras escolhidas com um tom valorativo, carregam as marcas discursivas do autor do meme, palavras essas que dialogam com outros entornos dialógicos, a saber: o conteúdo imagético e o contexto histórico-social, os quais evocam a construção de sentidos. A escolha de uso da linguagem informal das palavras "pro" ao invés de "para o" e "vc" ao invés de "você" demonstra a frequência de uso dessas formas em escritas por usuários de redes sociais na internet. Ao utilizar termos da linguagem informal, o autor possibilita que o

auditório compreenda a mensagem passada de forma mais fácil, já que os leitores que verão o meme serão aqueles que fazem uso dos meios virtuais e que provavelmente já tiveram contato com essa forma de linguagem em mídias digitais na internet. Percebemos que a informalidade nas materialidades linguísticas seletas demonstra que o sentido de expressões ou palavras do contexto imediato de uso da língua pode gerar um efeito humorístico à situação.

No que diz respeito a uma era digital e tecnológica, é preciso pensar na imagem como algo central. Observe-se:
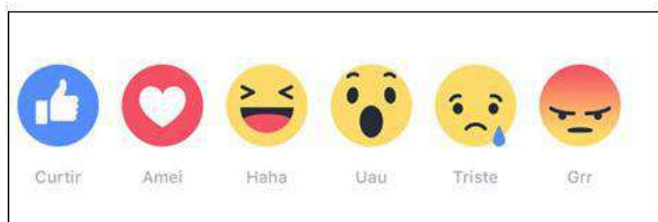
Fig.2– Botões de reação do Facebook

Fonte: G1

A plataforma Youtube contém recursos online que contam com as opções "gostei" e "não gostei" ao lado de comentários. Nas cadências da tela virtual, estudantes de diversos lugares podem aprender a se posicionar de forma responsável e ativa, em que o leitor e o usuário reagem demonstrando sua conclusão sobre o comentário lido.

De acordo com Volóchinov (2017), o contexto de uso da língua (fatores históricos, sociais, ideológicos, culturais imediatos) é decisivo para a constituição do sentido, isto é, do tema da língua. Dessa forma, tema e significação são processos discursivos distintos, mas que se complementam, se compõem.

IV.   CONSIDERAÇÕES FINAIS

Esperamos, com nossa pesquisa, ter adentrado ao processo de contextualização dos enunciados na perspectiva dialógica, determinante para a constituição dos sentidos múltiplos em cada enunciado. É oportuno entender que os memes, enquanto enunciados concretos, são repletos de contornos entoacionais, isto é, de tonalidades apreciativas.

É necessário pesquisar/ler/produzir, tendo em vista a mudança de sentido de palavras e expressões devido aos aspectos sociais, históricos, ideológicos e culturais em que se insere a enunciação. Em suma, o meme analisado tem como traço o humor como resultado da junção composição imagética e linguística. Para cumprir tal efeito, a apreciação expressa pelos mecanismos (contexto/discurso reportado/escolhas lexicais) funciona como uma referência cruzada para contrapor, assemelhar, ironizar (um panorama

mundial pandêmico no momento de circulação do meme) em função do discurso humorístico. Por fim, a valoração por meio das escolhas linguísticas – signos linguísticos –, é geradora de força ideologicamente argumentativa. Essa apreciação busca convencer, de forma humorística e irônica, o interlocutor.

As reflexões aqui empreendidas sobre educação, inclusão e responsabilidade em meio a uma espaçotemporalidade tecnológica nos permitem perceber que a compreensão faz parte de um processo ininterrupto e, por isso, contextual da linguagem. Essas análises proporcionam um aprofundamento da linguagem indo muito além do aspecto formal da língua.

REFERÊNCIAS

[1] ALMEIDA, M. F; SANTANA, W. K. F. Ensino de línguas sob a perspectiva estilística: contribuições da Teoria Dialógica da Linguagem. **Revista de Letras JUÇARA**, Caxias – Maranhão, v. 02, n. 02, p. 310 – 326, dez. 2018.

[2] ANIMALE. **O que é e para que serve um colar Elizabetano**. Disponível em: https://www.animale.me/o-que-e-e-para-que-serve-um-colar-elizabetano/. Acesso em: 29. jan. 2021.

[3] BAKHTIN, Mikhail. **Os gêneros do discurso**. Paulo Bezerra (Organização, Tradução, Posfácio e Notas). Notas da edição russa: Seguei Botcharov. São Paulo: Editora 34, 2016.

[4] BAKHTIN, Mikhail. **Para uma Filosofia do Ato**. Texto completo da edição americana Toward a Philosophy of the Act. Translation and Notes by Vadim Liapunov Edited by Michael Holquist & Vadim Liapunov. Tradução de Carlos Alberto Faraco e Cristovão Tezza (Tradução não revisada, destinada exclusivamente para uso didático e acadêmico). Austin: University of Texas Press, 1993.

[5] **DECLARAÇÃO DE SALAMANCA**: Sobre Princípios, Políticas e Práticas na Área das Necessidades Educativas Especiais, 1994, **Salamanca**-Espanha. FOUCAULT, Michel. Os Anormais. São Paulo: Martins Fontes, 2001.

[6] G1.COM. **Facebook libera cinco novos botões alternativos ao 'curtir'.** Disponível em: https://g1.globo.com/tecnologia/noticia/2016/02/facebook-libera-cinco-novos-botoes-alternativos-ao-curtir.html Acesso em: 01.02.2022

[7] LEAL, José Luciano et al. Tema e significação em tirinhas: nas reminiscências de Mikhail Bakhtin e Valentin Volóchinov. **Revista Foz,** São Mateus – ES, v. 1, n. 2, p. 160-173, 2018.

[8] MELO, Raniere Marques de. **A valoração em memes:** um estudo dialógico no campo da comunicação do discurso religioso. (Mestrado em Linguística). Universidade Federal da Paraíba. João Pessoa, 2018.

[9] VOLOCHÍNOV, Valentin. (Círculo de Bakhtin). **Marxismo e filosofia da linguagem -** Problemas fundamentais do método sociológico na ciência da linguagem. Tradução de

Sheila Grillo e Ekaterina Vólkova Américo – Ensaio introdutório de Sheila Grillo. 1. ed. São Paulo: Editora 34, 2017.

[10] Veja Saúde**. OMS decreta pandemia do novo coronavírus. Saiba o que isso significa,** 11 de março de 2020. Disponível em: https://saude.abril.com.br/medicina/oms-decreta-pandemia-do-novo-coronavirus-saiba-o-que-isso-significa/ Acesso em 29. jan. 2020.

[11] ZOZZOLI, R. M. D. Diálogo social: cruzamentos discursivos a partir de um enunciado-acontecimento-tema. In: RODRIGUES, R. H.; ACOSTA-PEREIRA, R. (Orgs). **Estudos dialógicos da linguagem e pesquisas em Linguística Aplicada**. São Carlos, SP: Pedro João Editores, 2016, p. 109-128.

Predictive models of epidemiological outcomes for patients with subarachnoid hemorrhage

Jarbas Galvão[1], Daniela Delwing de Lima[2], Leandro José Haas[3],Eduardo Manoel Pereira[4]

[1]Departamento de Enfermagem, Universidade Regional de Blumenau-FURB
e-mail: galvao@furb.br
[2] Programa de Pós-Graduação em Saúde e Meio Ambiente da Universidade da Região de Joinville-UNIVILLEe-mail:danidelwing@hotmail.com
[3]Departamento de Medicina da Universidade Regional de Blumenau-FURB
e-mail:ljhaas@terra.com.br
[4]Departametno de Ciências Farmacêuticas da Universidade da Região de Joinville-UNIVILLE e-mail:eduardo_manoel@yahoo.com.br

Abstract— Subarachnoid hemorrhage-SAH is considered a serious disease with a high potential for mortality and disability worldwide. This study aimed to evaluate the epidemiological outcomes in patients with SAH from 2006 to 2018 through a predictive equation, considering the following variables: risk factors, early manifestations, complementary needs, neurological and systemic complications. The subjects of this study were hospitalized patients with a proven diagnosis of SAH, evaluated by the Hunt-Hess and Fisher scales and classified by the modified Rankin scale (mRS). To reach this objective, binary logistic regression was applied, with risk factors as independent variables and epidemiological outcomes as dependent. A total of 148 patients were documented, 65% female and 35% male, with a mean age of 53.7 years. Heart disease was an important predictor for the severe disability outcome, the combination of sensory impairment and syncope explained cases of death by 75.7%. Among neurological complications, hydrocephalus and vasospasm explained the severe cases and ischemic injury and rebleeding explained the death. For systemic complications, hyperglycemia and aspiration pneumonia together represented predictors for severe cases and death events, which can be explained by the presence of sepsis and fever. There is a need to intensify health prevention programs for chronic diseases and women's health, as well as implement hospital assessment protocols.

I. INTRODUCTION

Stroke is the second leading cause of death and one of the main causes of disability worldwide, affecting an economically active part of the population and resulting in significant socioeconomic burden [1]. Stroke can be ischemic or hemorrhagic. Among the non-traumatic hemorrhages, subarachnoid hemorrhage (SAH) is a type of hemorrhagic stroke, in which there is blood extravasation into the subarachnoid space, resulting from the rupture of a cerebral aneurysm in 80% cases, with a mortality rate of 35% within 30 days [2].

Intracranial aneurysms are defined as abnormal dilatations of cerebral arteries, which occur at the weakest spots along the blood vessel wall, as a result of the increase in hemodynamic pressure to which they are subjected, and

are classified according to their shape and etiology, most commonly distinguished between ruptured and unruptured aneurysms [3].

Ruptured aneurysms are the most frequent cause of SAH, with considerable variation in incidence worldwide and a high lethality rate of up to 50%, and only 20% to 35% cases show good functional evolution [4,5] due to complications and little information about their management when compared to ischemic stroke [6]. The etiology of the aneurysm is multifactorial, and the risk factors may be related to family and genetic history, clinical conditions associated with the aneurysm, morphological characteristics, advanced age, sex and modifiable risk factors [7].

Among the modifiable predictors with greater predisposition and that can increase the risk of SAH are those related to lifestyle, such as tobacco and alcohol use, in addition to controllable comorbidities, arterial hypertension, dyslipidemia and diabetes [8]. As for the causes of death resulting from aneurysm rupture, findings in the literature reveal that many of them are related to the patient's own condition, associated with advanced age and comorbidities [9]. When hospitalized, the cause of death is related to the low clinical score in the early assessment, complications during hospital stay and the treatment of this stroke [10].

Recent epidemiological studies have shown that, contrary to the traditional concept, the incidence of SAH increases with age and is predominant in women, however, men are at greater risk of death [11,12]. As for the prevalence of females, hypotheses have been raised relating the decrease in hormonal rate (estrogen) with inhibition of collagen formation, affecting the layers (intima, media and adventitia) of cerebral blood vessels (arteries), which may explain the greater incidence of aneurysm rupture in women [13].

Another factor raised as a possible cause of cerebral aneurysms is the anatomical alterations of cerebral arteries of the Circle of Willis between men and women. The internal diameter of arteries in women is smaller compared to men, which would lead to a greater risk of aneurysm formation in this group [14].

For patients who survive the initial crisis, morbidity is up to 50%. Depression is present in 28.1% cases, significantly related to functional impairment, unemployment and low quality of life. Cognitive deficits can develop in the long term in 27% to 46% of cases, as well as a high prevalence of sleep disturbances [15,16,17], with a mortality rate of 12% before hospital admission and 26% to 40% after treatment, within 30 days [18]. Therefore, the primary strategy is still prevention, given that the etiology of SAH is mainly environmental. However, the implementation of preventive measures in tertiary care are

equally important, since some conditions causing mortality in this environment are still unknown. Thus, the development of accurate care and treatment protocols for patients with SAH in the hospital area is valuable.

In this context, this study aimed to evaluate the epidemiological outcomes in patients with SAH from 2006 to 2018, treated at a referral hospital in southern Brazil, through a predictive equation, based on risk factors, early clinical manifestations, complementary needs, neurological and systemic complications.

II.   METHOD

Data collection was based on secondary data, provided by the hospital, made available through an electronic spreadsheet, without information that would allow the identification of patients, that is, through an electronic spreadsheet containing only the requested data, previously screened by the Information Technology System.

Thus, data were collected from patients for the years 2006 to 2018, totaling 1,680 patients. And after screening, we obtained 148 records of SAH, only residents in the municipality. To achieve the proposed objective, preliminary analyses were performed, such as the calculation of absolute and relative frequencies of demographic, clinical, neurological, evaluative, treatment, topographic and patient outcome variables. Afterwards, the prevalence of risk factors in different outcomes was evaluated, according to the modified Rankin scale. Thus, cross-tabulation and Mann-Whitney U test were used to check for differences in risk factors between outcomes. In this test, value slower than 0.05 for the p-value indicate a statistical difference.

Binary Logistic Regression was also applied; the demographic, clinical, neurological, evaluative, treatment, topographic variables were predictor variables and the death was the dependent variable. In this analysis, the Odds Ratio (OR) allowed to assess the odds ratio that death will occur given a particular predictor variable.

Finally, predictive equations were generated for epidemiological outcomes using binary logistic regression, in which the outcome studied was coded as "1" and the others as "0". This procedure was performed for all outcomes.

To facilitate the analysis and determine equations that could explain the epidemiological outcomes, the Rankin scale was pooled. In this way, instead of seven groups, four were generated. Patients who at the time of hospital discharge were classified as asymptomatic formed group 0 (Asymptomatic), those who presented symptoms without disability or mild disability made up group 1 (Mild Disability); moderate, moderate-severe and severe

disabilities formed group 2 (Severe Disability); and deaths, group 3 (Death).

In relation to risk factors, we sought to verify whether they present a gradual increase in the complexity of outcomes.

To prove this perception, binary logistic regression was applied, with risk factors as independent variables and epidemiological outcomes as the dependent variable. Data were arranged in tables and only significant variables were kept.

The base equation of logistic regression for predicting outcomes is as follows:

$$g(x) = \beta_0 + \beta_1 X_1 + \cdots \beta_n X_n$$

where:

$g(x)$ = epidemiological outcome function

β_0 = constant of the equation

β_1 = coefficient/weight of the variable in the equation

X_1 = independent or predictor variable

To calculate the probability of a certain epidemiological outcome occurring, the result of the equation is used in the following inverse function:

$$E(Y) = \frac{e^{g(x)}}{1 + e^{g(x)}}$$

where:

$E(Y)$ =Probability that the event will occur

e = Euler number with an approximate value of 2.71

The results were presented in tables and descriptive texts.

III. ANALYSIS AND DISCUSSION OF RESULTS

Initially, a lower prevalence of systemic arterial hypertension-SHT was evidenced in the group of asymptomatic patients, which suggests that patients without this comorbidity are 3.7 (OR = 3.771; CI = 1.706 – 8.336; p = 0.001) more likely of not having sequelae at discharge (Table 1).

Regarding severe outcomes, the presence of heart disease increased by 13 times (OR = 13.2; CI = 3.340 – 52.840; p = 0.000) the chances of a patient having moderate, moderate-severe or severe sequelae and in the cases of death, no comorbidity was found associated with this outcome, but it was identified that patients between 41 and 50 years of age are less likely to die (OR = 0.377; CI = 0.153 – 0.934; p = 0.035).

For the outcome of mild disability, it was not possible to generate a predictive equation since no risk factor was significant to discriminate this outcome. This is due to the fact that risk factors have a similar prevalence when comparing patients with mild disability with other outcomes (Table 1). The other risk factors were not discriminating for the complexity of outcomes.

In short, it is reinforced that risk factors are not good predictors of epidemiological outcomes, especially death; but that may suggest more severe outcomes in the presence of SAH and heart disease.

Table 1 – Risk Factors as predictors of epidemiological outcomes

		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B) Lower	Upper	Classification power
Asymptomatic	SHT	-1.327	.405	10.760	1	.001	3.771	1.706	8.336	76.4%
	Constant	-1.792	.300	35.773	1	.000	.167			
Milddisability	Constant	-.554	.171	10.538	1	.001	.574			0%
Severedisability	Heart disease	2.587	.704	13.485	1	.000	13.286	3.340	52.840	87.8%
	Constant	-2.181	.282	59.851	1	.000	.113			
Death	41-50years	-.975	.462	4.447	1	.035	.377	.153	.934	73.6%
	Constant	-.768	.214	12.907	1	.000	.464			

Note: S.E- Standard error; df-Degree of freedom; Sig-significance; Exp(B)-Odds Ratio.
Source: Analysis result

Regarding the early clinical manifestations of the patient at the time of admission to the emergency room, sensory impairment, torpor and syncope can determine, with limitations, the epidemiological outcomes.

According to Table 2, sensory impairment had a negative relationship with the asymptomatic group. This means that the presence of sensory impairment at the time of hospital admission reduces the chances of the patient

being discharged from the hospital without sequelae (OR = 0.218; CI = 0.084 – 0.556; p = 0.002).

Similarly, patients who were intubated in the emergency room are less likely to be asymptomatic at the time of hospital discharge, since it is the most important variable characterizing asymptomatic patients. In addition, a descriptive analysis indicated that all patients with this outcome were not intubated in the emergency room. In other words, intubation in the emergency room reduces the chances of patients leaving asymptomatic at hospital discharge by 100%.

As for mild disability, the presence of sensory impairment also decreased the chances of belonging to this outcome (OR = 0.458; CI = 0.225 – 0.933; p = 0.031). Comparing the outcomes, the prevalence of sensory impairment in the mild disability group was higher than in the asymptomatic group.

Severe outcomes were characterized by the occurrence of torpor upon hospital admission. This event

increased by 4 times (OR = 4.143; CI = 1.344 – 12.774; p = 0.013) the chances of the patient having significant sequelae at discharge.

Patients who were admitted conscious were less likely to die (OR = 0.060; CI = 0.006 – 0.635; p = 0.019), but the presence of sensory impairment (OR = 4.305; CI = 1.869 – 9.914; p = 0.001) and syncope (OR = 2.267; CI = 0.992 – 5.177; p = 0.052) contributed to this outcome. It is noteworthy that syncope did not reach statistical significance (p>0.05), but was included in the model as the third most important variable. This condition indicates that syncope represented a predictor for the studied sample, but it may not be a predictor if tested in other samples.

In summary, patients without sensory impairment were more likely to have mild outcomes, and non-intubation may contribute to discharge without sequelae. Patients with torpor were more likely to have severe outcome, while sensory impairment and syncope were more favorable to death.

Table2 – Early clinical manifestations as predictors of epidemiological outcomes.

		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I. para EXP(B)		Classification power
								Lower	Upper	
Asymptomatic	ER Intubated	-19.619	9054.796	.000	1	.008	.000	.000	.	76.4%
	Sensoryrelegation	-1.232	.495	6.194	1	.013	.292	.111	.770	
	Constant	-.640	.229	7.778	1	.005	.527			
Milddisability	Sensoryrelegation	-.780	.363	4.627	1	.031	.458	.225	.933	63.5%
	Constant	-.254	.216	1.383	1	.240	.776			
Severedisability	Torpor	1.421	.574	6.121	1	.013	4.143	1.344	12.774	86.5%
	Constant	-2.115	.283	55.856	1	.000	.121			
Death	Sensoryrelegation	1.460	.426	11.761	1	.001	4.305	1.869	9.914	75.7%
	Syncope	.818	.421	3.770	1	.052	2.267	.992	5.177	
	Conscious	-2.806	1.200	5.466	1	.019	.060	.006	.635	
	Constant	.565	1.195	.223	1	.636	1.759			

Note: S.E- Standard error; df-Degree of freedom; Sig-significance; Exp(B)-Odds Ratio.
Source: Analysis result

With regard to neurological complications, there was a low prevalence of vasospasm in the asymptomatic group (OR = 0.302; CI = 0.129 – 0.706; p = 0.006) and absence of cerebral edema and hydrocephalus. According to Table 3, only vasospasm was significant, but the other two variables were selected as important since there were no cases of cerebral edema and hydrocephalus among asymptomatic patients. These results should be analyzed with caution, as they may be a characteristic of the study sample and not of the population of patients with SAH.

In the case of mild disability, low occurrence of rebleeding was a characteristic of this outcome. Patients who had rebleeding were less likely to be discharged without significant sequelae (OR = 0.158; CI = 0.020 – 1.274; p = 0.083).

For severe disabilities, patients with vasospasm (OR = 3.733; CI = 1.134 – 12.289; p = 0.030) and hydrocephalus (OR = 12.613; CI = 3.252 – 48.919; p = 0.000) were more likely to have this outcome.

In summary, asymptomatic patients with mild

disabilities were found to have no episodes of vasospasm, hydrocephalus, cerebral edema, and rebleeding. As for the severe outcomes, vasospasm and hydrocephalus were

prevalent neurological complications. And in cases of death, rebleeding and ischemic injury seem to be determinant for this outcome.

Table 3 – Neurological complications as predictors of epidemiological outcomes

		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I. for EXP(B)		Classification power
								Lower	Upper	
Asymptomatic	Cerebral Edema	-20.157	11103.42	.000	1	.999	.000	.000	.	76.4%
	Hydrocephalus	-20.539	9765.012	.000	1	.998	.000	.000	.	
	Vasospasm	-1.197	.433	7.647	1	.006	.302	.129	.706	
	Constant	41.501	14786.53	.000	1	.998				
Milddisability	Rebleeding	-1.842	1.063	3.001	1	.043	.158	.020	1.274	63.5%
	Constant	1.382	1.106	1.561	1	.212	3.981			
Severedisability	Hydrocephalus	2.535	.692	13.434	1	.000	12.613	3.252	48.919	87.2%
	Vasospasm	1.317	.608	4.694	1	.030	3.733	1.134	12.289	
	Constant	-6.884	1.611	18.266	1	.000	.001			
Death	Ischemicinjury	1.929	.607	10.105	1	.001	6.885	2.095	22.624	77.7%
	Rebleeding	1.873	.675	7.704	1	.006	6.506	1.734	24.414	
	Constant	-5.234	1.074	23.750	1	.000	.005			

Note: S.E- Standard error; df-Degree of freedom; Sig-significance; Exp(B)-Odds Ratio.
Source: Analysis result

In relation to complementary needs, which refer to the use of materials and equipment that patients used during hospitalization, in the group of patients with asymptomatic outcomes (Table 4), there was a low prevalence of use of urinary catheter (UC). In other words, patients using UC had a low chance of being discharged without sequelae (OR = 0.035; CI = 0.010 – 0.124; p = 0.000). In addition, none of the patients with an asymptomatic outcome used Nasoenteral Tube (NET), tracheostomy, gastrostomy, mechanical ventilation or required intubation and decompressive craniectomy. However, they did not obtain statistical significance to explain the outcome.

In the group of patients with mild disabilities (Table 4), there was an occurrence of UC use, but less frequently than in groups with severe disability and death. Also in this group, most patients did not use mechanical ventilation. The use of mechanical ventilation reduced by 85.2% the chances of the patient being discharged without significant sequelae (OR = 0.148; CI = 0.053 – 0.412; p = 0.000).

Regarding patients with severe outcomes, the use of NET and tracheostomy were determinant for sequelae. Thus, the use of NET (OR = 5.913; CI = 1.201 – 29.113; p = 0.029) increased the chances of the patient having severe sequelae by almost six times, while tracheostomy (OR = 4.107; CI = 1.360 – 12.407; p = 0.012) increased this chance by four times.

Finally, for the cases of death, the use of NET and mechanical ventilation represented predictors for this outcome. It appears that NET increased the chances of death by 6.6 times, compared to those who did not use it (OR = 6.688; CI = 1.085 – 41.236; p = 0.041); and that mechanical ventilation increased this chance by 7.5 times (OR = 7.489; CI = 1.864 – 30.095; p = 0.005).

In general, patients who did not use UC and mechanical ventilation were likely to have asymptomatic outcomes and mild disability. The use of NET and tracheostomy can lead to severe outcomes. The criticality for death lies in the combination of the use of NET and mechanical ventilation.

Table 4 – Needs as predictors of epidemiological outcomes

		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I. for EXP(B)		Classification power
								Lower	Upper	
Asymptomatic	SV	-3.340	.640	27.271	1	.000	.035	.010	.124	77%
	Constant	3.372	.774	18.960	1	.000	29.125			
Milddisability	SV	1.041	.501	4.320	1	.038	2.832	1.061	7.561	68.2%
	Mechanicalventilat	-1.913	.523	13.361	1	.000	.148	.053	.412	
	Constant	.495	.604	.672	1	.412	1.640			
Severedisability	NET	1.777	.813	4.775	1	.029	5.913	1.201	29.113	86.5%
	Tracheostomy	1.413	.564	6.273	1	.012	4.107	1.360	12.407	
	Constant	-6.716	1.493	20.226	1	.000	.001			
Death	NET	1.900	.928	4.192	1	.041	6.688	1.085	41.236	76.4%
	Mechanicalventilation	2.013	.710	8.050	1	.005	7.489	1.864	30.095	
	Constant	-7.589	1.495	25.781	1	.000	.001			

Note: S.E- Standard error; df-Degree of freedom; Sig-significance; Exp(B)-Odds Ratio.

Source: Analysis result

Finally, when analyzing the clinical complications, in the asymptomatic group, fever may have a predictive power (Table 5), although less prevalent than in mild, severe outcomes and deaths. Thus, fever reduced the chances of a patient being discharged without sequelae (OR = 0.054; CI = 0.007 – 0.407; p = 0.005).

For patients with mild disability, the absence of pneumonia and the presence of polyuria seem to characterize this group. Patients with pneumonia were less likely to have mild disabilities (OR = 0.073; CI = 0.008 – 0.634; p = 0.018), while patients with polyuria were four times more likely to have this same outcome (OR = 4.034; CI = 1.137 – 14.316; p = 0.031).

Based on the records (Table 5), severe disabilities were marked by the presence of aspiration pneumonia and hyperglycemia. Aspiration pneumonia increased the chances of serious outcomes by 4 times (OR = 4.137; CI = 1.142 – 14.988; p = 0.031), a chance similar to patients with hyperglycemia (OR = 4.474; CI = 1.577 – 12.697; p = 0.005).

Finally, sepsis can increase the chances of death by 20.4 times (OR = 20.413; CI = 4.103 – 101.548; p = 0.000) and fever by 3.6 times (OR = 3.656; CI = 1.557 – 8.583; p = 0.000). It is noteworthy that all hypotensive patients with hemodynamic instability died.

In general, patients with asymptomatic outcomes did not present clinical complications. Those with mild disability had polyuria; the severe patients had aspiration pneumonia and hyperglycemia and the death cases had fever and sepsis.

Table 5 – Clinical complications as predictors of epidemiological outcomes

		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I. for EXP(B) Lower	Upper	Classification power
Asymptomatic	Fever	-2.925	1.033	8.009	1	.005	.054	.007	.407	76.4%
	Constant	-.764	.208	13.543	1	.000	.466			
Milddisability	Aspiration pneumonia	-2.624	1.106	5.625	1	.018	.073	.008	.634	
	Polyuria	1.395	.646	4.659	1	.031	4.034	1.137	14.316	65.5%
	Pneumonia	-1.535	.659	5.422	1	.020	.215	.059	.784	
	Constant	-.361	.200	3.262	1	.071	.697			
Severedisability	Hyperglicemia	1.498	.532	7.928	1	.005	4.474	1.577	12.697	85.8%
	Aspiration pneumonia	1.420	.657	4.675	1	.031	4.137	1.142	14.988	
	Constant	-2.840	.447	40.359	1	.000	.058			
Death	Fever	1.296	.435	8.865	1	.003	3.656	1.557	8.583	
	Sepsis	3.016	.819	13.577	1	.000	20.413	4.103	101.548	79.7%
	Constant	-1.769	.280	39.867	1	.000	.170			

Note: S.E- Standard error; df-Degree of freedom; Sig-significance; Exp(B)-Odds Ratio.

Source: Analysis result

With the information listed from the generation of predictive models by group of variables, it was possible to construct a summary box of the characteristics of each epidemiological outcome.

Table 6–Synthesis of clinical characteristics of epidemiological outcomes.

	Asymptomatic	**Milddisability**	**Severedisability**	**Death**
Risk factors	(-) SHT		(+) Heart disease	(-) 43 to 50 years
Early manifestations	(-) Sensoryrelegation (-) Intubation	(-) Sensoryrelegation	(+) Torpor	(-) Conscious (+) Syncope (+) Sensoryrelegation
Neurological complications	(-) Vasospasm (-) Hydrocephalus (-) Cerebral edema	(-) Rebleeding	(+) Hydrocephalus (+) Vasospasm	(+) Ischemicinjury (+) Rebleeding.
Needs	(-) UC	(+) UC (-) Mechanical ventilation	(+) NET (+) Tracheostomy	(+) NET (+) Mechanical ventilation
Clinical complications	(-) Fever	(-) Pneumonia (-) Aspiration pneumonia (+) Polyuria	(+) Hyperglicemia (+) Aspiration pneumonia	(+) Sepsis (+) Fever

(+) indicates the presence or higher prevalence and (-) indicates the absence or lower prevalence

IV. FINAL CONSIDERATION

The considerations of this study lie on two aspects: health development and promotion; and protocols in hospital care. For the first aspect, one must take into account the demographic data that are related to risk factors for aneurysm. Thus, it is suggested the development of prevention strategies and health education programs for greater adherence to the treatment of chronic diseases. And for the Municipal Health Department, to provide

sociodemographic data and risk factors characterizing patients with aneurysm in order to create prevention and screening strategies based on the phenotype raised.

For the second aspect, the development of proper care and treatment protocols for patients with SAH, as well as professional skills in the scope of tertiary care regarding the performance of screening, procedures and techniques.

With regard to the limitation of the present study, it is worth noting that data of this research come from medical records and the information collected such as risk factors, early manifestations, neurological and clinical complications, needs and outcomes were treated in a dichotomous way, which limits the possibilities of analysis and interpretations.

REFERENCES

[1] Ekker, M. S.; Boot, E. M.; Singha, A. B (2018). Epidemiology, etiology, and management of ischemic stroke in young adults.The Lancet Neurology, 17(9):790-801.

[2] Rabinstein, A.A.; Lanzino, G (2018). Aneurysmal subarachnoid hemorrhage: unanswered questions. Neurosurgeon. Neurosurgery Clinics of North America, 29(2): 255-262.doi: 10.1136 / jnnp.2006.112730.

[3] Rodríguez, L F.; Pujol Lereis, V.; Ameriso, S (2013). Mortalidad intrahospitalaria por accidente cerebrovascular. Medicina (Buenos Aires), 73(4):331-334.

[4] Rinkel, GJ.; Algra, A(2011). Long-term outcomes of patients with aneurysmal subarachnoid haemorrhage. The Lancet, 10(4):349-356.

[5] Fountas, K. N. (2012). Serum and cerebrospinal fluid C-reactive protein levels as predictors of vasospasm in aneurysmal subarachnoid hemorrhage. Clinical article. Neurosurg. Focus, United States, v. 26, n. 5, E22.

[6] Balami, J. S.; Buchan, A. M (2012). Complications of intracerebral haemorrhage. The Lancet Neurology, 11(1):101-118.

[7] Brisman, J.L; Song, J.K.; Newell, D.W (2006). Cerebral Aneurysms. New England Journal of Medicine, 355(9):928-939.

[8] Tatlisumak, T.; Cucchiara, B.; Kuroda, S (2018). Nontraumatic intracerebral haemorrhage in young adults. Nature Reviews Neurology, 14(4):237-250.

[9] Lantigua, H.; Ortega-Gutierrez, S.; Schmidt, J. M (2015). Subarachnoid hemorrhage: who dies, and why? Critical Care,19(1):309.

[10] Suwatcharangkoon, S.; Meyers, E.; Falo, C (2015). Loss of consciousness at the onset of subarachnoid hemorrhage as an important marker of early brain injury. JAMA Neurology, 23(12):30-33.
<https://www.mdedge.com/neurology/article/104724/stroke/loss-consciousness-predicts-worse-outcomes-   after-subarachnoid>

[11] Aigner, A.; Grittner, U.; Rolfs, A (2017). Contribution of Established Stroke Risk Factors to the Burden of Stroke in Young Adults. Stroke, 48(7):1744-1751.

[12] Rosi Júnior, J.; Telles, J. P. M.; Silva, S. A.; Iglesio, R. F.; Brigido, M. M(2019). Epidemiological analysis of 1404 patients with intracranial aneurysm followed in a single Brazilian institution. Surgical Neurology International, 10(249).

[13] Holzapfel, G.A; Gasser, T.C.; Ogden, R.W.A (2000) New constitutive structurefor arterial wallmechanics and a comparative study of material models. Journal of Elasticity, 61 (13): 1-48.doi: 10.1023 / to:1010835316564

[14] Ghods, A. J.; Lopes, D.; Chen, M (2012). Genderdifferences in cerebral aneurysmlocation. Frontiers in Neurology, 3:78.<https://www.frontiersin.org/articles/10.3389/fneur.2012.00078/full9>

[15] Labovitz, D. L.; Halim, A. X.; Brent, B (2006). Subarachnoid hemorrhage incidence among Whites, Blacks and Caribbean Hispanics: the Northern Manhattan Study. Neuroepidemiology, 26(3):147-150.

[16] Rinkel, G.J.; Algra, A (2011). Long-termoutcomes of patients with an eurysmalsubarachnoidhaemorrhage. The Lancet, 10(4):349-356.

[17] Al-Yassin, A; Ouyang, B.; Temes, R (2017). Depression and anxiety after aneurysmal subarachnoid hemorrhage are associated with highersix-monthunem ploymentrates. The Journal of Neuropsychiatry and Clinical Neurosciences, 29(1):67-69.

[18] De Rooij, N. K.; Linn, F. H. H.; Van Der Plas, J. A. (2007). Incidence of subarachnoidhemorrhage: a systematic review with an emphasison trends in the region, age, gender and time. Journal of Neurology, Neurosurgery, and Psychiatry, 78(12):1365-1372.

Study Comparison of the Efficiency of a Photovoltaic System with Fixed Panels and with Solar Tracker in the Northwest of Brazil

Rodrigo Machado Cavalcanti[1], Elissandro Monteiro do Sacramento[2], Lutero Carmo de Lima[3], Natasha Esteves Batista[4]

[1]Centro de Ciências e Tecnologia Universidade Estadual do Ceara´ Fortaleza, CE, Brazil
E-mail: rodrigo.cavalcanti@aluno.uece.br
[2]Instituto Federal de, Educação Ciência e Tecnologia-IFCE Fortaleza, CE, Brazil
E-mail: elissandro.monteiro@ifce.edu.br
[3]Centro de Ciências e Tecnologia
Universidade Estadual do Ceara´ Fortaleza, CE, Brazil
E-mail: lutero.lima@uece.br
[4]Departamento de Engenharia Elétrica Universidade Federal do Ceara Fortaleza, CE, Brazil
E-mail: natashaestevesbatista@gmail.com

Abstract— The performance of small photovoltaic (PV) systems connected to the grid in the state of Ceará is analyzed in this study. Three systems were developed, two of them with fixed angles of 18 and 22 degrees and one with a variable angle (solar tracker), which provided different results of generation efficiency, all of them have the same power of 2310 kW installed and are located on a building slab in the city of Fortaleza, in this configuration the systems have the same inputs to compare. The variation in generation efficiency be-tween systems is quite significant, reaching 19% between fixed and 27% when compared the worse fixed system and solar tracker, the higher costs for these types of system with tracker can increase the rate of return on investment turning into 2.9 years, higher than that of the fixed system with an angle of 22, which was 2.38 years.

I. INTRODUCTION

The source of energy is divided into non-renewable energy or known as conventional energy and renewable energy. Non-renewable energy is defined as an energy source that cannot be recreated in a short period of time, such is coal, natural gas and oil. Renewable energy is another type of energy that has unlimited sources, such as hydropower, solar energy, biomass energy. etc.

The capacity to generate renewable energy is intensified each year through global warming. The trends in the use of this type of energy only tend to increase, with this the Government of the State of Ceará in 2019, launched the first and only hybrid atlas (wind and solar) in Brazil, this document has technical information aimed at professionals in the sector, identifying the best regions in the state to invest. Having a better idea of the best areas of solar and wind generation, with the numerical potentials such as wind speeds and solar radiation indices throughout the state of Ceará. [1]

The solar energy produced by the sun as call solar photovoltaics energy, this type of energy is divided in two categories. The first one is centered energy (solar power farms) the state of Ceará occupied the fifth place on country raking of state in 2021 with the production of 2951.6 MW. The second category is distributed energy (residential, rural, industry and commercial places), that is

characterized by possibility to produce your own energy. The state has tenth place on country state ranking on 2021 with the production of 239.3 MW. As we know this amount is far way from the state potential. [2]

Taking this in consideration, this paper has focus in category distributed energy to increase the efficiency in around 15% reducing the payback time to less than three years. [3]

Justification

Due to the high capacity of the solar energy generation farms in state of Ceará and only a few places in the country have this solar irradiation. It is expected that with the use of small sized solar trackers, solar farms will have a large generation capacity per hectare, with this characteristic the generation curve would be more stable throughout the day. This work is justified by the prediction of reduced damage to

the environment, in addition to increasing the efficiency of solar photovoltaic generation, making applications in small distributed generation more viable.

Objectives

The general objective of this work is to compare the efficiency between a fixed photovoltaic system and one with a horizontal tracker, taking into account the gain in generation per area and costs.

The specific objectives of this study are:

1. Analyze the data of the Fortaleza resources stations (Fuceme and Solcast);

2. Develop an automatic control system for solar tracker;

3. Compare performance of the solar tracker system with the fixed system;

4. Calculate the systems(tracker and fixed) paybacks.

II. EFFICIENCY STUDIES ABOUT PHOTOVOLTAICS SYSTEMS

The studies of PV systems have increase each year by academics and companies that aim to improve higher capacity systems. The most compared set-ups are shown in the options below:

1. Between angles of each PV.

2. Direction of then PV.

3. Location on the Earth.

4. Compare between tracker and fixed system efficiency.

This article approach is related to the topic fourth. To improve both systems finding the best fixed angle and also compare what is the best system from a financial point of view.

In [4] a comparison between a fixed system of 38 degree inclination and a tracker, is made in Greece. The results yearly production was significant, 24.68% more efficiency on the tracker system. [4]

A experiment in Indonesia compare 2 systems one fixed solar panels in a angle of 15 degrees with a solar tracker. The results showed the power output of solar trackers does not in-crease compare with the fixed system. The conclusion was that have some loss with the power in the actuator and the average capacity factor was 9.6% and the final yield percentage was 2.37%. [5]

Empirical studies were made too reviewing various methods of solar tracking, with gains in energy due to tracking and different MPPT algorithms. Results found that the active trackers were more commonly used when compared to passive trackers. Among the active trackers it was found that, the maintenance issues related to dual axes active trackers is irrelevant to maximize the efficiency of the PV system and allows controlled and competent collection and distribution of energy. The review further concludes that the increase in gain due to active tracking is approximately 30% with respect to the fixed system. [6]

One of the primary reasons of PV tracking systems is to improve the low efficiency of PV modules and consequently, the lower generation of electrical energy. Improvement in photovoltaic tracking systems can be made by using PV systems with concentrating mirrors (CPV) and photovoltaic/thermal hybrid systems (PV/T). Each of these systems has the potential to increase the yield of electrical energy. A fixed system compare to a system that has tracker and mirrors can have efficiency improved up to 22-56%. [7]

Some studies compare fixed PV and double axis tracker in the same latitude have an improvement of 30.79% yearly. Using crystalline silicon PV, the differences between single and doubles axis were estimated and varied around 5%. [8]

In the University of Ceará a study was developed regarding the calculus of the potential of generation in the state. The results showed that the total energy production during the measured period was 3708.2 kWh and the nominal energy production was 1685.5 kWh / kWp, showing a great potential of energy production that can be explored. [9]

III. MATERIALS AND METHOD

Material

The system will have the following items installed:

1. Two systems with seven solar panels in each of the fixed

generation system. The panels are from Canadian So-lar brand model: 6S6U-330P and two solar inverters Ecosolys Ecos 2000 Plus.

2. One photovoltaic system with solar tracker (linear shifter), that has linear movement seeking greater performance (500 mm x 750 N linear actuator). This sys- tem has a inverter Ecosolys Ecos 3000 and 7 Canadian Solar panels model: 6S6U-330P.

3. One electrical panel for the system solar tracker movement (own manufacturing). Is a electronics PCB was made with the following components LM7805,LM393N, LDR, Transistor BC327.

Data irradiation collection

The irradiation data use on the project was collect on the Fuceme PCD installed on the University of Ceará that is 14 km from the FV system and the temperatures were use the data from the station of Fuceme in Praia do Futuro that is 4 km from the PV system. In the Figure 1 are the values collected on the PCDs from Fuceme and also include the in-formation from Solcast website to validate the results. The method use from the is type meteorological year and the results were very similar to the collecting stations.

Method

Many studies have develop renewable energy and give effort in finding the optimum method to harness the energy, one of the discussing is tilt angle on PV panels. The ability of solar farms to produce energy is very dependent on the intensity of irradiance and duration of sun exposal on the PV panel [10]. The current technology for a PV system is installing actuators on the panel so can follow the direction of the sunlight, this is the system mentioned on topic 3.1 subtopic 2.

Month/Year	Temperature (C°) Fuceme Praia do futuro	Fuceme Uece irradiation kw/m2	Solcast irradiation kw/m2
Dec-20	28.27	180.56	184.02
Jan-21	25.41	165.73	168.50
Feb-21	28.15	153.03	153.80
Mar-21	27.57	141.30	141.83
Apr-21	28.14	163.39	163.38
May-21	27.44	142.78	146.03
Jun-21	27.82	156.36	159.82
Jul-21	27.38	168.88	172.71
Aug-21	27.13	197.67	194.63
Sep-21	27.46	198.03	195.169

Fig. 1. Irradiation and temperature data.

There is a fixed angle solar generation system shown in Figure 2 which is connected to 2 kw ecosolys inverters, these data are compared with each other and with the other system, the solar tracker showns in Figure 3 (this movement is done through a mobile system with

linear shifter) is connected to a 3 kW Ecosolys inverter, the system has the samepanels power as the others.

Fig. 2. Fixed systems of the roof of the building.

The inverters manufacturer has its own application, to which one of the inverters connects via the internet to the manufacturer's server keep the records of generation daily, monthly and annually. This provides accurate information on the system's generation data.

Fig. 3. System with Tracker.

IV.   MAIN EQUATIONS

Energy output

The total energy output is given by the total generation of power by the system over a given period of time. The monthly energy produced can be determined by the Equation1:

$$E_{AC,m} = \sum_{h=1}^{N} E_{AC,h}$$

(1)

System efficiencies

The system efficiency can be PV array efficiency and system efficiency. Depending of the time resolution it can be hourly, daily, monthly or annually, in the project case was used monthly. The array efficiency is η_{PV} , is giving by the formula 2, where P_{PV} is the power of each solar panel has the power of 330 watts each (330*7 panels) / 1000, Y_{PV} is the monthly read values of radiation readied in (KWh/m^2/month), [11] Y_R is the power generated of the sys-tem and A_{PV} is the area of this system in square meter. As can be seen in Figure 4. [12]

3.3.1 Payback

In the figure 10 has the payback data table with the values of the three systems. To convert the values of money in

$$\eta PV = \frac{100.P_{PV}.Y_{PV}}{Y_R.A_{PV}}$$

(2)

dollars was used the exchange rate of one dollar to R$ 5,60 reais. The interest rate of the energy values was 10% per year in the first 4 years gave the U$0,17 per kilowatt. This value

The performance of all system installed is given by the formula number 3.

was multiply per total yearly production and divided by the investment in each system giving the payback in years.

$$\eta sys = \frac{100.E_{CA}}{H.A_{PV}}$$

(3)
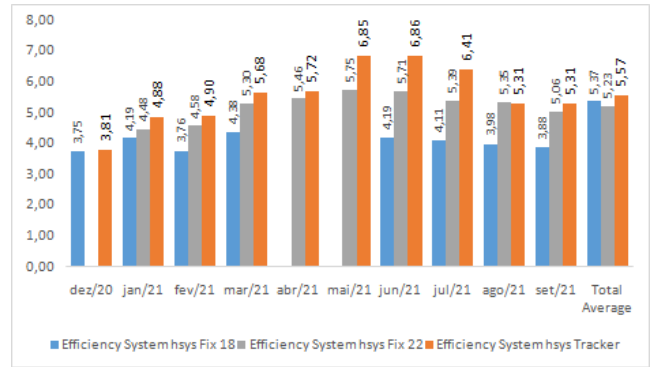
Fig. 4. Efficiency of the System.

Performance ratio

The performance ratio (PR) is showed in Figure 5 the calculus of this system indicates a overall effect of losses on a PV array´s normal power output. The PR values show how close the value is to the optimal performance during real operation and allows a comparison of PV systems independent of location, tilt angle, orientation and their nominal rated capacity. The PV system efficiency is compared with the nominal efficiency of the photovoltaic generator under standard conditions. Performance ratio is defined as the ratio of the final energy yield of the PV system Y_F to the reference yield Y_R: [13]

Month/Year	Performance Ratio - Fix 18	Performance Ratio - Fix 22	Performance Ratio - Tracker
dez/20	50,99	0,00	51,88
jan/21	56,96	61,04	66,47
fev/21	51,23	62,40	66,71
mar/21	59,60	72,20	77,28
abr/21	0,00	74,32	77,87
mai/21	0,00	78,22	93,17
jun/21	57,04	77,77	93,39
jul/21	55,87	73,29	87,25
ago/21	54,13	72,79	72,21
set/21	52,80	68,85	72,24
Anual average	**73,10**	**71,21**	**75,85**

Fig. 5. Performance Ratio.

V.   CHANGES AND PRESENTED DIFFICULTIES

There were some problems in the inverters of this manufacturer's line. Because they are in process of guaranteed, the factory requires that the equipment has to be sent for re-pair on site, which is 4815 km away from where the system is installed. For this reason, there were two months that fixed angle system was unread, decreasing the history of collected data. In this process, the Ecososys 2 K brand Inverters ended up having their versions updated, to the Ecos 2 K+ version, with electronic improvements.

It is noteworthy that the inverter that was connected

to the solar tracker system did not show any damage during the months of data collection (from December 2020 to September 2021).

VI. RESULTS AND DISCUSSION

Taking into account the efficiencies of fixed solar generation systems have a loss of 15 to 25% of power, the objective is to reduce this loss and also reduce the investment required to purchase a solar generation system.

Three systems were assembled, two fixed with different angles and one with a tracker. The data collection prove the real efficiency percentage of the system.

The project's goal is a maximum payback of 4.0 years, taking into account the KW value of 0.17 dollars/KW. As show in the Figure 10 the systems had values with less the 3 years payback.

Results obtained

The fixed system 01 has an angle of 18 degrees, the fixed system 02 has an angle of 22 degrees and one tracking system has a horizontal movement of 1 axis as shown in Figure 3, all facing north.

4.1 Capacity Factor

$$PR = \frac{100.Y_F}{Y_R}$$

(4)
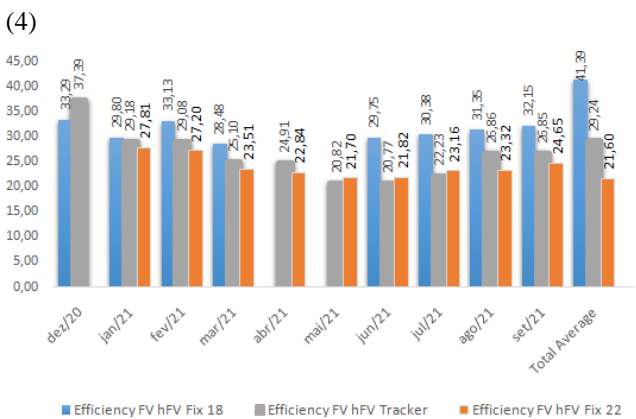
Fig. 6. *Efficiency of the arrangement.*

The capacity factor is used to present the energy delivered by an electric power generating system is defined as the ratio of AC energy produced by the PV system over a period of time, to the energy output that would have been generated if the entire period. [14]

Tracking generation system data was collected from December 2020 to September 2021, also inside the rainy sea- son, this was considered for the percentage analysis because both are in the same location. The system with a tracker in compared to the fixed system of 18 degree

produces 27% and

$$CF = \frac{EAC}{P_{PV}.8760}$$

(5)

between tracker and system with 22 degree produces 10% more as shown in Figure 10.

This shows that the direction angle at which the panels are mounted is essential for the system's energy result, as this small monthly difference is crucial for the medium-term return of the investment.

The Figure 7 shows the average monthly of radiation of the three systems in KWh/m^2/month , from December 2020 to September 2021. The irradiation varied between 180,56 kWh/m^2 in December 2020 to 198,03 kWh/m^2 in September 2021. The lowest month of radiation was May 2021.

Fig. 7. *Monthly energy production of each system and in-plane irradiation.*

VII. CONCLUSIONS

Regarding the production of each system the fixed with 18 degrees was 2904 kwh/year, fixed with 22 degrees was 3576 kwh/year and the system with tracker was 3953 kwh/year, is a good producing average to the systems com- paring to the radiation level on the same period.

Figure 8 represent the efficiency of the PV module and also the efficiency of the systems, this values vary between each system, the fixed 18 degree has values between 29,75% to 33,29 % for PV efficiency and the system efficiency vary between 3,75% to 4,38%, the fixed 22 degree has values be-tween 21,70% to 27,81% for PV efficiency and the system efficiency vary between 4,48% to 5,75 %, the tracker PV efficiency has values between 20,77% to 37,39% for PV efficiency and the system efficiency vary between 3,81% to 6,86%. This values represent the result of the energy produced in each system considering the climate of the region showing the months between December to March the worse ones because is the raining season on Ceará. Figure 9 shows capacity factor of all system shows the result of position and the angle of each system can have different results for the so- lar power

generation. Figure 1 fixed system has 22 degrees produces 19% more energy compared to fixed system 18 degrees, this shows that with a simple study, a better earning results can be obtained simply by better calibrating the angle of incidence, it is clear that this is not a simple reality for the majority, of the distributed generation installations that we have installed in the state of Ceará. The vast majority of them are roof installations and not on slabs or ground, thus making the adjustment of angle difficult, but at the same time it leaves the gap for analysis in places that they have space for installation on the ground, like farms in the interior of the state, that have distributed generation, which they end up supplying through discounted credits on the bills of customers residences who live in cities, making better use of the land in the interior of the state.
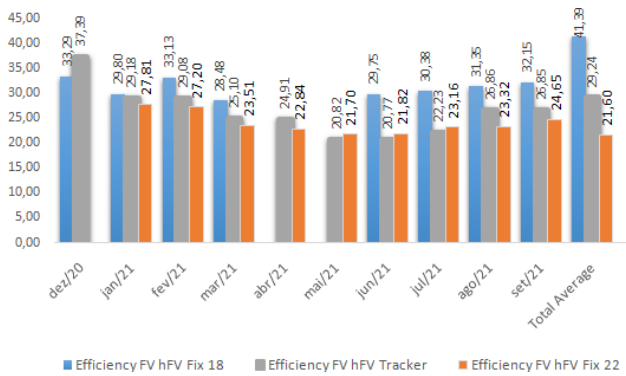
Fig. 8. Efficiency of the systems.

Month/Year	Capacity factor fixed 18	Capacity factor fixed 22	Capacity factor Tracker
dez/20	40%	0%	41%
jan/21	41%	44%	48%
fev/21	34%	41%	44%
mar/21	36%	44%	47%
abr/21	0%	53%	55%
mai/21	0%	48%	58%
jun/21	39%	53%	63%
jul/21	41%	54%	64%
ago/21	46%	62%	62%
set/21	45%	59%	62%
Anual average	27%	51%	54%

Fig. 9. Capacity Factor.

Opens the discussion regarding developing projects of new structures that can be install in roofs with the possibility of adjusting the angle.

Also was installed a trackers system with a additional cost of 350 dollars that has a solar follower, as seen in figure 2, with 2 kw peak power system, but which generates an extra 10% compare to the system of 22 degree is best fixed angle system. So we can make the

following calculations seen in figure 10.

Based on the results presented in figure 10, it can be seen that the additional cost to install a system with a solar tracker ended up generating an additional value in this case that was not higher then financial value generated for energy in the scale of 10%, thus the system with the follower ended up having a payback time superior to the 22 degree system, being economically more profitable only after 2.90 years, a new system that requires less maintenance. It is worth high-lighting the search for the perfect fixed angle and position of the panels that best adapt for each region, it can bring great results without raising costs, reducing the return on investment in up to 6 months.

All the three proposed systems have a good performance, but they have different prices of installation and power generation, as was seen on the results, with the numbers the more profitable project for short scale is the one with less payback in years, is the one with fixed angle of 22 degree, but also open the door to analyze structures the can have a little adjustment of angle and be install in roofs to get better results with lower investments.

Description	Fixed (18°) KW/Year	Fixed (22°) KW/Year	Tracker KW/Year
Anual Generation	2904.2	3576.8	3953.04
Annual interest rate	10.0%	10.0%	10.0%
Value of the Kw	$0.17	$0.17	$0.17
Savings in a yead	$487.49	$600.39	$663.55
Costs of each system	$1,428.57	$1,428.57	$1,571.43
Aditional cost	$0.00	$0.00	$350.00
Total cost system	$1,428.57	$1,428.57	$1,921.43
Payback investment in years	2.93	2.38	2.90

Fig. 10. Pay back of the systems

REFERENCES

[1] CEARA, G. E., 2020. Atlas do Eolico Solar do estado do Ceara. See also URL https://www.ceara.gov.br/.

[2] ABSOLAR,2021. Associacao Brasileira de Energia Solar Fotovoltaica. See also URL https://www.absolar.org.br/mercado/.

[3] GURGEL VIEIRA, R.", 2014.". In Tese Analise comparative do desempenho entre um painel solar estatico e com rastreamento no município de Mossoro-RN.

[4] V.Perraki, and Megas, L., 2016. Single axis tracker versus fixed tilt pv: Experimental and simulated results, Department of Electrical and Computer Engineering, Greece.

[5] Herdian Wibowo, Yohandri Bow, C. R. S., 2021. Performance comparison analysis of fixed and solar-tracker installed panel at pv system, Departament of Renewable Energy Engineering, Politeknik Negeri Sri-wijaya.

[6] Sumathi, V., and Jayapragasha, R., 2019. Solar tracking methods to maximize pv system output – a review of the

methods adopted in recent decade, School of Electrical Engineering, VIT University, Chennai Campus, India.

[7] Seme, S., and Štumberger, B., 2020. Solar photovoltaic tracking systems for electricity generation, Faculty of Energy Technology, University of Maribor, Slovenia.

[8] Eke, R., and Senturk, A., 2012. Performance com- parison of a double-axis sun tracking versus fixed pv system, Mugla Sıtkı Kocman University, Clean Energy Research Development Centre, Turkey.

[9] De Lima, L. C., and de Araújo Ferreira, L., 2017. Performance analysis of a grid connected photovoltaic sys tem in northeastern brazil, Mestrado Acadêmico em Ciências Físicas Aplicadas, Universidade Estadual do Ceará, Brazil.

[10] Kurniawan. A., Taqwa A., 2019. PLC Aplication as an Automatic Transfer Switch for on-grid PV System. See also URL https://doi.org/10.1088/.

[11] Adaramola MS, V. E., 2016. Preliminary assessment of a small-scale rooftop pv-grid tied in norwegian climatic conditions., Climate and Average Weather Year Round in Fortaleza.

[12] Sharma V, C. S., 2013. Performance analysis of a 190 kwp grid interactive solar photovoltaic power plant in india, Centre for Energy and Environment, National In- stitute of Technology.

[13] Ozden T, Akinoglu BG, T. R., 2016. Long termout- door performance of three different on-grid pv arrays in central anatolia, Electrical and Electronics Engineering, Gümüşhane University, Turkey.

[14] Elhadj Sidi CEB, Ndiaye ML, B. M., 2016. Performance analysis of the first large-scale (15 mwp) grid- connected photovoltaic plant in mauritania, Unite´ Energies Renouvelables, Departement physique, Universite des Sciences, de Technologie et de Médecine (USTM), Mauritania.

Application of Earned Value Analysis Method on Building Rehabilitation and Renovation Project Works Iain Library and Laboratory, Sirimau District, Ambon City

Rusly Lestaluhu[1], Rudi Serang[2]

Ambon State Polytechnic , Indonesia
Email: [1] lestaluhurusly97@gmail.com
          [2] rudiserang65@gmail.com

Abstract— In one construction project, overall cost and time control is part of construction management. By applying the Earned Value method, cost control and completion time can be done well. Thus avoiding cost and time, project control can be carried out properly in terms of time and cost. The results of this study are to determine the cost and time aspects of project performance each month and predict the costs and time to be able to complete the rest of the work so that corrective actions will be taken next. The results of the analysis of the Rehabilitation and Renovation Work of the Library and Laboratory Building of IAIN Sirimau District, Ambon City, the SPI value at week 16 was 1.04 or (>1) while the CPI was 1.05 or (>1) which means the project was implemented more faster than planning on a smaller budget. ETC value of IDR. 20,831,175,738 and the EAC value of IDR. 31,160,101,437.

I.   INTODUCTION

A project is a series of temporary activities that take place for a limited period of time, with the allocation of certain resources and the puIDRose of carrying out the tasks whose targets have been clearly outlined (Soeharto, 1995). In project implementation, there are several important components that determine the success of a project. These components are in the form of cost, time and quality which are interrelated with each other. These three components must be processed as well as possible to obtain profits in accordance with the plan (Soeharto, 1995). In implementation in the field, it is not uncommon to find projects that experience delays in completion and even stop their implementation. Therefore, it is necessary to control so that the storage that occurs can be overcome, so that the project can be completed on time as planned. In an effort to succeed in a construction project , a good technique or management method is needed to increase efficiency, productivity and work quality. In this regard, it

is necessary to carry out supervisory and control measures in all sectors, especially time control. Project duration is the length of time a project lasts until it produces a product that has been planned. In a project, time planning is prepared by making a time schedule, in which there is a time division and sequence of project work from the beginning of the work to the final work. In the analysis of variance, it only shows the difference in work results at the time of reporting compared to the budget or schedule. The weakness of the Variant Analysis method is that it only analyzes the cost and schedule variants of each separately so that it cannot reveal the performance problems of the activities being carried out. Meanwhile, with the result value concept method, it can be seen the performance of the activities being carried out and can increase effectiveness in monitoring project activities.

Currently, the IAIN Ambon Library and Laboratory Rehabilitation and Renovation Project is underway. The contractor for this project is PT. Anugrah Putra Perkasa,

JO. PT. Laleva Indah Lestari. During project implementation, it is necessary to control the time aspect of what has been planned. In the work on the Rehabilitation and Renovation of the Library and Laboratory Building of IAIN Ambon, it is not known that deviations or delays occurred. Therefore, a study is needed to evaluate time control in the Library and Laboratory Rehabilitation and Renovation Project of IAIN Ambon, using the Earned value concept. Earned value concept is one of the methods used in project control methods that combines elements of schedule, cost, and job performance to calculate the estimated cost and time required to complete the project to completion. The results of the Earned value concept analysis in each project evaluation then provide information about the conditions of project implementation and can be used by project managers as a basis for making decisions that are needed to make improvements so that project implementation can achieve the project's initial goals.

II.   LITERATURE REVIEW

2.1. Result Value Concept.

The project control method used is the Integrated Cost and Schedule Control Method (*Earned Value*). This method examines the trend of Schedule Variants and Cost Variants at a time period during the project (Soeharto , 1995).

1.   Understanding *Earned Value Analysis*

The " *Eaned Value* " method is a control method used to control costs and project schedules in an integrated manner. This method provides information on the status of project performance in a reporting period and provides predictive information on the costs required and time for completion of all work based on performance indicators at the time of reporting.

2.   The Concept of Earned Value (Earned Value)

The concept of value for results is the concept of calculating the amount of costs according to the budget in accordance with the work that has been completed or carried out (*budgeted cost of works performed*). When viewed from the amount of work completed, it means that this concept measures the size of the unit of work completed, at a time when assessed based on the amount of budget provided for the work. With this calculation, it is known the relationship between what has actually been achieved physically and the amount of the budget that has been issued (Soeharto, 1995).

In construction work, cost management is divided into 2 parts, namely the estimation of direct costs and indirect costs

2.2. Direct costs and indirect costs

1.   Direct cost

Direct costs are costs that are directly allocated for the implementation of work on *the items* stated, such as:

- Provision of materials (direct effect on work)
- Provision of labor (direct effect on work)
- Equipment (direct effect on work)
- subcontracting services (direct effect on work)
- transportation and construction equipment such as cranes, trucks (direct effect on work) for project implementation according to plans and specifications within the scope of work

2.   Indirect costs

Indirect costs are costs that must be incurred by the contractor for the implementation of activities but are not directly allocated for the implementation of work such as:

- Provision of working water (direct effect on work)
- Provision of work electricity (direct effect on work)
- Provision of wifi (does not directly affect work)
- provision of salaries of employees and staff in the field (does not directly affect the work)
- laboratory costs, field testing (does not directly affect the work)
- material and warehouse arrangement costs (direct effect on work)
- board of directors construction costs (no effect on work)

2.3. Basic Value Concept

According to Suharto (1995) the basic concept of result value can be used to analyze performance and make estimates of target achievement. For this puIDRose, 3 indicators are used, namely;

1.   ACWP (*Actual Cost of Work Performed*)

Is the actual cost of the work that has been carried out. These costs are obtained from accounting or project financial data at the reporting date (eg month-end), which is a record of all actual cost expenditures from work packages or accounting codes including overhead calculations and others .

ACWP = Planned weight (%) x contract value

2.   BCWP (Budgeted Cost of Work Performed)

Is an indicator that shows the value of the results from the point of view of the value of the work that has been completed on the budget provided to carry out the work. When the ACWP figure is compared with the BCWP, it will be seen a comparison between the costs that have been incurred for the work that has been carried out against the costs that should have been spent for that puIDRose (Soeharto, 1995).

BCWP = Realized Weight (%) x contract value

3. BCWS (Budgeted Cost of Work Scheduled)

It is the same as a budget for a work package, but is structured and linked to an implementation schedule. So here there is a combination of costs, schedules, and scope of work, where each element of work has been allocated a cost and schedule that can be used as a benchmark in carrying out work (Soeharto, 1995).

According to (Soeharto 1995) using the 3 indicators above, various factors can be calculated that indicate the progress and performance of project implementation, such as:

a. Cost Variance Cost Variance (CV) and Schedule Variance (SV) schedule integrated;
b. Determine the variance change against the standard number;
c. Productivity and performance index;
d. Estimated project completion costs

The criteria for the cost performance index (CPI) and schedule performance index (SPI) are as follows:

- If the performance index is less than one (<1), the expenditure is greater than the budget or the implementation time is longer than the planned schedule. And if the budget and schedule have been made realistically, then there are irregularities in the implementation of the work .

- If the performance number is more than one (> 1), then the performance in project implementation is better than planning, in the sense that the project expenditure is smaller than the budget or the schedule is ahead of the predetermined plan.

- The greater the difference from the number one (1), the greater the deviation from the basic planning or budget. If the number is too high, which means that the performance of the work is very good, then it is necessary to cross-check whether the planning or budget is unrealistic.

The results of the final project analysis are:

1. *Cost Performance Index* (CPI) that is, the main indicator used to analyze costs. For the calculation of CPI can be used using the following formula
    CPI = BCWP / ACWP
2. *Schedule Performance Index* (SPI), that is, an indicator used to analyze time performance. To get the SPI value can be used by using the following formula
    SPI = BCWP / BCWS
3. *Cost variance* (CV) is the difference between the project value and the actual cost, or can also be said to be the budget value that occurs between BCWP and ACWP. To calculate the cost variance can be used the formula;

Cost Variance (CV)= BCWP – ACWP

If CV :
- Negative (-) = Cost above budget
- Zero (0) = On budget
- positive (+)   = Cost under budget

4. Estimated cost for remaining work / *Estimate to Completion* (ETC) is the estimated cost required to complete the remaining work costs. The estimated cost for the remaining work can be calculated using the following formula
    ETC = Total Project Budget (BAC) – BCWP/CPI
5. Estimate at Completion (EAC) is an estimate of the total cost at the end of the project obtained from
    EAC = ACWP + [(BAC – BCWP)/(CPI X SPI)]

2.4. Previous Research

Lucy Octafiani, 2018 has the research title "Earned value analysis of cost control and building construction time" which contains several conclusions, namely: project performance in terms of cost and time in the construction of the Kalibokor type B building at CV.Trinedyatekama for 5 (five) months when viewed from the results of the CPI (Cost Performance index) the results obtained are good, the project status when reporting at the end of the month benefits with an estimated profit of IDR. 235,245,016 or if the percentage is 19.788%.

Eka regitra deska febri, 2015 research title is "cost and time performance analysis using the earned value analysis method which contains several conclusions and suggestions, namely: project implementation costs are the same as the contract value, final cost estimates in the last week, namely week 13 of the final cost estimation results. the project obtained EAC (Estimated Temporary Cost): the estimated total cost of IDR. 681,818,606.91, the value of SPI (cost performance index) is positive (1.00) in week 1 to week 10 this means that the work is carried out exactly according to plan (on schedule), but in week 11 to week the 13 jobs did not go according to plan. The suggestions in this research are: based on the results of the analysis and discussion on this project, the work was *off schedule,* but in the end the work went exactly as planned. In carrying out the project, one should pay attention to the cost and time factors in order to achieve maximum results, in using the *Eraned Value method* for project control, accuracy of data in the field is needed in weekly reports, budget plans, implementation budget plans and *time schedules* . Good communication and coordination between the project management parties is needed so as not to cause work obstacles that result in delays in work in the field.

Fandi Achmad Pahalawan, 2015 This research is entitled "Analysis of the concept of the value of the results (Earned Value Analysis) of the time and cost of the project work on the construction of the MCS SBU II Surabaya building." This research has several conclusions, namely at the end of the review at week 21, the performance of the project schedule (SPI) of 0.858 is smaller than 1, indicating that the project experienced a delay of 10.99% from the initial plan of the project which was planned at 70.023% with the realization of work 59.033% while the cost performance CPI value was 1.061 greater than 1 which means there is savings or costs which is smaller than the work that has been done. The conditions in which the completion time is experienced must be anticipated by predicting the progress of the project at the next time, namely by calculating the project completion time (ECD). Estimated project completion time increased from 28 weeks to 29 weeks while the estimated cost for remaining work (ETC) is IDR. 2,763,530,293 and the total project cost (EAC) is IDR. 6,662,540,478. based on reporting in the last week the CV at the end of the review was IDR. 237,035,975 where there were fewer actual expenses or the contractor experienced profits during the project. as for suggestions from this research, namely good communication and coordination between project managers is needed so that there are no work obstacles that result in delays in work, accurate data is needed including RAB, Time Schedule, daily reports on work implementation and weekly project reports. So that it can correctly predict the condition of project performance, due to delays, it is recommended that the relevant parties control the progress of performance in the following weeks and find solutions so that the project is completed on time with remaining costs.

III.   METHODOLOGY

3.1. Research Sites

IAIN Ambon Library and Laboratory Building Project Location Located at Jl. Dr. H. Tarmizi Taher, Sirimau sub-district, Ambon city

Fig.1 : Map of Research Locations

3.2. Data Type

The types of data used in this writing are:

• Primary data

Primary data is data obtained by researchers directly. Primary data collection is done by conducting interviews or discussions about the application of the value of the results on the project

• Secondary Data

Secondary data is data obtained by researchers from existing sources. In this study, secondary data were obtained from PT. LALEVA INDAH LESTARI, which is the project implementing contractor. The data obtained are project location map data, company organizational structure and project work items.

The data - the data obtained are as follows:

1. Time schedule
2. Plan drawing
3. Material price list and wages
4. Weekly/daily reports
5. Project cost calculation recapitulation

3.3. Data collection technique

Data collection techniques are the methods used to obtain data.

1. Through Study Literature
2. Collecting data from the field
3. Research / Data Processing Independently,

3.4. Data source

The data obtained for this writing is sourced from the library method, books, journals and from the PT. LALEVA INDAH LESTARI as the implementing contractor.

3.5. Analysis Method

From the data obtained, the authors grouped the data, then tabulated it, after that the calculations were carried out based on the research flow chart as follows:

1. Applying the method of analysis of the concept of value of results (*Earned Value Concept*)
2. Define BCWP and BCWS.
3. Determining the SV Schedule Variance.
4. Calculating SPI.
5. Calculating ETC and EAC

3.6. Research Flowchart
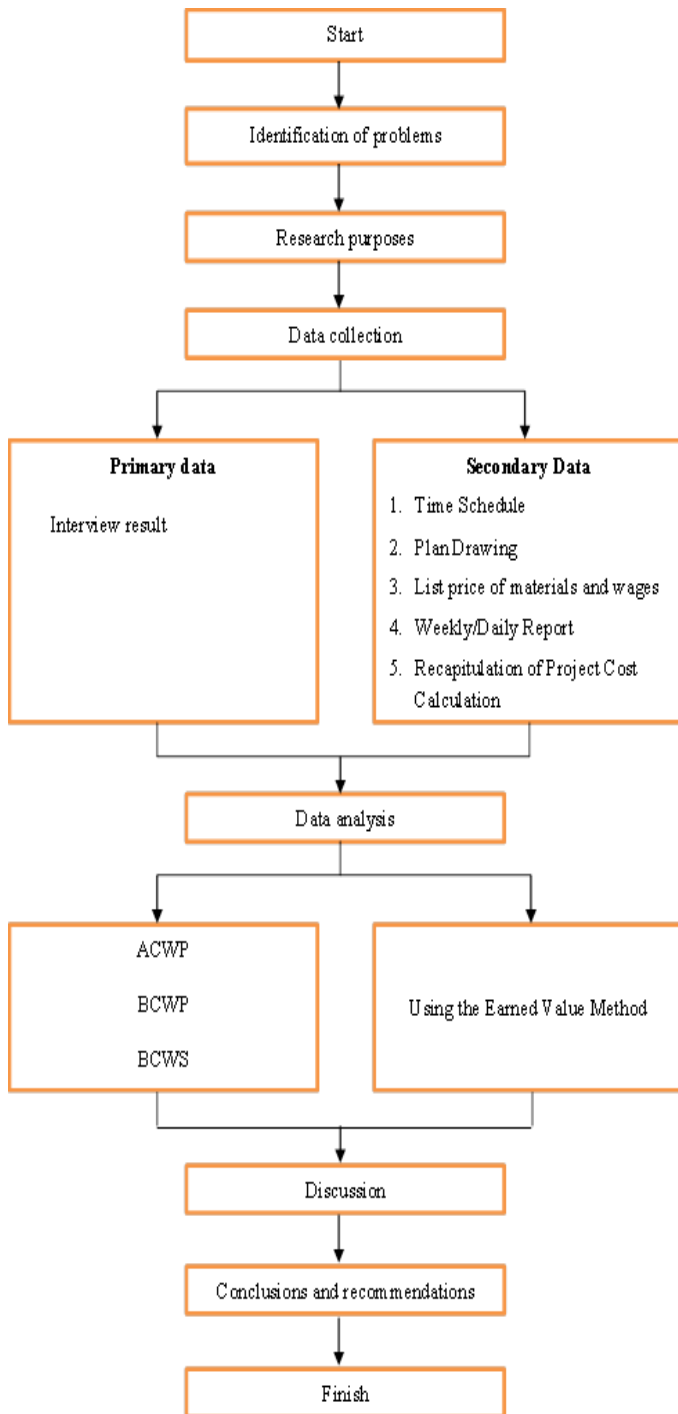
Fig.2: Research Flowchart

IV.   ANALYSIS AND DISCUSSION

4.1. Project Overview

In order to increase students' enthusiasm for learning so that they can study actively to develop their knowledge, the construction of a Library and Laboratory building which has project specification data is as follows:

Project Name   : Rehabilitation And Renovation

IAIN Libraries and Labs

Ambon

Contract Number   : HK 0102/PPWM-PBL/2020/07

Contract Value   : IDR. 32,953,631,000.-

Contract Date   : 01 September 2020

Location   : Ambon City

Execution time   : 240 Calendar Days

Implementing Contractor : PT. Anugrah Putra Perkasa JO

                          PT. Laleva Indah Lestari

Supervisory Consultant   : PT. True Mighty Star JO

                          CV. Charm Consultant

4.2. Calculating ACWP (*Actual Cost Of Work Performed).*

Formula : ACWP = Planned Weight x Contract Value.

Planned Weight $= \frac{8th\ Week\ Total\ Cost}{Contract\ Value}$x 100

Note: Contract Value = IDR. 29,355,921,900 .

ACWP value at the time of the 8th Week Reporting

ACWP = Planned Weight % x Contract Value.

ACWP   = 4,671 % x IDR. 29,355,921,900

         = IDR. 1,371,273,990 ,00

ACWP value at the time of the 12th Week Reporting

ACWP = Planned Weight % x Contract Value.

ACWP = 17.955 % x IDR. 29,355,921,900 .-

         = 5,270,886,134,290

ACWP value at the time of the 16th Week Reporting

ACWP = Planned Weight % x Contract Value.

ACWP = 35.185 % x IDR. 29,355,921,900 .-

         = IDR. 10,328,925,699 ,480

For the next week's calculations can be done in the same way as above, as follows This ACWP calculation result from week 8 to week 16 can be seen in the table below

Table .1: ACWP (Actual Cost Of Work Performance) Value.

Week-	% Cumulative	ACWP Value (IDR)
1	0%	0
2	0%	0
3	0.043%	12,742,532
4	0.188%	55,308,411
5	0.689%	202,256,003

6	1.682%	493,654,409
7	3.198%	938,835,466
8	4.671%	1,371,273,990
9	6.631%	1,946,532,158
10	9.167%	2,691,166,663
11	13.648%	4,006.376,243
12	17.955%	5,270,886,134
13	22.263%	6,535,396,026
14	26.570%	7,799,905,917
15	30.878%	9,064,415,808
16	35.185%	10,328,925,699

Source: Analysis Results (2021)

4.3. Calculating BCWP (*Budgeted Cost Of Work Performanced*)

Formula : $BCWP = \frac{\% \, Actual \, Weight}{100} x$ Contract Value.

Note: Contract Value = IDR 32,953,631,000

BCWP value at the time of the 8th Week Reporting.

$BCWP = \frac{\% \, Actual \, Weight}{100} x$ Contract Value.

BCWP = 9.08 % x 32,953,631,000

= IDR 2,992,189,694,80

BCWP value at the time of the 12th Week Reporting.

$BCWP = = \frac{\% \, Actual \, Weight}{100} x$ Contract Value.

BCWP = 23,85 % x 32,953,631,000

= IDR 7,859,440,993 ,50

BCWP value at the time of the 16th Week Reporting.

$BCWP = \frac{\% \, Actual \, Weight}{100} x$ Contract Value.

BCWP = 32.81 % x 32.953.631.000

= IDR 10,812,086,331 ,10

For the next week's calculation can be done in the same way as above, the following is the result of BCWP calculation from week 1 to week 16 can be seen in the taber below.

Table .2: Value of BCWP (Budgeted Cost Of Work Performance).

Week -	% BCWP Plan Weight	BCWP (IDR)
1	0.00%	-
2	0.00%	-
3	0.04%	13,181,452
4	0.23%	75,793,351
5	0.82%	270,219,774
6	3.75%	1,235,761,163
7	6.03%	1,987,103,949
8	9.08%	2,992,189,694.80
9	9.91%	3,265.704,832.10
10	14.61%	4,814,525,489.10
11	18.79%	6,191,987,264.90
12	23.85%	7,859,440,993.50
13	26.63%	8,775.551,935.30
14	28.73%	9,467,578,186.30
15	30.78%	10,143,127,621.80
16	32.81%	10,812,086,331.10
Project Value	100%	32,953,631,000

Source: Analysis Results (2021)

4.4. Calculating BCWS (*Budgeted Cost Of Work Schedule*)

Formula : $BCWS = \frac{\% \, Planned \, Weight}{100} x$ Contract Value.

Note: Contract Value = IDR 32,953,631,000

BCWS value at the time of the 8th Week Reporting.

$BCWS = \frac{\% \, Planned \, Weight}{100} x$ Contract Value.

BCWS = 4,94 % x IDR 32,953,631,000

= IDR 1,627,909,371 ,40

BCWS value at the time of the 12th Week Reporting.

$BCWS = \frac{\% \, Planned \, Weight}{100} x$ Contract Value.

BCWS = 17,14 % x IDR 32,953,631,000

= IDR 5,648,252,353,40

BCWS value at the time of the 16th Week Reporting

$BCWS = \frac{\% \, Planned \, Weight}{100} x$ Contract Value.

BCWS = 31,43 % x IDR 32,953,631,000

= IDR 10.357.326.223 ,30

For the next week's calculation, it can be done in the same way as above, the following results of the BCWS calculation from week 1 to week 16 can be seen in the taber below.

Table .3: Value of BCWS (Budgeted Cost Of Work Schedule).

Week -	% BCWS Plan Weight	BCWS (IDR)
1	0.00%	-
2	0.00%	-
3	0.04%	13,181,452.40
4	0.19%	62,611,898,90
5	0.49%	161,472,791.90
6	0.96%	316,354,857.60
7	1.75%	576,688,542.50
8	4.94%	1,627,909,371,40
9	6.38%	2,102.441,657.80
10	9.41%	3,100,936,677,10
11	13.44%	4.428.968.006.40
12	17.14%	5,648,252,353.40
13	20.85%	6,870,832,063.50
14	24.41%	8,043.981,327.10
15	28.68%	9,451,101,370.80
16	31.43%	10,357,326.23.30
Project Value	**100%**	**32,953,631,000**

Source: Analysis Results (2021)

4.5. Analysis of the result value indicators CV (*Cost Variance*) and SV (*Shedule Variance)*

Formula: CV = BCWP – ACWP

SV = % BCWP – % BCWS

CV and SV value at the time of the 8th Week Reporting.

CV = BCWP - ACWP

= IDR 2,992,189,695 – IDR 1,371,273,990

= IDR 1,620,915,705

SV = % BCWP – % BCWS

= 9,08 % – 4,94 %

= +4,14 %

CV and SV value at the time of the 12th Week Reporting.

CV = BCWP - ACWP

= IDR 7,859,440,994 – IDR 1,371,273,990

= IDR 2,588,554,859

SV = % BCWP – % BCWS

= 23,85 % – 17,14 %

= + 6,71 %

CV and SV value at the time of the 16th Week Reporting.

CV = BCWP - ACWP

= IDR 10,812,086,331– IDR 10,328,925,699

= IDR 483,160,623

SV = % BCWP – % BCWS

= 32.81 % – 31.43 %

= +1,38 %

Table .4: ACWP, BCWS, and BCWP values

Week -	BCWS (IDR)	ACWP (IDR)	BCWP (IDR)
1	-	-	-
2	-	-	-
3	13,181,452.40	12,742,532	13,181,452
4	62,611,898,90	55,308,411	75,793,351
5	161,472,791.90	202.256003	270,219,774
6	316,354,857.60	493.654,409	1,235,761,163
7	576,688,542.50	938,835,466	1,987,103,949
8	1,627,909,371.40	1,371,273,990	2,992,189,695
9	2,102.441,657.80	1,946,532,158	3,265,704,832
10	3,100,936,677.10	2,691,166,663	4,814,525,489
11	4,428,968,006.40	4,006.376,243	6,191,987,265
12	5,648,252,353.40	5,270,886,134	7,859,440,994
13	6,870,832,063.50	6,535,396,026	8,775,551,935
14	8,043,981,327.10	7,799,905,917	9,467,578,186
15	9,451,101,370.80	9,064,415,808	10,143,127,622
16	10,357,326,223.30	10,328,925,699	10,812,086,331

Source: Analysis Results (2021)
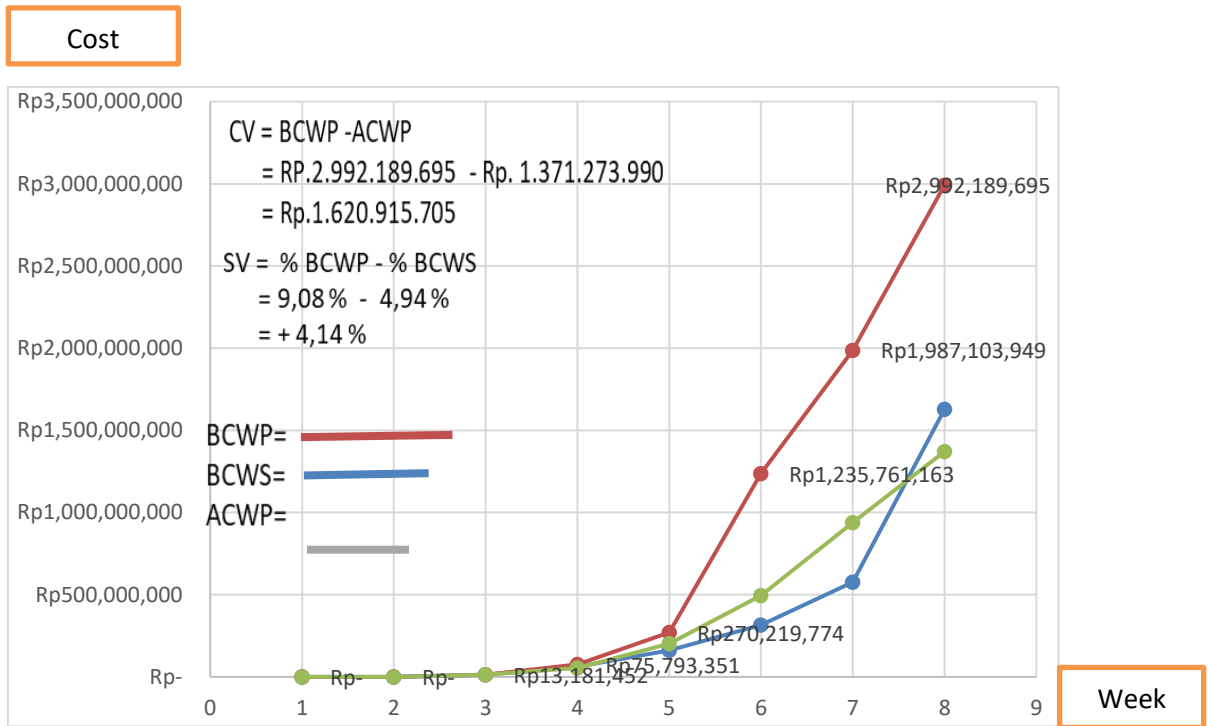
Fig.3: Graph of the S Earned Value Curve at Week 8.

So, in the picture above, the blue graph is the result of the calculation of the BCWS (*Budgeted Cost Of Work Schedule)* week 1 to week 8, the orange colored graph is the result of the calculation of the BCWP *(Budgeted Cost Of Work Pervormanced)* week 1 to week 8. 8th week where SV *(Schedule Variance)* got a positive result which means the work was faster than the planned

time by 4.14% and the gray graph is the result of the ACWP *(Actual Cost Of Work Performance) calculation* from week 1 to week 1. 8 where CV (Cost Variance) gets a negative result which means that the cost of the ACWP that is issued is smaller than the BCWP so that it has an excess cost in the 8th week of IDR. 1,620,915,705
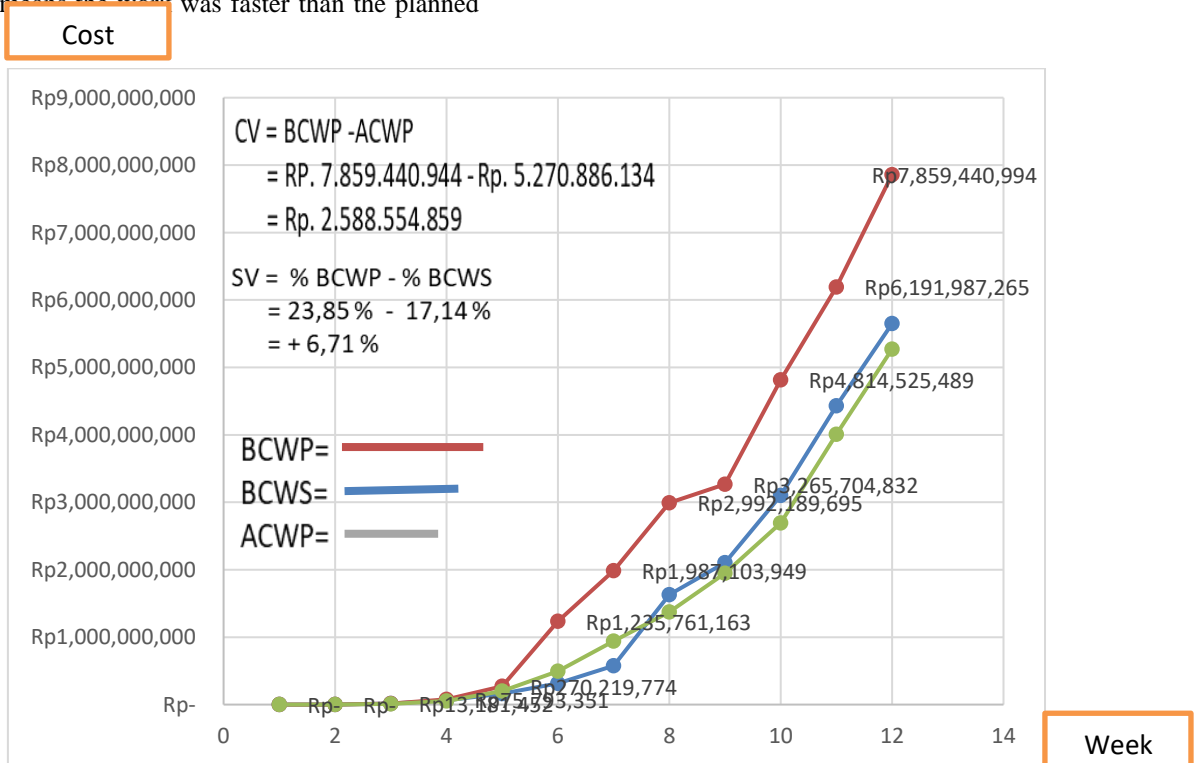
Fig.4: Graph of the S Earned Value Curve at Week 12.

So, in the picture above, the blue graph is the result of calculations from the 1st week of bcws (Budgeted *Cost Of Work Schedule)* week 12, the orange colored graph is the result of the calculation of the 1st week of BCWP *(Budgeted Cost Of Work Pervormanced)* . until the 12th week where SV *(Schedule Variance)* got a positive result which means that the work was faster than

the planned time by 6.71% and the gray graph is the result of the calculation of ACWP *(Actual Cost Of Work Performance)* week 1 to week 1 12th where CV (Cost Variance) gets a negative result, which means that the cost of the ACWP that is issued is smaller than the BCWP so that it has an excess of costs in the 12th week of IDR. 2,588,554,859
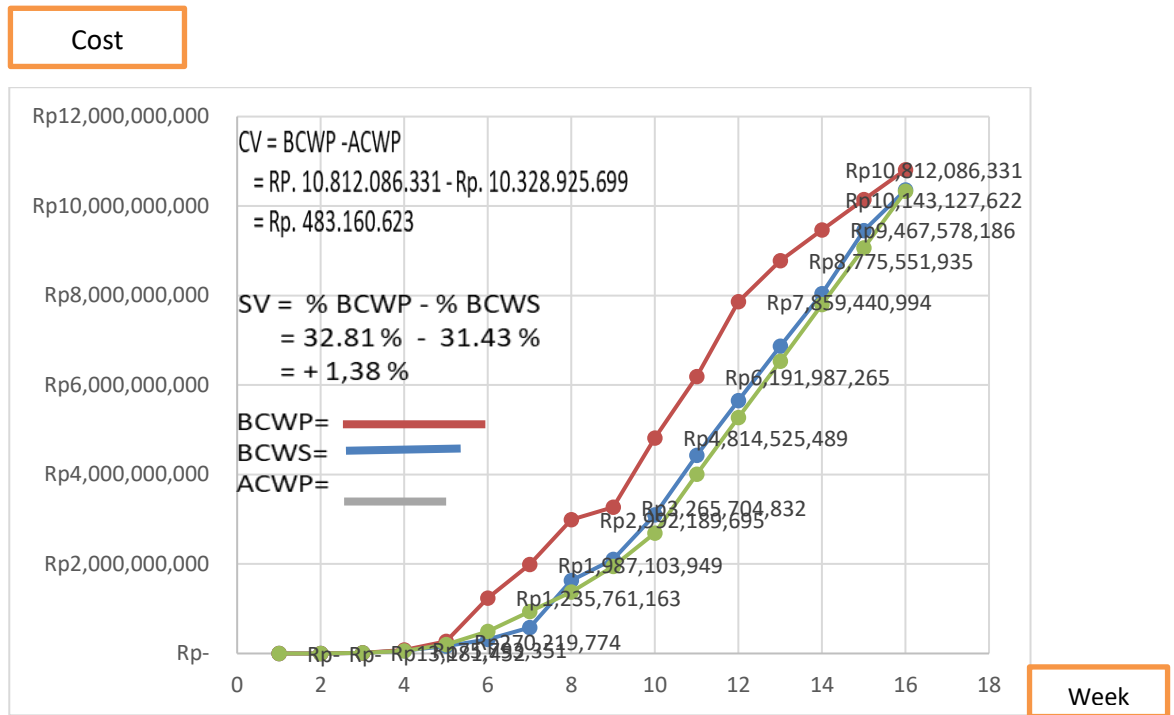
Fig . 5: Graph of the S Earned Value Curve on Week 16

So, in the picture above, the blue graph is the result of calculations from the 1st week to 16th week of bcws (Budgeted Cost *Of Work Schedule)* . week 16 where SV *(Schedule Variance)* got a positive result which means the work was faster than the planned time by 1.38% and the gray graph is the result of calculating ACWP *(Actual Cost Of Work Performance)* week 1 to week 1. 16 where CV (Cost Variance) gets a negative result which means that the cost of the ACWP that is issued is smaller than the BCWP so that it has an excess cost in the 16th week of IDR. 483.160,623

4.6. Calculating SPI (*Schedule Performance Index*)

Formula : $\text{SPI} = \frac{\text{BCWP}}{\text{BCWS}}$

SPI value at the time of reporting week 8.

$$\text{SPI} = \frac{\text{BCWP}}{\text{BCWS}}$$

$$= \frac{9,08}{4,94}$$

$$= 1.84 \%$$

1,84 > 1 means the project performance is ahead of the planned schedule.

SPI value at the time of reporting week 12.

$$\text{SPI} = \frac{\text{BCWP}}{\text{BCWS}}$$

$$= \frac{23,85}{17,14}$$

$$= 1.39 \%$$

1,39 > 1 means the project performance is ahead of the planned schedule.

SPI value at the time of reporting week 16.

$$\text{SPI} = \frac{\text{BCWP}}{\text{BCWS}}$$

$$= \frac{32,81}{31,43}$$

$$= 1.04 \%$$

1,04 > 1 means the project performance is ahead of the planned schedule.

calculation for the next week can be done in the same way as above, the following is the result of the SPI calculation from week 1 to week 16, which can be seen in the taber below.

Table .7: Calculation of SPI (Schedule Performance Index).

Week-	% BCWP	%BCWS	SPI
1	0.00	0.00	0
2	0.00	0.00	0
3	0.04	0.04	1
4	0.23	0.19	1.21
5	0.82	0.49	1.67
6	3.75	0.96	3.91
7	6.03	1.75	3.45
8	9.08	4.94	1.84
9	9.91	6.38	1.55
10	14.61	9.41	1.55
11	18.79	13.44	1.40
12	23.85	17.14	1.39
13	26.63	20.85	1.28
14	28.73	24.41	1.18
15	30.78	28.68	1.07
16	32.81	31.43	1.04

Source: Analysis Results (2021)

4.7. Calculating CPI (*Cost Performance Index*).

Formula : $CPI = \frac{BCWP}{ACWP}$

SPI value at the time of reporting week 8.

$CPI = \frac{BCWP}{ACWP}$

$= \frac{IDR.2.992.189.695}{IDR.1.371.273.990}$

$= 2.18 \%$

2,18 > than 1 , it means the actual cost (ACWP) incurred is smaller than the planned work (BCWP)

SPI value at the time of reporting week 12.

$CPI = \frac{BCWP}{ACWP}$

$= \frac{IDR\ 7.859.440.994}{IDR\ 5.270.886.134}$

$= 1.49 \%$

1,49 > from 1 , it means the actual cost (ACWP) incurred is smaller than the planned work (BCWP)

SPI value at the time of reporting week 16.

$CPI = \frac{BCWP}{ACWP}$

$= \frac{IDR\ 10.812.086.331}{IDR\ 10.328.925.699}$

$= 1.05 \% \ \_$

1,05 > than 1 , it means the actual cost (ACWP) incurred is smaller than the planned work (BCWP)

For the next week's calculation can be done in the same way as above, the following is the result of the CPI calculation from week 1 to week 16 can be seen in the taber below.

Table .8: Calculation of CPI (Cost Performance Index).

Week-	BCWP (IDR)	ACWP (IDR)	CPI%
1	-	-	-
2	-	-	-
3	3,181,452	12,742,532	1.03%
4	5,793,351	55,308,411	1.37%
5	270,219,774	202,256,003	1.34%
6	1,235,761,163	493,654,409	2.50%
7	1,987,103,949	938,835,466	2.12%
8	2,992,189,695	1,371,273,990	2.18%
9	3,265.704,832	1,946,532,158	1.68%
10	4,814,525,489	2,691,166,663	1.79%
11	6,191,987,265	4,006.376,243	1.55%
12	7,859,440,994	5,270,886,134	1.49%
13	8,775.551.935	6,535,396,026	1.34%
14	9,467,578,186	7,799,905,917	1.21%
15	10,143,127,622	9,064,415,808	1.12%
16	10,812,086,331	10,328,925,699	1.05%

Source: Analysis Results (2021)

4.8. Calculating CV (*Cost Variance*).

Formula: CV = BCWP – ACWP

CV value at the time of reporting week 8.

CV = BCWP – ACWP

= IDR. 2,992,189,695 – IDR. 1,371,273,990

= IDR. 1,620,915,705

In the 8th week analysis the results are negative (-) which means the cost is above the plan (*Cost Overrun*) so that the amount of cost deviation in the 8th week is IDR. 1,620,915,705

CV value at the time of reporting week 12.

CV = BCWP – ACWP

    = IDR 7,859,440,994 – IDR 5,270,886,134

    = IDR 2,588,554,859

In the 12th week analysis the results are negative (-) it means the cost is above the plan (*Cost Overrun*) so that the amount of deviation costs in the 12th week is IDR. 2,588,554,859

CV value at the time of reporting week 16.

CV = BCWP – ACWP

    = IDR. 10,812,086,331 – IDR. 10,328,925,699

    = IDR. 483.160.632

In the analysis of the 16th week the results are negative (-) which means the cost is above the plan (*Cost Overrun*) so that the amount of deviation in costs in the 16th week is IDR. . 483.160.632

calculation for the next week can be done in the same way as above, the following is the result of calculating CV from week 1 to week 16, which can be seen in the taber below.

Table .9: Calculation of CV (Cost Variance).

Week-	% BCWP	%ACWP	CV
1	IDR -	IDR -	IDR -
2	IDR -	IDR -	IDR -
3	IDR 13,181,452	IDR 12,742,532	IDR 438,920
4	IDR 75,793,351	IDR 55,308,411	IDR 20,484,940
5	IDR 270,219,774	IDR 202,256,003	IDR 67,963,771
6	IDR 1,235,761,163	IDR 493,654,409	IDR 742,106,753
7	IDR 1,987,103,949	IDR 938,835,466	IDR 1,048,268,483
8	IDR 2,992,189,695	IDR 1,371,273,990	IDR 1,620,915,705
9	IDR 3,265.704,832	IDR 1,946,532,158	IDR 1.319.172.674
10	IDR 4,814,525,489	IDR 2,691,166,663	IDR 2,123,358,826
11	IDR 6,191,987,265	IDR 4,006.376,243	IDR 2,185,611,022
12	IDR 7,859,440,994	IDR 5,270,886,134	IDR 2,588,554,859
13	IDR 8,775.551.935	IDR 6,535,396,026	IDR 2,240,155,910
14	IDR 9,467,578,186	IDR 7,799,905,917	IDR 1,667,672,269
15	IDR 10,143,127,622	IDR 9,064,415,808	IDR 1,078,711,814
16	IDR 10,812,086,331	IDR 10,328,925,699	IDR 483.160.632

Source: Analysis Results (2021)

4.9. Calculating ETC (*Estimate Temporary Cost*).

    Formula : ETC $= \frac{BAC - BCWP}{CPI}$

Estimated time for work remaining week 8

ETC $= \frac{BAC - BCWP}{CPI}$

    $= \frac{IDR\ 32.617.691.000 - IDR\ 2.992.189.695}{2,18}$

    = IDR. 13,576,906,388

Estimated time for work remaining week 12

ETC $= \frac{BAC - BCWP}{CPI}$

    $= \frac{IDR\ 32.617.691.000 - IDR\ 7.859.440.994}{1,49}$ IDR **.**

= IDR. 16,603,969,261

Estimated time for work remaining week 16

ETC $= \frac{BAC - BCWP}{CPI}$

    $= \frac{IDR\ 32.617.691.000 - IDR\ 10.812.086.331}{1,05}$

= IDR. 20,831,175,738

For the next week's calculation can be done in the same way as above, the following is the result of ETC

calculation from week 1 to week 16 can be seen in the taber below.

Tabel.10: Calculation of ETC (Estimate Temporary Cost).

ETC= (BAC – BCWP) / CPI				
Week-	BAC	BCWP (IDR)	CPI	ETC (IDR)
1				
2				
3		13,181,452	1.03	31,518.834,675
4		75,793,351	1.37	23,746,682,628
5		270,219,774	1.34	24,211,663,461
6	IDR 32,617,691,000	1,235,761,163	2.50	12,536,263,889
7		1,987,103,949	2.12	14,471,855,623
8		2,992,189,695	2.18	13,576,906,388
9		3,265.704,832	1.68	17,495,330,384
10		4,814,525,489	1.79	15,541,085,473
11		6,191,987,265	1.55	17,098,115,212
12		7,859,440,994	1.49	16,603,969,261
13		8,775.551.935	1.34	17,755,899,804
14		9,467,578,186	1.21	19,072,322,231
15		10,143,127,622	1.12	20,084,415,297
16		10,812,086,331	1.05	20,831,175,738

Source: Analysis Results (2021)

4.10. Calculating EAC (*Estimate At Completion*).

Formula : EAC = ACWP + ETC

Estimated time for work remaining week 8

EAC = ACWP + ETC

= IDR . 1,371,273,990 + IDR. 13,576,906,388

= IDR. 14,948,180,378

Estimated time for work remaining week 12

EAC = ACWP + ETC

= IDR . 5,270,886,134 + IDR. 16,603,969,261

= IDR. 21,874,855,396

Estimated time for work remaining week 16

EAC = ACWP + ETC

= IDR . 10,328,925,699 + IDR. 20,831,175,738

= IDR. 31,160,101,437

For the next week's calculation, it can be done in the same way as above, the following results of the EAC calculation from week 1 to week 16 can be seen in the taber below.

Table .11: Calculation of EAC (Estimate At Completion).

Week-	ACWP (IDR)	ETC (IDR)	EAC (IDR)
1	12,742,532	31,518.834,675	31,531,577,207
2	55,308,411	23,746,682,628	23,801,991,040
3	202,256,003	24,211,663,461	24,413,919,464
4	493.654,409	12,536,263,889	13,029.918,298
5	938,835,466	14,471,855,623	15,410,691,089
6	1,371,273,990	13,576,906,388	14,948,180,378
7	1,946,532,158	17,495,330,384	19,441,862,542
8	2,691,166,663	15,541,085,473	18,232,252,136
9	4,006.376,243	17,098,115,212	21,104,491,455
10	5,270,886,134	16,603,969,261	21,874,855,396

11	6,535,396,026	17,755,899,804	24,291,295,829
12	7,799,905,917	19,072,322,231	26,872,228,147
13	9,064,415,808	20,084,415,297	29,148,831,105
14	10,328,925,699	20,831,175,738	31,160,101,437

Source: Analysis Results (2021)

V.   CONCLUSION

1. From the results of cost performance, in the 16th week the cost performance index (CPI) was 1.05 % or greater than one (>1) which means that there are savings or actual costs are smaller than the work that has been done.

2. From the results of the last analysis in the 16th week, the project schedule performance (SPI) was 1.04% greater than 1, indicating that the project performance was faster than the planned schedule, or 1.38% from the initial project plan. plan at 31.43%. with the realization of 32.81%

REFERENCES Bachtiar I, (2009), *Plan and estimate Real of Cost* , publisher of Bumi Aksara , Jakarta .

[2] Eka regitra deska febri, 2015 the title of his research is "analysis of cost and time performance using the earned value analysis method.

[3] Fandi Achmad Pahalawan, 2015 This research is entitled "Analysis of the concept of the value of the results (Earned Value Analysis) of time and cost in the construction project of the MCS SBU II Surabaya building"

[4] Gray et al, (1997), *Project management* , LPFE University of Indonesia, Jakarta.

[5] Kotler and Armstrong (2001), *Fundamentals of Marketing* , PT INDEKS GRAMEDIA group.

[6] Lucy Octafiani, 2018 has a research title "Earned value analysis of controlling costs and building construction time"

[7] Nursahid M, (2003), *Construction Management* , Muhammadiyah University Surakarta

[8] Suharto I, (1995), *Project management from conceptual to operational* , Erlangga Publisher, Jakarta.

[9] Suharto I, (2002), *Industrial project feasibility study* , Erlangga Publisher, Jakarta.

[10] Suad H, Suwarsono, 1993. *Project Feasibility Study* , AMP, YKPN, Yogyakarta.

[11] Pujawan IN, (1995), *Technical Economics* , PT. Candimas Metropole, Jakarta

Prototype of distribution transformer load reliability system based using visual basic interface

Firman Yudianto, Fajar Annas Susanto, Teguh Herlambang

Department of Information System, Universitas Nahdlatul Ulama Surabaya, Indonesia
Corresponding Author Email :firman_yudianto@unusa.ac.id

Abstract— *Developing the operation and maintenance of distribution transformers is one of the services in keeping and maintaining the process of electricity distribution to customers run well. Services to meet the demand for electrical stability require improvement in determining transformer trouble points not proportional to the number of State Electricity Company officers available dealing with the measurement of the transformer peak load that keeps changing due to the large number of new customers or those adding electrical power load. The development of the constantly increased electrical power load cannot be monitored properly anymore, and there is not yet appropriate technology applied for monitoring it. Therefore a new device is required so as to function facilitating officers in the distribution transformer load monitoring across various places in real time 24 hours, and the data can also be retrieved in real time as desired. The output of this device is in the form of visual data. If the transformer is overloaded, it can be designed using a visual basic interface, and in the system there is a microcontroller able to provide information for the officers quickly, to reduce investment in purchasing new transformers.*

I. INTRODUCTION

Performing distribution transformer maintenance is an important task to keep the optimal operation of the transformers. One way to do so is by monitoring the transformer load. The measurements of the peak load of the distribution transformers are carried out during the day (office and market loads) and during the night (housing loads). To be able to measure the maximum load (at peak load hours) the officers commonly have difficulty due to the large number of transformers not proportional to that of the officers available. As well as that the posts of the transformers scattered in various locations can be an obstacle for officers to measure the load on time.[1]

The condition of the unbalanced transformer load is a warning for the officers to immediately take actions to make it balanced or move the transformer load, otherwise

damage occurs. As the transformer gets loaded unbalanced, one of the transformer phases gets loaded more than the other. As the load increases, it increases the risk of the phase becoming overloaded. Besides, the unbalanced transformer loading causes neutral current losses.[1]

The expected benefit of measuring the load of the distribution transformer is that the officers are able to see the progress of the transformer load so as to take an effective action as soon as possible in the event that things get abnormal. Thus, to help overcome such problems, a special equipment is required to make it easier for the state electricity company officers to monitor the transformer properly. Maintenance measures are necessarily taken to prevent any possible sudden equipment breakdowns and to maintain the maximum possible performance of it, in

accordance with the technician age. This can keep the positive image of PLN's services.[2]

II.   LITERATURE REVIEW

2.1 Distribution Transformer

Transformer is an electrical equipment functioning to distribute electrical power from high to low voltage or vice versa with the same frequency. It is also the main utility at the distribution substation, so in its installation it is equipped with safeguards to protect influences from outside the system and from within the system itself. The larger the transformer capacity, generally the more complete safety system, the more complete maintenance within the shorter period of time. The distribution transformer is a power transformer having a smaller power capacity than a substation transformer and is used to lower the voltage from a medium voltage of 20 kV (the output voltage of the substation transformer) to a low voltage (380 V) for further distribution to the load.[3]

The working principle of a transformer is as shown in Figure 1. When the primary coil is connected to an alternating voltage source, changes in the electric current in the primary coil cause a changing magnetic field. The changing magnetic field is amplified by the presence of an iron core and the iron core is delivered to the secondary coil, so that at the ends of the secondary coil causes an induced emf (electromotive force).[4]
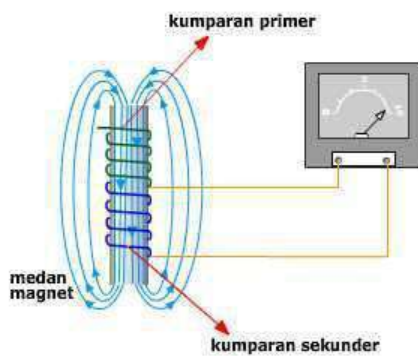
Fig.1. Primary and Secondary Coils of a Transformer against a Magnetic Field

Material is used in this paper is transformer and microcontroller atmega 128. Transformer is an electrical equipment to distribution electric power from high voltage to low voltage or vice versa in same frequency. Transformer is also a major utility in the distribution substation and when installation is equipped with protector to protect it from influence from outside system or within system itself. The greater capacity of transformer, protector must be more complete and maintenance must be

done in routine. The distribution transfomer is a power transformer that has function to decrease voltage like from medium voltage of 20 KV (output voltage from substation transformer) to low voltage of 380 V to distribute load. Figure 3 are:

(a) shows a vector flow diagram in a balanced state. Here it can be seen that the sum of the three current vectors (IR, IS, IT) is equal to zero so that there is no neutral current (IN). While in Figure 3

(b) shows a vector diagram of unbalanced currents. Here it can be seen that the sum of the three current vectors (IR, IS, IT) is not equal to zero so that a magnitude appears, namely the neutral current (IN) whose magnitude depends on how big the imbalance factor is.

Alternating current source when the applied load is purely resistive which has a cos phi value of 1. then the voltage and current waves are in phase. The flow of alternating current is caused by an alternating voltage with the same frequency. If the current and voltage pass through zero and rise to their highest value in the same direction at all times, the current is said to be in phase with the voltage. But in some types of circuits the zero and highest values of current and voltage do not occur at the same time. If this happens, the current is said to be out of phase with the voltage. The current and voltage may be in phase as shown in Figure 2.[3]
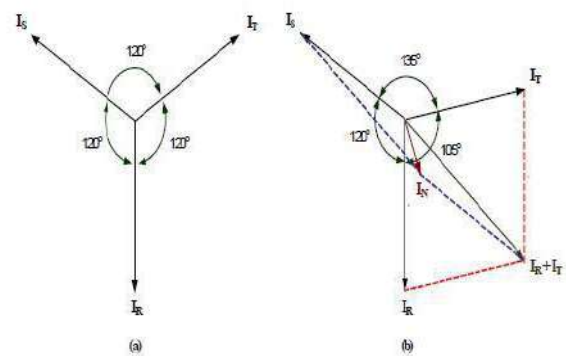
Fig.2. Diagram Vector Current

2.2 Interface Visual Basic (IVB)

VBI, Visual Basic 6.0 Interface, and its parts discussed includem : ●Toolbox ●Properties ●Project ●Explorer ●Form ●Code Editor ●Event ● Project Management. All these were needed during the interface making until running or implementing the interface we created. See the visual basic interface with its parts below (Figure2)
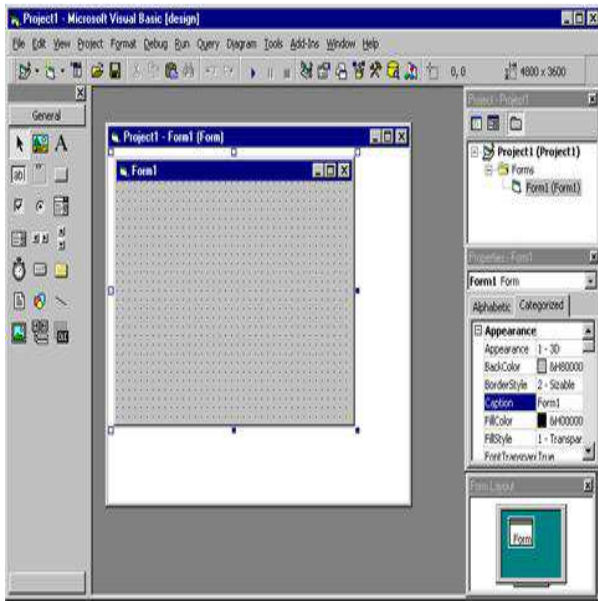
Fig.3. Interface Visual Basic

The Visual Basic Interface is a large environment consisting of several small parts, all of which have property of being able to slide to any position you desire, able to resize as you can resize Windows window and paste to other adjacent parts.(Figure 3) [5]

1. Control Menu

Control menu is a menu primarily used to manipulate the Microsoft visual basic window. From the menu we can resize, move, or th Microsoft visual basic window or other windows. The control menu consists of Restore, Move, Size, Minimize, Maximize, dan Close.

2.Menu Bar

The microsoft visual basic menu consists of all microsoft visual basic commands that can be selected to perform a specific task. The menu contents are almost the same as most programs in general.

3.Toolbar

Toolbar are bottons representing specific commands from the microsoft visual, functioning to access any command quickly. Each of the buttons can be directly clicked to perform a specific command. melakukanperintahtertentu. Usually the bottons are commands frequently used and there is also a Microsoft visual basic menu.

4.Form Window

Form window is the main work area, where we can make visual basic visual basic application programs. In this form we can design text, images, command buttons, scrollbar, and others. This form window, at first, looks small, but its size can be changed according to the needs of the application we make.

5.Toolbox

Toolbox is a box of tools covering all objects or controls needed to make an application program.

6. Properties window

The properties window contains all information of the objects provided in the Microsoft visual application. Properties of objects are as identified by their names such as color, size, position, and so on.

7.Form Layout Window

Form layout window is a window describing the position of the form displayed on the monitor screen. The position of the form the form layout window is an indication of where the application created will be displayed.

8. Code window

The code window is one of the most important windows in Microsoft Visual Basic. This window contains program codes, instructions for visual basic applications created. Each object in Visual Basic can be added with program codes to perform specific tasks such as closing applications, canceling commands, and so on

9. System Application

Making application programs using Visual Basic is done by making the application display on the form, then given a script program in the required components. The form is composed of components that are in the [Toolbox], and each component that is used must have its properties set through the [Property] window.
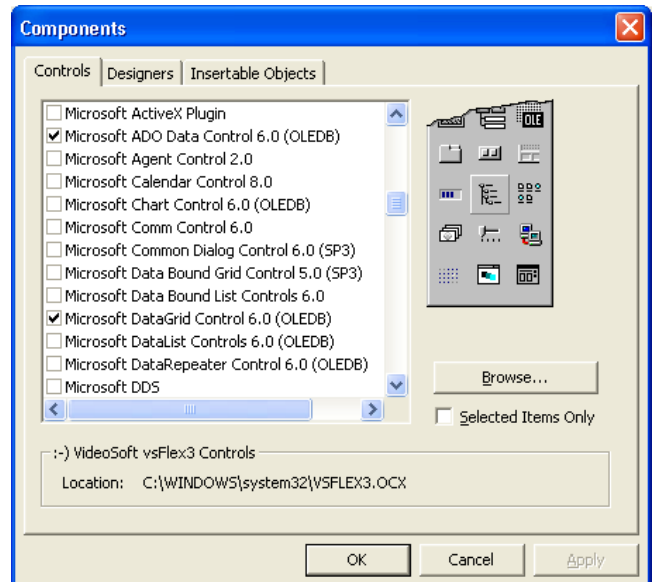
Fig.4. Interface Visual Basic Properties

III. DESAIN SYSTEM

3.1Visual Basic 6.0 Interface InterfaceDesain Planning

To make it easier to monitor overload and unbalance loads.distribution transformer, a Visual Basic 6.0-based interface is used which is connected to the microcontroller via a serial USB connection. On the interface, the results of the sensor readings are displayed in the form of current, voltage, zero cross detector and power. This interface is also used to make it easier to see the monitoring of the transformer remotely.

In conducting monitoring, it is necessary to carry out various preparations, both the preparation of the required software and hardware. Because this tool is related to current sensor readings, voltage sensors, zero cross detector sensors and can send SMS if there is an overload and imbalance in the load on the transformer. And also can request sms if we want to know the load is in balance. In general, the test results are not really accurate data, but an estimate. So it is not uncommon for errors caused by software or hardware.

3.2 System Prototipe Result

The result of the IVC prototype using Code Vision AVR in Figure 4 with C programming language, with programming logic principles and producing a binary number. The ATMega 128 IC has 8 bytes. So that it has a broad and diverse program thinking.

Monitoring transformer load need some preparation both software and also hardware. Because this hardware is related to reading some sensor like current sensor, voltage sensor, zero cross detector sensor and sending messenger if there is overload and unbalance of transformer load. Messenger can be requested if officer want to know load in balance condition.Making application programs using Visual Basic is done by making the application display on the form, then given a script program in the required components. The form is composed of components that are in the [Toolbox], and each component that is used must have its properties set through the [Property] window.

Alternating current source when the applied load is purely resistive which has a cos phi value of 1. then the voltage and current waves are in phase. The flow of alternating current is caused by an alternating voltage with the same frequency. If the current and voltage pass through zero and rise to their highest value in the same direction at all times, the current is said to be in phase with the voltage. The Visual Basic Interface is a large environment consisting of several small parts, all of which have property of being able to slide to any position you desire, able to resize as you can resize Windows window and paste to other adjancent parts.

Fig.5. Code Vision AVR programming

The use of Visual Basic to get information in real time is the same as the results shown by the LCD, in Figure 5 is a program snippet from Visual Basic which will be synchronized with the microcontroller whose results are displayed on the LCD and Visual Basic interface.

Fig.6. Visual Basic Interface Prototype Programming

Fig.7. Visual Interface when Overload

Fig.9. AC Voltage Waveform Toroidal Current Sensor Output

In Figure 7 shows data from current sensor, voltage, cos phi and power through visual interface with red of led is on. In this condition can take conclusion if transformer is in overload condition so microcontroller will process report and send message by modem like in Figure 6. After then, a delay of 10 seconds contactor will work by turning off the auto transformer and load automatilly so transformer in safe mode. Installing and setup motion detection on raspberry pi, first of all installing Raspbian on micro SD or Interface Visual Basic . And the installing and setup motion detection voltage sensor output signal (Figure 8).[6]

Fig.8 . Voltage Sensor output sign

The toroidal current sensor is used as a reading of the incoming current to the source that has been loaded with light bulbs from all three phases, after that, it is entered and processed by the microcontroller whose results appear on the LCD.(Figure 9)

Fig.10. Toroidal Current Sensor Input Current

IV.   CONCLUSION

The transformer load experiencing overload and imbalance was immediately known by the officer through the *IVC* design prototype sent to the officer's cellphone.The officer was able to see the transformer load in real time through the officer's cellphone by sending an *SMS* to the device and sending the temporary transformer load data directly. So, the need for accurate and fast data could be fulfilled. Transformer load is divided in three categories are balance condition, unbalance condition and overload. When transformer is unbalance condition or overload, officer will get message from modem about value of current, voltage, cos phi and power. So with immendiately action from office, transformer will not burned by fire and will be in safe mode.

REFERENCES

[1] Yudianto, F. (2017, August). *Design monitoring of distribution transformer load by messenger based on microcontroller atmega 128*. In 2017 4th International Conference on Computer Applications and Information Processing Technology (CAIPT) (pp. 1-3). IEEE.

[2] Yudianto, F., Budiarti, R. P. N., & Mufarikkoh, Z. (2019). *Design and Installation of Street Light for Public Lighting Business in Industrial 4.0*. Applied Technology and Computing Science Journal, 2(2), 109-117.

[3] Yudianto, F., & Kamil, A. S. (2019*). prototipe pemodelan monitoring pengisian dan pencegahan kebakaran batubara pada silo berbasiskan plc-scada menggunakan fuzzy*. Prosiding SNST Fakultas Teknik, 1(1).

[4] Yudianto, F., & Budiarti, R. P. N. (2018). *analysis of electrical distribution systems java-bali 500 kv based on steady state stability limit using radial equivalent independent (rei) dimo*. In proceeding International Conference Technopreneur and Education 2018 (Vol. 1, No. 1).

[5] D Rahmalia, T Herlambang, A S Kamil, R A Rasyid, F Yudianto, L Muzdalifah, E F Kurniawat, 2019, *Comparison between Neural Network (NN) and Adaptive Neuro Fuzzy Inference System (ANFIS) on sunlight intensity prediction based on air temperature and humidity*,The Third International Conference on Combinatorics, Graph Teory and Network Topology, University of Jember-Indonesia, 26-27 Oct 2019

[6] Yudianto, F., & Susanto, F. A. (2020). *design of smartschool webcam security system using raspberry pi with motion detection in smk pgri sukodadi*. journal asro-sttal-international journal, 11(1), 202-206.

Induction Factors of the Built Environment to Sustainable Mobility – The case of the *Nova Marquês do Paraná* Project in the Downtown Area of Niterói/RJ - Brazil

Bernardo Granville de Paula Cople[1], Giovani Manso Ávila[2]

[1]Master´s student of the Urban Engineering Program - Polytechnic School of the Federal University of Rio de Janeiro (UFRJ), Brazil.
bernardocople@poli.ufrj.br
[2]Master´s professor of the Urban Engineering Program - Polytechnic School of the Federal University of Rio de Janeiro (UFRJ), Brazil
giovani@poli.ufrj.br

Abstract— This paper aims to analyze how the induction factors of the built environment from the revitalization works of Marquês do Paraná Avenue, in the central area of the municipality of Niteroi/RJ- Brazil. Moreover, their relations with the advances brought by the Sustainable Urban Mobility Plan (PMUS) released in 2019, which influenced the transformations of the mobility paradigm along the avenue and in its nearby neighborhoods, were also objects of evaluation. It was applied an analytical and exploratory methodology of the attributes executed in the Nova Marquês do Paraná Project, evaluating the improvements of mobility noticed on the street when compared to the urban planning of this avenue in the past. It was possible to contrast the current induction factors of the built environment to sustainable mobility with the mobility attributes historically prevalent in the avenue that characterized it as a street axis of passage, inviting only motorized traffic. It was observed that these induction factors acquired the potential to transform local dynamics of displacement and permanence, induced the choice of active modes of travel integrated to public transport and enhance social, economic and leisure activities at the adjacent public spaces of the avenue. This research concluded that the new induction factors are means that can incorporate the human scale on the avenue, promote integrated management of public transport and land use and become reference practices for future masterplans and urban projects in Niterói and similar cities.

I. INTRODUCTION

The structuring of mobility is one of the key elements for the planning and effective functioning of sustainable urban areas (PORTAS, 2008). This organizational portion of the territory has been focused more and more on infrastructure to the active modes of travel linked to the formation of new centralities, the attractiveness of new land uses and the urban treatment of the built environment inserted in the networks of movement of people in cities worldwide.

The emphasis given to the provision of hierarchical and integrated accessibility between modes of transport meets the demand to make urban spaces more attractive and safer to pedestrians and cyclists. A dynamic and attractive urban environment to this target audience must integrate sustainable ways of transport with different types of public space (GIL, 2009). It is necessary to continuously review the conditions of juxtaposition between the spaces-design of encounter and experience of people (streets, avenues, squares and parks), the displacement spaces (stations, stops and means of transport) and the spaces generated (buildings, equipment and urban systems) to value the pedestrian and the cyclist. This integration between the three types of spaces is relevant for the induction of a better readability of landmarks, arches and nodes along the routes, providing guidance and satisfaction to people and maximizing their feeling of belonging to the place (PAOLI, 2007).

Gehl and Hook (2010) point out the need to harmoniously distribute urban furniture in the environment to provide pleasant breaks during commuting and build and conserve sidewalks and public spaces with quality paving materials. Germani (2004) exhibits urban afforestation initiatives and landscape solutions to ensure climatic, acoustic, and aesthetic comfort on the streets. Rosito (2009), in turn, shows urban lighting solutions with the objective of highlighting the importance of inserting remarkable luminance points in the paths to make the streets safe at night.

The principles that guide Transit Oriented Development (TOD) and the concept of Complete Streets advocate the balanced and safe integration between the public spaces for longer permanence of the pedestrian and cyclists and the routes of rapid flows of motorized traffic in central areas requalified. For such principles, Cervero et al. (2009) and Grieco et al. (2015) point out that a built environment of high density built, diversified and accessible in its activities and integrated with public transport directly influences the adoption of walks and cycling as first options for short trips, the known "first mile" and "last mile".

The objective of this research is to analyse the recent transport planning paradigm shift towards sustainable mobility to the central area of Niterói, a municipality located in the metropolitan region of Rio de Janeiro, Brazil. Through the study of the Nova Marquês do Paraná Project,

it is proposed to verify the hypothesis that the avenue presents improvements in patterns of active mobility and increase in social coexistence and vivacity on its public spaces. An analytical and exploratory methodology is chosen about the main induction factors already executed in the works of the Nova Marquês do Paraná Project, evaluating the positive points brought from the interventions and the ones that still need to be improved. Besides, the search compares the actual local scenario with the urban planning of the avenue occurred in the past through urban and transport plans predecessors to the Sustainable Urban Mobility Plan released in 2019, such as the Jaime Lerner Plan dated to 2012.

It is expected that this study of the Nova Marquês do Paraná Project might help guide public policies and future urban projects in Niteroi and other large and medium-sized Brazilian cities, which have urban contexts and morphologies like the Marquês do Paraná Avenue corridor. At the end, suggestions are formulated for future researches, aiming to fill the specific gaps on sustainable and active mobility themes, as well as to identify additional opportunities for Avenida Marquês do Paraná.

II. HISTORY AND URBAN CHARACTERISTICS OF THE DOWNTOWN AREA OF NITERÓI AND ITS REFLECTIONS ON MARQUÊS DO PARANÁ AVENUE

The Niterói city center and the neighborhood of *Icaraí*, more traditional places of the city, are connected by the corridor of Marquês do Paraná Avenue, main object of this search. These areas have urban singularities and planning references related to the embryonic process of development of the municipality dating from the nineteenth century.

Marcolini (2011) observes two opposing models used in the history of urban planning in Niterói. The first, which has occurred until the early 1920s, was guided by the establishment of "neighbourhood centres" connected by junction points of the transport system, in particular, the tram lines services that were integrated with the ferryboat known as *Barcas.* At the same time, there was a dynamic local trade and an atmosphere of vibrant social life, as well as a small fleet of cars. Thus, Icaraí and the city center were pleasant neighbourhoods to walking trips and had

characteristics of urban development oriented to sustainable mobility.

However, this local scenario changed speedily under the influence of the European modernist highway model developed in the twentieth century, through the growth of the motorization of the middle class, the decay of public management of trams, the urban expansion to neighbourhoods far from the city center and Icaraí and the reduction of demand for metropolitan waterway transport.

In this scenario, the Marquês do Paraná Avenue acquired an essential role for the individual motorized transport network, as it became naturally the main circulation corridor of the city. Thus, the other transport modals, especially the active ones, had been devalued by the municipal administrations for years, being only rescued in recent decades. For this reason, it is observed that the actions and decisions for active mobility on the avenue did not reach the expected positive achievements, such as inducing walking and cycling trips, taking advantage of short distances between the neighbourhoods of downtown, *Icaraí, Santa Rosa and Fátima* (local average routes are around 1.5 km)

Figure 1 presents a current satellite figure of the study´s region, highlighting the network aspect of convergence of Marquês do Paraná Avenue (marked with the green square) in relation to the adjacent neighbourhoods (downtown in the upper left corner, *Fátima* in the upper right corner and *Icaraí* in the lower right corner).

Figure 1 also shows the scale of proximity between the neighbourhoods cited, emphasizing the potential for accessibility origin and destinations peers through walking trips and bicycles, the influence of the rugged topography that reinforces the compaction of the environment built, the lack of pleasant public spaces and alternative public transport routes, and the distribution of bus stops/shelters.

The mobility paradigm, once focused on motor vehicles, has been changing slowly in recent years, especially from 2019 to now through Niteroi's recent urban and mobility policies, for instance the newest Master Plan and the Sustainable Urban Mobility Plan - PMUS. Therewith, these two instruments have been used more and more firmly by local managers in order to reorient the urban development of the city center through the combination of active mobility

improvements, diversification of land use and efficacy of public transport networks.
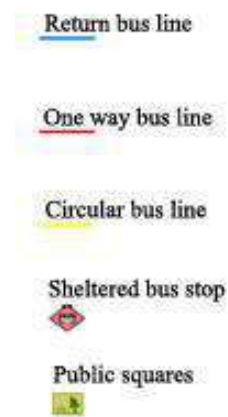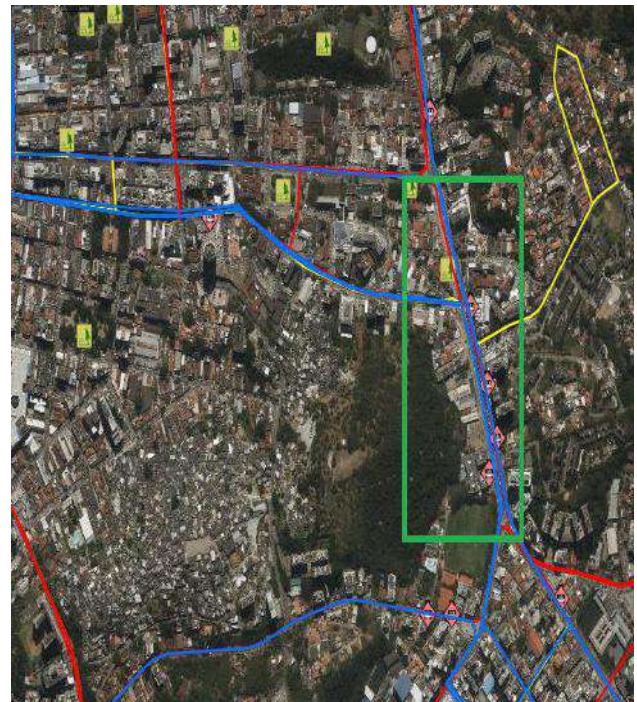
Fig. 1 Aerial view of Avenida Marquês do Paraná and neighboring neighborhoods.

Source: Geoportal Civitas - City Hall of Niterói (2019) - adapted by the authors.

Within these transformative initiatives, Marquês do Paraná Avenue has gained prominence as from the realization, since 2018, of the *Nova Marquês do Paraná* Project. In June 2020, the first stage of this urban intervention was ready, being the first delivery of the PMUS project booklet.

In due course, it is perceived that, although the greatest advances made in the last two years, there are good

heritages of the projects and plans prior to the PMUS for Marquês do Paraná Avenue. It can be cited as an example the inauguration of the work of Tunnel Angela Fernandes in 2013 provided by the Jaime Lerner Plan, which was elaborated between 2009 and 2011. This plan could improve the safety of pedestrians and cyclists locally, by having diverted the flow of vehicles from the surface of the street. This allowed the availability of a walkable stretch with good conditions to the population and a greater fluidity of traffic from the descent of the Rio-Niterói Bridge to the neighborhood of *Icaraí*, separating it from the traffic directed to the city center (LERNER, 2009).

Therefore, it can be seen through the last implemented projects that Marquês do Paraná Avenue has been undergoing a gradual change of paradigm of mobility towards walkability, cycling and an integrated public transport system. In addition, the potential of the built environment with efficient urban infrastructure, the population densification and the concentration of opportunities and activities make the referred project an alibi for the intensification of socioeconomic exchanges and local development.

For this reason, the following chapter proposes to present the attributes of sustainable mobility that were implemented in the *Nova Marquês do Paraná* Project.

III.   IMPACTS AND EXPECTATIONS RELATED TO NOVA MARQUÊS DO PARANÁ PROJECT

The *Nova Marquês do Paraná* Project can be considered as a catalyst vector for the increase of walking and bicycles trips percentages in the modal matrix of Niterói for the coming years. It should be emphasized that the city has already an expressive 29.37% of walking trips and 4.04% in bicycles (NITERÓI, 2019a), but needs to advance even further in these active mobility types to reach the Brazilian average of 40.2%, considering both, observed in municipalities with a population of more than 60,000 inhabitants (ANTP, 2012).

For this reason, the PMUS emphasizes the relevance of favorable topographic and dimensional conditions presented on Marquês do Paraná Avenue, such as the average distance of the displacements being equal to or less than 1.5 km. Beyond that, according to the literature, the

savings of space consumed by pedestrians and bicycles, in the order of 95% and 90%, respectively, when compared to the cars, are important to be argued as well for this scenario (NITERÓI, 2019a).

Regarding walkability, the requalification of the local sidewalks was guided by the Accessible Sidewalks Program (NITERÓI, 2012). In this program, the expansion, reform and standardization of sidewalks, the guarantee of universal ramps aligned with the pedestrian lanes on each corner, the regulation of horizontal and vertical signage, the spatialization of landscaping and afforestation and lightning elements were proposed to attract and give comfort to the users of this mobility infrastructure. All these induction factors were applied with the objective of transforming the Marquês do Paraná Avenue and others corridors into attractive poles of sociability, full of activities, making them urban boulevards (NITERÓI, 2019a; NITERÓI, 2019b).

For bicycle enthusiasts, a two-way bike path was implemented and segregated from the vehicle lanes (NITERÓI, 2019a). It is noteworthy that the cycling infrastructure is still restricted to the main roads connected to the Marquês do Paraná Avenue (as shown in Figure 2), needing to spread it in the internal streets of the neighbourhoods.

Other points that can hinder the dynamics of active mobility on the avenue are the fact that the *Nova Marquês do Paraná* Project has considered the traditional "Predict and Provide" model by providing the construction of an additional traffic lane. It is seen as a weakening factor to encourage locally walking and cycling cultures as opposed to the ones related to cars and motorcycles. Another regional concern lies in the effectiveness of maintaining new pedestrian and cycling infrastructures in the coming years by future municipal management, as an offshoot of the *Nova Marquês do Paraná* Project.

Figure 3 illustrates the planned changes for the *Nova Marquês do Paraná* project, highlighting the quality public sidewalks, the segregated bidirectional bike path, and the synergies of these elements with the revitalized environment of the avenue.
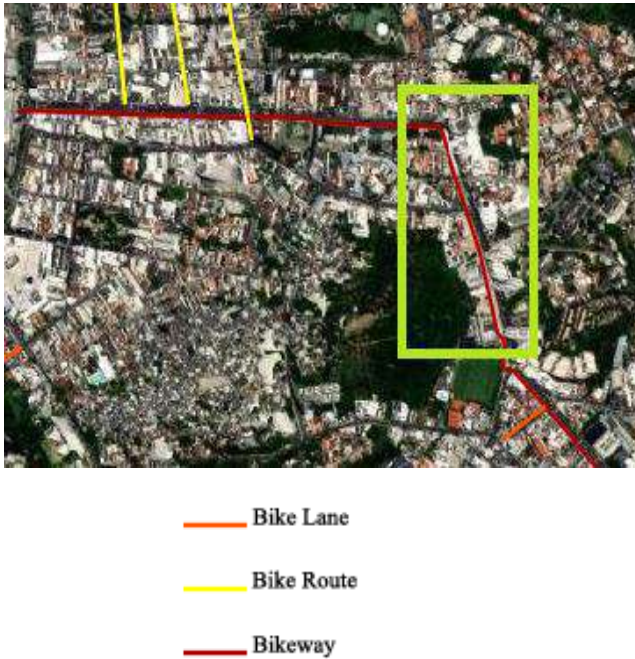
Fig. 2 Cycle Infrastructure and Av. Marquês do Paraná (green rectangle).

Source: Geoportal Civitas - City Hall of Niterói (2019) - adapted by the authors.

Fig. 3 Requalification project of Marquês do Paraná Avenue.

Source: City Hall of Niterói - PMUS Project Book (2019).

Despite the limiting aspects previously presented, the renovation of sidewalks and the implementation of the bike path on *Marquês do Paraná* Avenue have great potential to positively modify socio-spatial relationships, provide more pleasant experiences of displacement, reduce the time lost in traffic jams and generate greater flexibility of movement and pauses during trips.

The landscape treatment of the avenue, including afforestation, new lighting and renovated urban furniture are also seen as important urban induction factors to achieve aesthetic attractions and public safety for the displacements of the population.

However, there is still a lack of integration between the new bus station and cyclists since there are not enough shared bike racks or bicycles on site to perform the modal change. Figures 5a and 5b present the before and after the situation shown of the bus stop on Marquês do Parana Avenue.

Fig.4 (a) Boulevard Marquês do Paraná Avenue - Direction Centre.

Source: The authors.

For the next few years, it is planned the continuity of the reurbanization works of Marquês do Paraná Avenue, adopting the same principles and guidelines of the first phase of the project. To ensure territorial development and

mixed and attractive land use for active mobility on the avenue, the construction of a shopping center is on the list of priorities of municipal managers, as well as the use of urban voids and underused commercial lots adjacent to the avenue axis.

Another project predicted for the region in order to develop increasingly an integrated public transport system for Marquês do Paraná Avenue and its surroundings is the implementation plan of a Light Rail Vehicle line, including 1 (one) stop station in the vicinity of the future shopping center (GIMENEZ E ANDRADE ARQUITECTOS e SINERGIA..., 2016). In this way, the urban integration and synergy between bus lines, VLT system, bike paths, great sidewalks and attractive buildings would be greatly enhanced and accessibility to opportunities on the avenue, leveraged.

cycling trips? What will be the impact of motorized traffic flow due to this attractive new travel hub? How to mitigate the impacts of the large supply of spaces planned for cars and motorcycles in the design of the mall´s parking lot? Will walkability be the predominant behavior of mobility for those who live in the central area of Niterói and want to access this commercial enterprise? How will the shopping center modify the characteristics of the built environment of the avenue? What measures should be taken to improve public transport service for this new travel demand, including the future perspective of the Light Rail Vehicle line? Answers to these questions and other queries should arise to settle down a fruitful field of debates about the future of mobility and urban management in this important structuring axis of Niterói.

*Fig. 4(b) Boulevard Marques do Paraná Avenue –
Direction Icaraí.*

Source: The authors.

*Fig. 5 (a) Old bus stop in Marquês do Paraná Avenue near
the tunnel Angela Fernandes.*

Source: Google Street View

IV. FINAL CONSIDERATIONS

Active mobility proposes to be an alternative solution regarding the way in which public spaces are occupied and used, mitigating or even reversing, depending on the scale of a given urban intervention, the lack of accessibility on foot and by bicycle to places of coexistence and equity, full of social activities, commerce and leisure options. Thus,

The proposal of the new mall has been dividing opinions between local urban managers and society to the extent that the impacts of the commercial enterprise on traffic and active mobility indicators on the avenue are not known for sure yet. Is it an extra incentive factor for walking and

combining active mobility with new innovated models of built environment planning has the power of contributing greatly to the execution of urban projects that value above all the human scale. Else, this association can promote safe, inclusive and sustainable circulation strategies, and integrated management between transport systems and land use.

This article investigated the spatial dynamics of mobility and accessibility of Marquês do Paraná Avenue with repercussions in its border neighbourhoods (*Icaraí, Centro, Santa Rosa and Fátima*). It was observed that this avenue is affected by until now, despite the improvements made, the saturation of road capacity, significant traffic jams, and the imbalance between the spaces of walkability, cycling and vehicle lanes.

The *Nova Marquês do Paraná* Project has brought encouraging perspectives for the diffusion of active mobility on the avenue, as well as the revitalization and appropriation of the adjacent deteriorated urban public space. Following the premises of the Niterói Master Plan of 2019 in line with PMUS, this intervention also seeks to induce the diversification of activities and new circulation ordering, making the avenue an attractive boulevard of walkability, cycling and sociability.
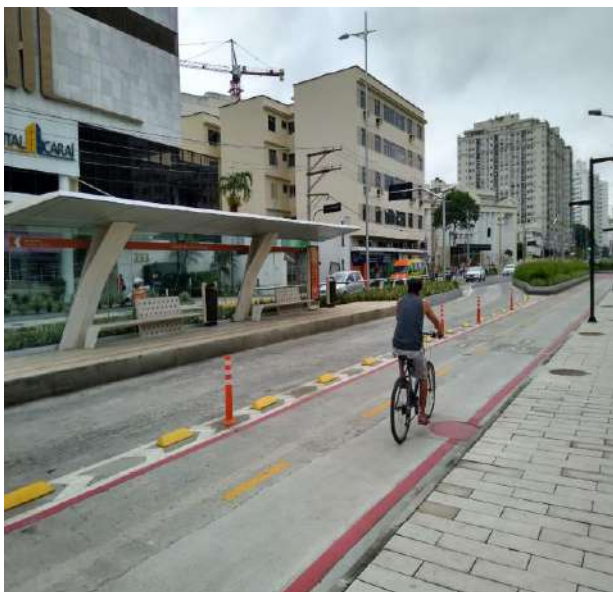
Fig. 5 (b) New bus stop in Marquês do Paraná Avenue and its integration with the bicycle lane.

Source: The authors

Due to this project, important modifications can already be noticed in the reinvigorated scenario of Marquês do Paraná Avenue, satisfying the hypothesis raised in the introduction. The remodeling of sidewalks and the implanting of bike paths showed positive results in this intervention´s beginning, noticing good quality of the materials appointed and more pleasant experiences of displacement.

The landscape treatment, including afforestation, efficient lighting and renovated urban furniture, has enabled people to enjoy a region with more aesthetic attractions, and public and road safeties. The implementation of a bus stop reached through a segregated bay in the upper slab of the Angela Fernandes *T*unnel, in turn, represents an important improvement to foster modal integration between bus lines and active modes, and a local urban gain through the better use of the built environment.

Despite the gains already achieved in the project, there is still a lack of shared bike racks, cycling routes and bicycle sheds supplied on site in order to intensify transport exchanges, and new attractive enterprises to promote walking trips in place of the exaggerated amount of particular motorized vehicles.

Finally, two local urban projects planned for the coming years were shown. The future implementation of a municipal line of Light Rail Vehicle, passing through the Marquês do Paraná Avenue with one stop stations predicted, can serve to reinforce the association of public transport, bike paths, sidewalks and accessibility to urban opportunities in the region. The lease planning of a new mall at the avenue has been motivating a series of discussions about the positive and negative impacts of this enterprise in terms of road capacity, active mobility and built environment attributes such as density, diversity and urban design.

Both projects are seen as potential themes for future researches that aim to keep evaluating Marquês do Paraná Avenue post-requalification. This way, complementary studies about new travel generating centers in the region, such as the mall, and demand management evolution of active and motorized transport are suggested. For sure, these issues are lines to be searched deeply in an attempt to understand the actions already included in PMUS and in

Niterói Master Plan, or possibly added in its developments, for the Marquês do Paraná Avenue scenario and, in extent, the entire central area of Niterói.

REFERENCES

[1] ANTP. U-bank Mobility Information System of the National Association of Public Transport - Simob/ANTP: *National Association of Public Transport.* General Report 2016, May 2018.

[2] Cervero, R., Sarmiento, O.L., Jacoby, E., Gomez, L.F., Neiman, A. Influences of Built Environments on Walking and Cycling: Lessons from Bogotá. *International Journal of Sustainable Transportation*, Vol. 3, n. 4, 2009.

[3] Gil, E.B.D. Pedestrian mobility in the public space: case study and application of project in Sete Rios, I.S.T, Lisbon. 2009.

[4] Gehl, J; Hook, W. 10 principles of liveable transportation, by Jan Gehl & Walter Hook. Smart Cities Dive.<https://www.smartcitiesdive.com/ex/sustainablecitie scollective/10-principles-livable-transportation-jan-gehl-walter-hook/12683/>. Accessed in: 20 August of 2020.

[5] Germani, A.M.G. *Study about the use of plant species in landscape projects for public green areas of Porto Alegre.* Dissertation (Master) of the Research and Graduate Program in Architecture, Federal University of Rio Grande do Sul (UFRGS), Porto Alegre, 2004.

[6] Gimenez e Andrade Arquitectos e Sinergia Estudos e Projetos LTDA. Road Impact Analysis - Commercial Building Av. Marquês do Paraná 340 - Niterói, 2016.

[7] Grieco, E. P., Portugal, L. S., Alves R.M. Application of an environmental index built to assess sustainable mobility. *Built* Environment, Vol. 16, Oct./Dec. 2016.

[8] Lerner, J. Improvements to the Road, Traffic and Public Transport System in the Municipality of Niterói - Final Report. Curitiba: Jaime Lerner Associated Architects. 2009.

[9] Marcolini, S. *Urban Environment and Travel Generation: Niterói, a case study.* Dissertation (Master) of the Urban Engineering Program, Polytechnic School of the Federal University of Rio de Janeiro (UFRJ), Rio de Janeiro, 2011.

[10] Niterói. Technical Notebook of the Accessible Sidewalk program. Undersecretary of Buildings, Department of Urbanism, Niterói, 2012.

[11] _____. (a). PMUS Niterói: Sustainable Urban Mobility Plan of Niterói (Technical Report III - Diagnosis). Department of Mobility and Urbanism (Prefeitura de Niterói).

[12] _____. (b). Niterói Master Plan. Law No. 3385/2019 (Prefeitura de Niterói), 2019.

[13] Paoli, D. *An analysis from the perspective of urban design.* Department of Architecture and Construction, State University of Campinas (UNICAMP), Campinas, 2007.

[14] Portas, N. Manual and methodology and good practices for the elaboration of a sustainable urban mobility plan. In: *Public space and sustainable mobility*, pp. 83 - 87. 2008.

[15] Rosito, L. H. Development of Public Lighting in Brazil, *The Electrical Sector Magazine*. Feb. 2009.

Analysis of students' science process skills by developing a Science Technology Society (STS) model that integrated religious values at Al-hasan Senior High School Jember

Widiet Nurcahyo Ramadhana, Suratno, and Yushardi

University of Jember, Indonesia

E-mail: suratno.fkip@unej.ac.id

Abstract— This study aimed to obtain information needs (need assessment). The implementation of this study used the descriptive and experimental study to develop a learning model of Science Technology Society (STS) integrated with religious values that effective, practical, and valid to improve students' science process skill. The current research used the 4D Thiagarajan model. This study used a validation sheet instrument of learning models and teaching materials which included teacher and student questionnaire sheets, and science process skill sheets. Data collection used quasi-experimental by giving students' pretest and posttest questions of science process skills covering 5 domains comprise the concept domain, process domain, application domain, creativity domain, and attitude domain to students at AL Hasan High School, Panti District, Jember Regency, 2020/2021 academic year. The data were collected from 35 students of the experimental class and 35 students of the control class. The experimental class was given learning treatment-oriented science discovery technology integrated community religious values, while the control class used conventional learning. Science process skills data were obtained based on observations. The results of the value of science process skills obtained an average increase in pretest and posttest experimental class by 33 points and an average increase in pretest and posttest control class by 14 points. The results of the science process skills hypothesis test of students in the experimental class and the control class had a significance value of less than 0.05, so it can be concluded that the learning model based on science discovery technology that integrated religious values had a significant effect on students' science process skills.

I. INTRODUCTION

Education is a lifelong process that starts from home and continues as formal and informal exercises [3]. How a human learned about life and the success in learning life lessons depends on what he has previously learned. Attitudes influence perception and development through the learning process and are ultimately manifested in behaviour. Physics is a science learning requires the right approach by the characteristics of science. In fact, in reality, the teacher prioritizes the results rather than the process of students acquiring knowledge. Teachers rarely provide direct experience to students in carrying out scientific activities to reinforce previously accepted theories. Due to the lack of interest of students in studying physics, it causes the learning process to be not optimal so that it affects students' cognitive outcomes [1]. The learning process based on the results of observations in

physics learning found that the teacher prioritizes the product aspect rather than the process aspect so that the involvement of students in the learning process is still lacking. Teachers rarely provide experience to students in carrying out scientific activities, such as loading problem formulations, making hypotheses, testing hypotheses, processing data, and communicating them in front of the class to strengthen the concepts that have been learned, so that it has an impact on students' scientific thinking skills. PISA 2012 revealed that Indonesian students are in position 64 out of 65 countries. So it is necessary to change the mindset of students that are formed when the learning process is carried out. Education is a lifelong process that starts from home and continues as formal and informal exercises [3]. How a human learned about life and the success in learning life lessons depends on what he has previously learned. Attitudes influence perception and development through the learning process and are ultimately manifested in behaviour. Physics is a science learning requires the right approach by the characteristics of science. In fact, in the field, the teacher prioritizes the results rather than the process of students acquiring knowledge. Teachers rarely provide direct experience to students in carrying out scientific activities to reinforce previously accepted theories. Due to the lack of interest of students in studying physics, it causes the learning process to be not optimal so that it affects students' cognitive outcomes [9]

Based on the purpose of science education, teachers must be able to develop students to make them interested in scientific problems, so that they can obtain and apply them properly for personal, social, and community interests. Physics learning must be able to provide understanding and meaning of science to students properly, which aims to make students able to relate physics concepts in real life so that students can construct their understanding from the material that they learned and apply it in everyday life because in the learning process students are allowed to share knowledge, find out for themselves science in everyday life [6]. Developing a scientific attitude is expected to be able to develop and discover the attitudes and values of students in carrying out the learning process. One of the expected scientific attitudes is science process skills. Science process skills are skills that include cognitive, manual, and social skills. Science process skills can be an alternative to improve the thinking skills of students in finding concepts as well as developing students' critical attitudes. Science process skills are the basis for students to develop scientific attitudes and problem-solving skills so that they are expected to be able to build creative, innovative, critical, open-minded and competitive students in facing global competition in society [4].

Results of interviews conducted with Physics teachers at AL Hasan High School, Panti District, Jember Regency showed that most students considered physics a difficult subject because there were many formulas and scientific languages without a good learning process causing students to have difficulty understanding and being bored. This causes the majority of students' scores less than Minimum Criteria of Mastery Learning (KKM) so that teachers often make remedial. Learning Physics should provide meaning and a good understanding of science for students so that students can connect concepts in physics with real-life and apply them so that students can construct their process of obtaining knowledge from the material obtained. Students' understanding will be better with active involvement than just seeing the content of the material concept [3]. The learning process with scientific activities had a positive impact on students in forming complex knowledge. Results of other studies indicate that the alignment of the cognitive and psychomotor aspects of students will be able to influence students' cognitive outcomes. Based on these problems, a learning model is needed that can accommodate the purpose and competencies that students must master, to be able to increase the value of science for the better. One of the models is science technology society learning (STS) [7]

The science technology society increases student knowledge by connecting science learning and technological developments in the community that exists in the student environment. So that in the learning process, students are trained to link the world of Science with human-made technology as well as the social experiences that students get in the environment of society that can improve students' abilities in the environment. Learning Physics that is integrated with the STS approach can evoke an attitude of science and technology, that science is not a science that only relies on memory to memorize, but is also related to the students' environment which can be applied in everyday life to facilitate human life [11]. Revealed that the integration of religion in learning is very important to achieve the students' purpose of being knowledgeable and believing which is the best human being (Insanul Kamil). The integration of the Holy Qur'an can stimulate students 'critical thinking skills and scientific attitudes as a benefit to study or study scientifically so that they can change students' paradigms towards religions that are different from science. Religion and science do not contradict each other either in concrete evidence through scientific studies in answering questions about the existence of the truth of revelation. On the material of physical quantities related to the Holy Qur'an, "We created everything in due measure and proportion "(Al Qamar: 49) [11].

The science technology society increases student knowledge by connecting science learning and technological developments in the community that exists in the student environment. So that in the learning process, students are trained to link the world of Science with human-made technology as well as the social experiences that students get in the environment of society that can improve students' abilities in the environment. Learning Physics that is integrated with the STS approach can evoke an attitude of science and technology, that science is not a science that only relies on memory to memorize, but is also related to the students' environment which can be applied in everyday life to facilitate human life. Ibrahim et al. (2018) revealed that the integration of religion in learning is very important to achieve the students' purpose of being knowledgeable and believing which is the best human being (Insanul Kamil). The integration of the Holy Qur'an can stimulate students 'critical thinking skills and scientific attitudes as a benefit to study or study scientifically so that they can change students' paradigms towards religions that are different from science. Religion and science do not contradict each other either in concrete evidence through scientific studies in answering questions about the existence of the truth of revelation. On the material of physical quantities related to the Holy Qur'an [11].
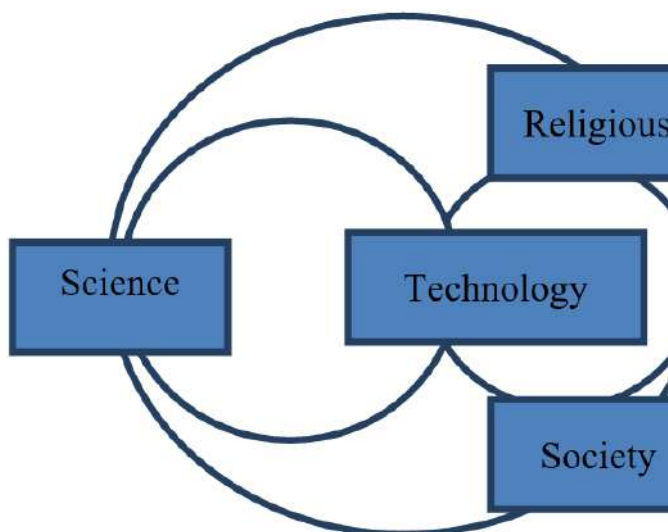
Fig.1. The correlation between science, technology, society, and religious values.

II.   METHOD

The research aims to obtain information about teachers and students need, as well as a preliminary test of the STSintegrated with religious values development model before conducting a large-scale test. This study aims to obtain information about assessment need. Meanwhile, the development activities aim to produce a valid and effective STS integrated with religious values learning model. This determination design uses the 4D development method from Thiagarajan which includes define, design, develop and disseminate [7]. The subject of this research is the Science, technology, society, and religious development model in physics learning for high school students. While the research respondents were students and physics teachers at AL-Hasan High SchoolPantiJember. The data collection from respondent included learning observation sheet instruments, teacher and student response questionnaires, lesson validation models, and student science skills tests. The data were analyzed based on their type of qualitatively and quantitatively. Learning guide models, lesson plans, student questionnaires, and production tables through validation tests were analyzed descriptively and compared with criteria for practicality, effectiveness, learning material instruments, student work reports and lesson plans. Meanwhile, qualitative analysis includes the implementation of the learning model in the classroom. Revisions were based on the results of measurements and opinions by experts and physics teachers [3].The effectiveness data of the model was obtained by giving pretest to the experimental class STS integrated with religious values and the control class (conventional) before being given treatment. Moreover, post-test for the experimental and control classes after the learning process was carried out to determine the difference average in students' science process skills scores.

Table 1. Data collection on the results of students' science process skills in the experimental class STSintegrated with religious values and the control class (conventional)

No	Class	Average score of students' science process skills				
		1	2	3	4	5
1	Eksperimental					
2	Control					

Mean Score of Science Process Skills (KPS)

$$KPS = \frac{Total\ Students'\ Score}{Total\ Score} x100$$

Information:

1: Mastery of concepts

2: Processing ability

3: Applicability

4: Creativity ability

5: Attitude[3]

Furthermore, statistical tests were carried out to determine the level of significance between the experimental class with the science technology society approach and religious values with the control class using conventional learning. Conducting a hypothesis test first carried out by the prerequisite test which includes the normality test, homogeneity, and one way ANOVA using the SPSS application. The total respondent in 10b class was 35 students as the experimental class and in 10c was 35

students class as the control class at Al Hasan High School, Panti District, Jember Regency on 11-12 September 2020.

III.　　RESULT

3.1 Need Assessment

Some information about teacher skills in the teaching process by distributing questionnaires to 100 teachers in various schools in Situbondo and Jember.

Table 2. Results of distributing need assessment questionnaires to.

No	Activity of Learning	Teacher Respond
1.	Society has known the Science technology model.	30%
2.	Implementing of religious values in learning.	15%
3.	Implementing Science Technology Society.	60%
4.	Knowing the domain of students' science process skills	40%
5.	Applying all domains in measuring students' science process skills	30%
6.	Involving students in the learning process	60%

3.2 Learning model

Results of the survey and analysis of students' science process skills used a physics learning model based on STS integrated with religious values. The validation of the learning model which includes lesson plans, worksheets, and assessment of students' science skills can be seen in the following table.

Table 3. Validation of Learning Models and Teaching Materials.

Validation Aspect	Expert Teacher	Expert validator	Average	Category
The practicality of the model	85	75	80	Valid
Model guide	81.2	79.2	80.2	Valid
Material validation	72	76	74	Valid
Syllabus Validation	87	81,2	84.1	Valid
Lesson plan validation	82	78	80	Valid
Assesment	76	79	78	Valid

3.3 Practicality of the model

Learning model research aimed to obtain data on the practicality of the model and learning materials. The STS integrated with religious values research was conducted in

4 meetings involving students as research objects and physics teachers at AL Hasan High Schoolas observers. The teacher was observing and ensuring the course of the learning process. The practicality assessment data model

was obtained by filling out the practicality sheet by the teacher as an observer and the student as the object of

research. The results of the validation of the learning model instrument are as follows.

Table 4. Validation of learning instruments.

Validation Aspect	Average	Category
The practicality of the model	81.60	Practical
Learning materials	79,25	Practical
Student involvement	86.25	Very Practical
Worksheet	78.25	Practical
Average	**81.37**	**Practical**

3.4 Effectiveness of Model

This study aimed to determine the differences in students' science process skills on the topic of physics quantities using the STS integrated with religious values approach with conventional learning. The data were collected and analyzed using the one way ANOVA test. However, before the one way ANOVA test was carried out, there are statistical prerequisites that must be fixed. Analysis of normality using the Kolmogorov-Smirnov test and homogeneity was a prerequisite that must be met before carrying out the one way ANOVA test. The data normally distributed if the significance value is $p > 0.05$, and the data variance was homogeneous if the significance probability value is $p > 0.05$.

Tabel 5. Normality test of data distribution.

Data Test	Experiment Class		Control Class	
	Sig	Result	Sig	Result
Data Normalitas Pre Test	0.010	Normal	0.011	Normal
Data Normalitas Post Test	0.200	Normal	0.022	Normal

Based on the normality test in the table above, the significance results of the pretest data for the experimental and control classes as well as the posttest data for the experimental and control classes were more than the significance value of 0.05. So it can be concluded that the data were obtained from a normally distributed population.

Table 6. Homogenity test of data distribution

Data Test		Levene S.	df2 df1	df2	Sig.
Data Homogenity	Based on Mean	1,133	3	136	,338
	Based on Median	1,082	3	136	,359
	Vased on Median and with adjusted df	1,082	3	125,670	,359
	Based on Trim mean	1,170	3	136	,323

As for the homogeneity test, it can be seen that the data tested has a significance value greater than 0.05, so it can be concluded that the data is homogeneous. This means that the data can be carried out further tests, namely the

one way ANOVA analysis test to determine the effectiveness of the model in improving students' science process skills.

Table 7. One way anova test.

Class	Sig.	Result
Experimen and Control	0.000	Different

Based on the one way ANOVA test, the significance value is less than 0.05. It means that there can be differences in the types of student skill outcomes between the experimental class and the control class. Furthermore, the descriptive analysis is carried out to describe the results of students' science process skills.

Table 8. Descriptive data.

	Pre Test of Experimental Class	Pre Test of Control Class	Post Test ofExperimental Class	Post Test of Control Class
Mean	45.11	44.49	78.80	58.89
Lower Bound	41.50	41.03	75.50	56.35
Upper Bound	48.73	47.94	82.10	61.42
Minimum	23	28	60	45
Maximum	65	60	98	70

Descriptive analysis showed that average of the pre-test of the experimental class was 45.11, while the control class was 44.49, which means that the average value of the pres test before being treated with the integrated STS integrated with religious values are almost the same so that the two classes are eligible to be research objects. Whereas the average of the post-test based on the descriptive analysis in the experimental class was 78.80 which was significantly higher than the average of the control class (58.89) as in the following graph.

Fig.2. Graph of students' science process skills improvement.

IV. DISCUSSION

4.1 Need Assesment

The results of the questionnaire given to 100 teachers can be seen in table 2. The results showed that 70% of the teachers knew the approach of technology science society model, while 30% did not know it, meanwhile, in implementing the STS approach model in the learning process 60% of the teachers implemented it, 10% did not implement it, and 30% sometimes implement it. The implementation of religious values in learning showed that only 15% of teachers say yes, 60% did not implement it, and 35% sometimes implement it. Meanwhile, for the teachers' knowledge about the science process skills for students was 40% of the respondents said they knew, and 60% said they did not know. The implementation of deep science process skills was 60% of respondents said yes, 30% sometimes, and 10% never. While the teachers' knowledge of science skills in students was 40% of respondents and 60% of respondents did not notice. The implementation of the domain concept, process domain, domain application, creativity domain, and domain attitude as references in the assessment were 30% of respondents said Yes to apply, 40% of respondents only applied a few, and 45% of respondents did not apply it at all. And student involvement in the learning process was 60% of respondents involved students actively, 15% sometimes, and 30% Not at all, it means that the teacher took all the time theory only without connecting to real life.

4.2 Learning Model Validity

The validation of the development of a physics learning model based on science, technology, and society integrated of religious values was carried out by 2 experts covering aspects of construction, content, and language accuracy. The lesson plan validation data, student worksheets, and assessments can be seen in table 3. The results of the validation of the STS learning model development

instrument was valid and fix category to be applied in the physics learning process following the chapter on physics quantities [2].

4.3 Practicality of The Learning Model

Results of learning observations showed that the learning model in a practical category and suitable for the teacher to apply in the physics learning process in the physics chapter. The assessment of teachers and expert validators on the lesson plans, worksheets and STS integrated with religious values models in the practical and fix category can be seen in table 2. Average of the results of the validation of the practicality model by students obtained was 81.37. It indicated that the indication of physics learning with the STSR model in the practical category and fix as improvement students' science process skills .

4.4 Effectiveness of the Learning Model

The effectiveness of the development model of science, technology, society, and religion to improve the process of student skills in terms of student competence in aspects of the 5 domains, comprise domains concept, domains process, domains application, domain creativity, and attitudes. Data obtained from the results of the pretest and posttest before learning and after learning began from the experimental class and control class to know the level of effectiveness. Average of science process skills of the experimental class students STSintegrated with religious values were higher than the control class (conventional) which can be seen in Figure 2. Average pretest and posttest scores of the experimental class showed that there was a significant increase compared to the control class. The average score of pretest in the experimental class was 45.11 (not good) and the posttest score was 78.80 (very good) the proportion of completeness of science skills on the determined score was 72% of all students. Whereas in the control class, the average score of the pretest was 44.49 (not good) and posttest was 58.89 (not good) and the proportion of completeness of science process skills was 20% of all students. Furthermore, it can be concluded that the development of learning models for science, technology, society, and religious efficiency in improving students' science process skills.

The STS approach was chosen with the consideration of developing students' science skills because of the interaction of cognitive, psychomotor, and affective aspects were formed when students constructed the process of obtaining knowledge by themselves [5]. The integration of religion in the STS approach was also able to stimulate the ability to think critically and scientifically at students' attitudes as a benefit to study or study scientifically. Moreover, it can change students' paradigms towards religion that is different from science. Religion and science

do not contradict each other either in concrete evidence through scientific studies in answering questions about the existence of the truth of revelation [12]. In the experimental class, learning about the chapter on physics quantities was given an apperception in the form of social problems related to physics and connected to the verse from the Holy Qur'an, "We created everything in due measure and proportion ". (Al Qamar: 49). Students were formed in groups and worked together in providing the phenomena of daily life and the verses of Holy Qur'an that relevant to physics on the worksheets.The group was formed of 5 students. Learning with groups was based on that learning with friends increased collaboration, the communication needed by students in their community which consists of communication, discussion, exchange opinions, and collaboration that was able to build new understandings about phenomena in the community. Every student had the same opportunity to argue, listen, and collaborate to achieve the purpose together. The STS model integrated with religious values approach model includes 4 phases.

   a. Stimulating students to formulate problems by observing phenomena/problems in the society environment and engaging students to understand the basic concepts of physical quantities, history, and objectives and their various quantities [1], and their relevance to the verse of Holy Qur'an, "We created everything in due measure and proportion". (Al Qamar: 49).

   b. Guiding students to find and construct their process of gaining knowledge and understanding by exploring based on society environment phenomena, comprise the use of physics to help humans in everyday life [8].

   c. Applying the concepts studied and the benefit in society environment and formulate measurement models based on the problems formulated on the student worksheets [8].

   d. Presenting the concept created from group discussions result through class presentations then evaluating the results for consideration in the future.

Phase one, engaging students to understand the basic concepts of physical physics with the phenomena that exist in society related to physical physics and their relevance to the verse of Holy Qur'an, "We created everything in due measure and proportion". (Al Qamar: 49) [3]. After that students asked to formulate problems from various problems in the environment, students propose a concept that was created based on it then presenting the concept in front of the teacher and friends. Phase two, students

explored themselves to find and construct their process of gaining knowledge and understanding by exploring the community environment Physics physics scale to help humans in everyday life and its relevance to Islamic values. Phase three, based on students' understanding of the concepts obtained by creating a formula to answer the problems on the student worksheet given. Then the students presented the results of the discussion from data analysis and provided the solutions needed to solve problems in the surrounding environment and shortcomings to be made new at a later date. Moreover, in the final phase, the teacher gave score on students' science process by giving post questions that were reviewed from 5 domains, comprise domains concept, domain processes, domain applications, domain creativity, and attitudes. STS learning was integrated with religious values that allowed students to think critically in problems solving, students be interested because the concept was integrated with religious values and opened students' insights to get out of the understanding that physics was a lesson that memorizes formulas only. STS learning was integrated with religious values that can be obtained because students were stimulated to look deeper into the subject matter because of its relevance to society and religious environment technology as an indication of a problem phenomenon and its problem solving. So that students were active independently to construct their knowledge through observing various phenomena in the society environment [6].

4.4.1 Social system

The social system that refers to this model approach was students form heterogeneous groups that allowed students to be able to have friends with different backgrounds. The effect for students received when reflecting on the integration of Al-Quran verses causes students to be active and curious about the relevance of religion and science so that the understanding of religion and science as two different aspects were broken. Students were expected to be knowledgeable and also believers on Religious, so it would be easy in building a relationship with the surrounding environment and society can be achieved [10].

4.4.2 Reactionprinciple

The principle of reaction in the STS Learning Model integrated with religious values was the teacher role as a facilitator who facilitates students in constructing their knowledge by providing basic understandings that related to religious values and science. Teachers form heterogeneous groups, thus it treated students to adapt to society with different backgrounds, teachers motivate students to provide positive feedback to develop student competence [9].

4.4.3 Supportingsystem

The support system that must be fulfilled in implementing the integrated STS approach model of religious values was teachers had to have good knowledge of religious and science and relevant, specific, and actual material to develop instruments. Also, students had to be active to find their knowledge through various supporting literature [13].

4.4.4 Instructionalimpact

The instructional impact of the STS learning model integrated with religious values comprises students were able to construct and associate their knowledge, treated scientific thinking skills in problems in the surrounding environment. This was in line with the cognitive capacity of students

4.4.5 Indirect impact

The indirect impact of the integrated STS approach model of religious values comprises students took an active role in the learning process, thus they were able to construct their knowledge process with the natural phenomena around them. Students who were able to be disciplined and work together with heterogeneous group members in order to prepare students' mentality to go directly to the environment and society and be actively involved in building relationships [12].

4.4.6 Science Skills process in STS integrated with the learning model of religious values

Students' science skills include 5 domains, comprise domains of concept, processes, applications, creativity, and attitudes which can be fulfilled in the STS approach model integrated with religious values. The domain concept includes facts about a particular theory. The domain process was focused on how the process of students acquiring knowledge, classifying, measuring, inferencing, regarding variables, interpreting from formulating hypotheses, communicating, defining operations and conducting experiments, and communicating. The domain of applying concepts and skills to solve everyday problems. The domain of creativity in students' imagination, intuition and elevation. The domain includes students' attitudes towards science, religion, environment, society, and themselves [9].

V. CONCLUSION

This study aims to produce an STS learning model that is integrated with religious values and their influence on students' science process abilities. The learning model developed is practical, valid, and effective to improve the science skills process of students at Al-Hasan High schoolJember. The average score of science process skills

of students who were given STS treatment with integrated religious values was 78.80 with a proportion that was by the minimum criteria of learning completeness of 70% of the total 35 students. Researcher's suggestions for teachers not to teach in a dichotomy, which is wrong between science, technology, society, and religion, all of which are related to forming a product that is useful for students in the community in the future, both in social, knowledge, and religious aspects.

REFERENCES

[1] Safaah, E. S., Muslim, M. and Liliawati, W. (2017) 'Teaching Science Process Skills by Using the 5-Stage Learning Cycle in Junior High School', *Journal of Physics*: Conference Series, 895(1). doi: 10.1088/1742-6596/895/1/012106.

[2] Primastuti, M. and Atun, S. (2018) 'Science Technology Society (STS) learning approach: An effort to improve students' learning outcomes', *Journal of Physics*: Conference Series, 1097(1). doi: 10.1088/1742-6596/1097/1/012062.

[3] Tirta, G. A. R., Prabowo, P. and Kuntjoro, S. (2018) 'Development of Physics Teaching Instruments Belong to Cooperative Group Investigation Model to Improve Students' Self-Efficacy and Learning Achievement', JPPS (*JurnalPenelitian Pendidikan Sains*), 7(2), p. 1464. doi: 10.26740/jpps.v7n2.p1464-1471.

[4] Kane, S. N., Mishra, A. and Dutta, A. K. (2016) 'Preface: International Conference on Recent Trends in Physics (ICRTP 2016)', *Journal of Physics*: Conference Series, 755(1). doi: 10.1088/1742-6596/755/1/011001.

[5] Dahlia Yuliskurniawati, I. et al. (2019) 'Science process skills based on genders of high school students', Journal of Physics: Conference Series, 1241(1). doi: 10.1088/1742-6596/1241/1/012055.

[6] Maulida, T., Susilawati., &Makhrus, M. (2019). The Influence of the Assisted Discovery Learning Model Business and Energy Practicum Tools on Students' Mastery of Physics Concepts. *JurnalPijarMipa*, 14 (3). 118-122.

[7] Estuhono, Festiyed and Bentri, A. (2020) 'Developing of physics learning devices through research based learning model to improve high students' four cs in the 4.0 industrial revolution era', International *Journal of Scientific and Technology Research*, 9(1), pp. 2648–2653.

[8] Minasari, M., Hadisaputra, S. and Setiadi, D. (2020) 'Analysis of high school students' science process skills through discovery learning model oriented science technology society', *Jurnal Pijar Mipa*, 15(3), p. 234. doi: 10.29303/jpm.v15i3.1888.

[9] Yustiqvar, M., Gunawan, G., & Hadisaputra, S. (2019, December). Green Chemistry Based Interactive Multimedia on Acid-Base Concept. In *Journal of Physics*: Conference Series (Vol. 1364, No. 1, p. 012006). IOP Publishing.

[10] Ozgelen, S. (2012). Student' science process skills within a cognitive domain framework. *Eurasia Journal of Mathematics, Science & Technology Education*, 8, 283 – 292.

[11] Susilowati, S. (2017) 'Development of Integrated Science Teaching Materials Islamic Values to Improve Student Attitudes and Achievements in Science Learning ', *Journal of Science Education Innovation*, 3(1), p. 78. doi: 10.21831/jipi.v3i1.13677.

[12] Usmeldi, Amini, R. and Trisna, S. (2017) 'The development of research-based learning model with science, environment, technology, and society approaches to improve critical thinking of students', *Jurnal Pendidikan IPA Indonesia*, 6(2), pp. 318–325. doi: 10.15294/jpii.v6i2.10680.

[13] Usmeldi (2016) 'The development of research-based physics learning model with scientific approach to develop students' scientific processing skill', *Jurnal Pendidikan IPA Indonesia*, 5(1), pp. 134–139. doi: 10.15294/jpii.v5i1.5802.

.

Modeling the brown eye spot sampling in Arabica coffee

José Salazar Zanuncio Junior[1], Hélcio Costa[1], Raíza Rainha Dorzenoni[2], Rogério Carvalho Guarçoni[1], Maurício Lorenção Fornazier[3], Suiane Reinaldo Sossai[2], Luciana Aparecida Botacim[4], Elaine Manelli Riva Souza[1], Maria Amélia Gava Ferrão[5], David dos Santos Martins[6], Luiz Fernando Favarato[1], Maurício José Fornazier[1*]

[1]Instituto Capixaba de Pesquisa, Assistência Técnica e Extensão Rural (INCAPER), State of Espírito Santo, Brazil
E-mail: jjzanuncio@gmail.com; helciocosta@incaper.es.gov.br; rogerio.guarconi@gmail.com; lffavarato@gmail.com; elaine.riva@gmail.com; mauriciofornazier@gmail.com
[2]Scientific scholarship holder/Consórcio Café (CONCAFE/FUNCAFE), State of Espírito Santo, Brazil
E-mail: raizarainha@outlook.com;suhrsossai@gmail.com
[3]Scientific scholarship holder/Fundação de Amparo à Pesquisa do Espírito Santo (FAPES), Instituto Federal do Espírito Santo (IFES)/Campus Alegre, State of Espírito Santo, Brazil
E-mail: mauzier_lf@hotmail.com
[4]Scientific scholarship holder/Fundação de Amparo à Pesquisa do Espírito Santo (FAPES)/Centro de Ciências Agrárias e Engenharia da Universidade Federal do Espírito Santo, CCAE-UFES/Campus Alegre, State of Espírito Santo, Brazil
E-mail:lucianabotacim@gmail.com
[5]Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA)/INCAPER, State of Espírito Santo, Brazil
E-mail: maria.ferrao@embrapa.br
[6]Researchscholarship holder/Fundação de Amparo à Pesquisa do Espírito Santo (FAPES)
E-mail: davidentomol@gmail.com
* Corresponding author: e-mail: mauriciofornazier@gmail.com

Abstract— *Coffee production has a great socioeconomic importance for Brazil. It generates direct and indirect jobs, and foreign exchange, with Brazilian Arabica coffee production estimated between 42 - 46 million bags (60 kg) in 2020. It is the main agribusiness activity in the State of Espírito Santo, Brazil with expected production between 13 - 15 million bags, and around 30% of this production is Arabica coffee. Technologies are recommended to coffee growers to increase yield, and production of specialty coffees on sustainable properties. Among the principles of integrated management is the monitoring of pests and diseases to determine the level of pest control. The estimate of the number of leaves to be sampled in the monitoring becomes an important tool to increase the accuracy of the obtained information. This research was carried out aiming to determine the minimum number of leaves necessary to evaluate the infestation of brown eye spot (BES) of coffee in Arabica coffee (Coffea arabica L.) without affecting the accuracy of the collection method. It was observed that the estimate of the minimum number for sampling was 46 leaves for the characteristics of incidence, and severity of BES in Arabica coffee. The modeling applied in this study allows to conclude that it is possible to recommend an optimum number of Arabica coffee leaves for these edaphoclimatic conditions, and variety, and it can*

serve as a basis for monitoring in an integrated pest and disease management program in Arabica coffee.

I.   INTRODUCTION

Coffee growing has great socioeconomic importance for Brazil, generating direct and indirect jobs, and foreign exchange. Between 57.15 - 62.02 million bags of processed coffee (60 kg) will be harvested, and it is estimated that between 42.20 - 45.98 million bags are Arabica coffee. Coffee is the main agribusiness activity in the State of Espírito Santo, Brazil with production expected to be between 13.02 - 15.44 million bags of processed coffee, with around 30.84% of Arabica coffee (CONAB, 2020).

A set of technologies is recommended for the production of specialty coffees on sustainable properties, aiming at the increasing of coffee growing in this Brazilian state. The choice of the variety with the production of inspected seedlings, correct implantation of crops, adequate nutrition, use of techniques for the integrated management of pests, diseases and soil conservation, good harvesting and post-harvesting practices is essential for obtaining special coffees. Biotic and abiotic factors can lead to reductions in coffee production with significant losses in beverage, productivity, and particularly in quality. Among these factor we may find the brown eye spot (BES) of coffee caused by *Mycosphaerella* (or *Cercospora*) *coffeicola* (Cooke) J.A.Stev. & Wellman (1944) that can attack coffee leaves, and fruits (Santos et al., 2008; Souza et al., 2015).

Integrated pest and disease management is one of the tools to be used to reduce the use of pesticides, minimize their impact on the environment, and increase the efficiency of pest and disease control. Monitoring of pests and diseases is one of the principles of integrated pest management. However, it is observed that there are several recommendations regarding the ideal number of leaves to be collected in different processes in conducting the coffee culture. Malavolta (1980) recommends sampling 100 leaves for the assessment of nutritional status, while Silva and Miranda (2016) recommend the collection of 100 to 200 leaves for monitoring diseases.

Several similar methodologies can be used to determine the optimal number of data to evaluate characteristics in order to leave the empirical method aside, such as Guarçoni et al. (2020) who determined the optimal size of plants per experimental plot to evaluate agronomic, and sensory characteristics of arabica coffee. Also, Guarçoni et al. (2017) determined the experimental plot size to evaluate agronomic characteristics of cabbage 'F1 Shinsei Hybrid'. Both surveys used simulation, and the linear plateau response model method, meanwhile Guarçoni (2017)

also used the maximum curvature method. Other works have also used this estimation, and simulation methods to determine the optimal number of experimental plot plants, such as for the pineapple 'Vitória' using the linear plateau response model and maximum curvature (LEONARDO et al., 2014). Guimarães et al. (2019) determined the ideal experimental plot size for the cactus 'Pera Gigante', and Pereira et al. (2018) determined the minimum number of Q-Graders, and R-Graders for sensory evaluation of Arabica and Conilon coffees.

These methods use blank or uniformity tests, where only one variety is planted, and receiving the same cultivation practices. Through the visual inspection method of the maximum curvature, the coefficients of variation CV (X) are calculated for each plot size X where V (X) is the variance of the plots with X basic units (UB) and X´ is the average. The set of points obtained from the pairs [X, CV (X)] are joined forming a curve where the point of maximum curvature is determined by visual inspection, and considering the value of the point's abscissa as the optimal size of the plot (Le Clerg, 1967).

The maximum curvature is a simple and easy method to be used. However, the fact of the visually determining the optimal size of the experimental plot may constitute a source of error because there is no criterion to identify the maximum curvature point on the curve (Paranaiba et al., 2009). The method of visual inspection of the maximum curvature was improved, and the optimal size of the X_OP plot was determined algebraically. This method was used to estimate the optimal size of experimental plots of single, double, and triple corn hybrids, where a function like $CV_X = \frac{A}{X^B}$ was established to explain the relationship between the variation coefficient (CV$_{(X)}$), and optimal size of the experimental plot (X); and then the size of the experimental plot was determined algebraically (Cargnelutti Filho et al., 2011). The linear plateau response model method was used to estimate the parameters, with the optimal size of the experimental plot obtained when the linear model turns into a plateau (Guarçoni et al., 2020).

Determination of the minimum number of leaves necessary to evaluate pests and diseases in Arabica coffee is important because if the number of leaves is less than necessary, less accurate estimates will be obtained. On the other hand, if excessive number of leaves is used, more time and resources will be spent than necessary. Thus, this determination is an important tool to increase the accuracy of the information obtained, and to optimize the

cost/benefit ratio of the labor used. The objective of this work was to determine the minimum number of leaves that can be collected for assessing the BESin Arabica coffee, without reducing the sampling reliability.

II.   MATERIAL AND METHODS

This research was carried out at the Experimental Farm of Venda Nova (FEVN) (20°222'59"S; 41°11'08"W, 736 m altitude), located in the municipality of Venda Nova do Imigrante, and atthe Experimental Farm Mendes da Fonseca (FEMF) (20°22'04"S; 41°03'42"W, 941 m altitude), located in the municipality of Domingos Martins, State of Espírito Santo, Brazil in a competition experiment for selection of Arabica coffee cultivars with 6-years-old, and spaced 2,5 x 1,0 m. The coffee crop has been conducted in a traditional cultivation system using Good Agricultural Practices. All cultural treats were carried out based on sustainable production techniques for Arabica coffee (Alixandre et al., 2020). Fertilization, and soil correction have been carried out according to the results of soil analysis; liming was carried out in June, and fertilization from October to March (Prezotti, 2016).

Sample Preparation

Each sample consisted of one hundred leaves collected at random from the 3rd and 4th pairs of leaves (Huerta 1963), in the median part of the canopy of the five central plants of the experimental plot of the Arabica coffee cultivar Obatã, and 20 leaves were collected from each plant (Malavolta, 1980; Barbosa Junior et al., 2019). Sampling was conducted in the beginning of September. The leaves were taken to the Entomology/Phytopathology laboratory of the Capixaba Institute for Research, Technical Assistance and Rural Extension (Incaper), and were individually analyzed for the incidence, and severity of the BES. The incidence was evaluated observing the presence of the symptoms of the BES.

Incidence (I) of BES was calculated according to the following equation:

I (%) = (NFD/NFT)∗100, where:

I = incidence (%);

NFD = number of diseased leaves;

NFT = total number of leaves.

For severity, the incidence was estimated by the number of symptoms per leaf, dividing this value by the number of infected leaves, and expressed in average of symptoms per infected leaf (Ribeiro et al., 1981; Cardoso et al., 2016; Lima et al., 2018).

Statistical analysis

Bootstrap method (Mammen and Sandi, 2012) was used aiming at a greater consistency of the regression methods in obtaining the optimal size of the experimental plot. This method consists of a statistical resampling technique that established a new framework for statistical analysis based on simulation. The linear plateau response model was used to determine the optimal number of leaves to assess the incidence, and severity of the BESin Arabica coffee. The bootstrap method was used to group the different number of leaves, and their respective variation coefficients, and 1,000 sample simulations were performed with 10, 20, 30, 40, 50, 60, 70, 80, 90, and 100 leaves (Leonardo et al., 2014; Guarçoni et al., 2020).

The groupings of the pairs [X, CV (X)] were used to estimate the parameters of the linear plateau response model. For this method, the optimal size of the number of leaves occurs when the linear model becomes a plateau (equation 1):

$$Y_i = \{ \begin{matrix} \beta_0 + \beta_1 X_i + \varepsilon_i seX_i \le X_0 \\ P + \varepsilon_i seX_i > X_0 \end{matrix} (equation\ 1),$$

where, Y_i is the response variable;β_0 is the linear coefficient of the linear model of the segment prior to the plateau; β_1 the slope of this same segment; $\varepsilon_i$is the error associated with i^{th} observation; P is the plateau, and X_0 is the connection point of the two segments. P and X_0 are parameters to be estimated.

The regression models were tested by the F test, and the angular coefficients by the t test. The software 'R' was used to carry out the simulations of the bootstrap process (R CORE TEAM, 2021), and SAEG program was used to obtain the statistics of the methods for obtaining the optimal plot size (Ribeiro Júnior and Melo, 2008).

III.   RESULTS AND DISCUSSION

BESseverities obtained were 0.38 (FEVN), and 0.66 (FEMF) lesions/leaf. The coefficient of variation of the characteristics depending on the number of leaves decreases up to 50 leaves. From this point on, the largest number of leaves sampled provides the least increase in sampling accuracy (Table 1).

The optimal number of leaves - Xof for incidence, and severity of the BESwere 46, and 45 leaves in the location of FEVN, and 46, and 43 leaves in FEMF(Figure 1), respectively, using the coefficient of variation of the infestation characteristics of the BES as a function of the number of plants, obtained from 1,000 sample simulations by the bootstrap method, with 10, 20, 30, 40, 50, 60, 70, 80, 90 and 100 leaves.

Methodologies for leaf diagnosis in coffee were developed to assess nutritional status, and there are

differences between the authors on the number of leavesthatmust becollected for thisdiagnosis, and itcan varyfrom 2 to 144 leaves (Cintra, 2012).

Table 1. Grouping of different number of Arabica coffee leaves, and respective coefficients of variation to the brown eye spot incidence and severity in two locations (FEVN – 736m, and FEMF – 941 m), Brazil

Number of coffee leaves	Coefficient of variation– CV (%)			
	FEVN[1]		FEMF[2]	
	Incidence	Severity	Incidence	Severity
10	70.25558	79.97715	40.42603	50.86065
20	49.37637	56.57730	29.86538	34.10877
30	39.50008	44.18615	24.56249	29.24666
40	35.22965	40.30568	20.38460	22.72637
50	30.11190	34.37184	18.89769	21.92404
60	27.79280	32.25399	16.67411	19.42357
70	25.72629	29.51076	15.47767	19.02895
80	24.20590	27.07437	15.23577	17.48351
90	23.30275	26.43872	13.67379	16.59606
100	22.15214	25.29883	12.79388	15.39272

[1.]Experimental Farm Venda Nova; [2.]Experimental Farm Mendes da Fonseca.

Among these methodologies, the most used is the recommendation of 100 leaves sampled (Malavolta, 1980).Other diagnostic methodologies recommend sampling the 4th pair of leaves, from the apex of the branch of mature plants, and collecting 50 leaves at the beginning of flowering (Mills and Jones Junior, 1996), or collecting 200 leaves at the four cardinal points, in the 3rd pair from the apex of the branches, at the median plant height (Raij, 2011). This methodology was also recommended to evaluate the incidence of the rust in Conilon coffee (Ventura et al., 2017).

These diagnostic sampling methods have also been used as a basis for monitoring coffee diseases (Silva and Miranda, 2016). However, there are no studies on the number of leaves collected for diagnosis of the BESin Arabica coffee. Results obtained in this research suggest that intensity, and severity of this disease can be evaluated using circa 46 leaves in each experimental plot. This shows that the standard sampling of 100 to 200 leaves (Fornazier et al., 1995, 2017, 2019; Silva and Miranda, 2016) does not provide an increase in the accuracy of the results, but more time, human labor, and financial resources will be spent. However, a number less than 46 leaves per experimental plot may compromise the accuracy in the evaluation of this disease in Arabica coffee.

Other samples have been carried out in other Arabica coffee cultivars in order to establish scientific criteria for sampling of the BESin experimental units under conditions of low, and high incidence. Also, work has been carried out aiming at evaluating rust and the coffee leaf miner, important pests in coffee growing. These data will make it possible to determine the ideal number of leaves to be sampled for joint monitoring of coffee diseases, and pests.

IV. CONCLUSIONS

- The minimum number of leaves required to sample the incidence and severity of the brown eye spot in Arabica coffee is 46.
- The number of leaves sampled can be reduced by approximately 50%, reducing the effort, and the sampling cost.
- Works to determine the number of leaves needed for sampling may increase the efficiency of monitoring other diseases and pests in coffee crop.

Scientific scholarship Magister Science to MLF and LAB, the research scholarship to DSM, the research productivity grants to RCG;to the Consórcio Café (CONCAFE/FUNCAFE) for the grant of research scholarship to SRS, to the Capixaba Institute for Research,

Technical Assistance and Rural Extension (INCAPER) for the support in conducting the experimental areas and equipment available for the research.
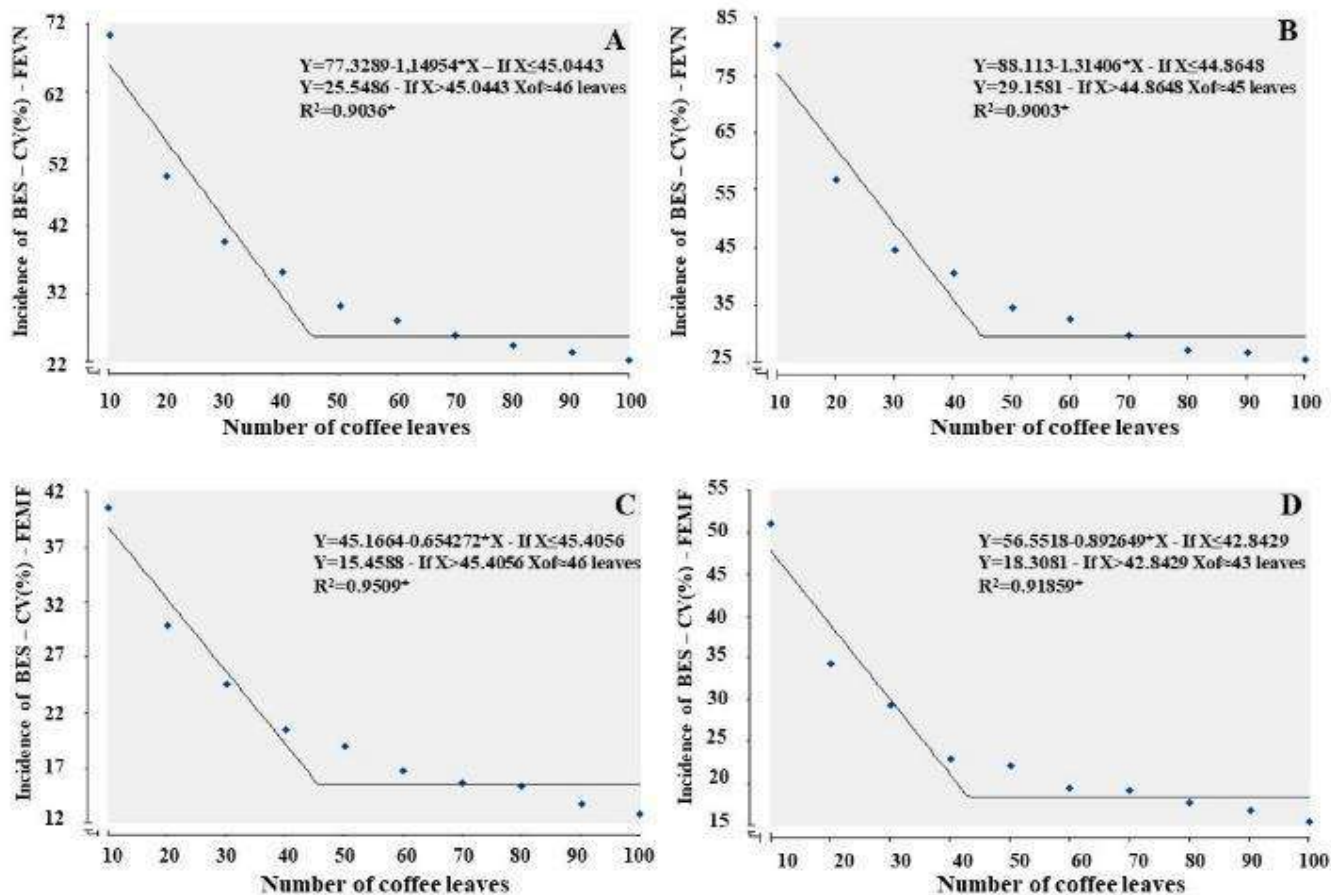
Fig.1 – Relationship between the coefficient of variation and plot size using the linear plateau response model for the incidence (A) and severity (B)at FEVN, and incidence (C) and severity (D)at FEMF of the brown eye spot in Arabica coffee cv. Obatã. * and ** = significant, respectively, at 5%, and 1% of probability, by the F and t tests; ns = not significant.

REFERENCES

[1] Alixandre, F.T.; De Muner, L.H.; Krohling, C.A.; Ferrão, M.A.G.; Fornazier, M.J.; Verdin Filho, A.C. (2020). Cafeicultura sustentável: boas práticas agrícolas para o café arábica. Vitória, ES: Incaper. 48 p. (Incaper, Documentos, 269).

[2] Barbosa Junior, M.P.; Pozza, E. A.; Santos Neto, H.; Silva, M.L.O.; Pozza, A.A.A.; Guimarães, R.J.; Paulo Estevão de Souza, P.E. (2019). Brown eye spot in coffee subjected to different drip irrigation and fertilization management. Australasian Plant Pathology, 48:245–252.

[3] Cardoso, D.A. et al. (2016). Seleção de progênies f4 de cafeeiros com resistência à ferrugem na região sul de minas gerais. Coffee Science, Lavras, 11:555-566.

[4] Cargnelutti Filho, A.; Toebe, M.; Burin, C.; Casarotto, G.; Dal'Col, L.A.(2011). Métodos de estimativa do tamanho ótimo de parcelas experimentais de híbridos de milho simples, triplo e duplo. Ciência Rural, v.41, n.9, p.1509-1516.

[5] Cintra, A.C.O. (2012). Amostragem de folhas em cafeeiro para fins de diagnose do estado nutricional. 2012. Dissertação de Mestrado em Ciências do Solo - Faculdade de Ciências Agrárias e Veterinário - UNESP, Jaboticabal, SP, 46 p.

[6] CONAB (Companhia Nacional de Abastecimento) (2020). Acompanhamento da Safra Brasileira de Café. Safra 2020. Primeiro Levantamento. Brasília, Janeiro de 2020. Available at: http://www.sapc.embrapa.br/arquivos/consorcio/levantamento/conab_safra_2020n1.pdf.

[7] Fornazier, M.J.; Benassi, V.L.R.M.; Martins, D.S. (1995). Pragas. In: Costa, E.B.; Silva, A.E.S.; Andrade Neto, A.P.M.; Daher, F.A. (Eds.) Manual Técnico para a cultura do café no Estado do Espírito Santo. p. 68-81.

[8] Fornazier, M.J.; Martins, D.S.; Fanton, C.J.; Benassi, V.L.R.M. (2019). Integrated pest management in Conilon

coffee. In: Ferrão, R.G.; Fonseca, A.F.A.; Ferrão, M.A.; De Muner, L.H. (Eds.). Café Conilon - 3ª edição.Vitória, ES. p. 493-533.

[9] Fornazier, M.J.; Martins, D.S.; Fanton, C.J.; Benassi, V.L.R.M. (2017). Manejo de Pragas do Café Conilon. In: Ferrão, R.G.; Fonseca, A.F.A.; Ferrão, M.A.; De Muner, L.H. Café Conilon - 2ª edição:atualizada e ampliada 2ed. Vitória, ES. p. 399-433.

[10] Guarçoni, R.C.; Alixandre, F.T.; Sousa, D.G.; Pereira, L.L.; Brioschi Junior, D.; Sousa. L.H.B.P.; Favarato, L.F.; Marcate, J.P.P.(2020). Plot size for evaluation of agronomic and sensorial characteristics of arabica coffee. Revista Brasileira de Biometria, v. 38, n. 1, p. 57-68.

[11] Guarçoni, R.C.; Souza, J.L.; Favarato, L.F.; Angeletti, M.D.P.; Bahiense, D.S.(2017). Determinação do tamanho ótimo de parcela experimental para experimentos com repolho utilizando simulação e métodos de estimação. Revista Científica Intelletto, v.2, n.2 p.79-87.

[12] Guimarães, B.V.C.; Donato, S.L.R.; Aspiazú, I.; Azevedo. A.M.; Carvalho, A.J.(2019). Methods for estimating optimum plot size for 'Gigante' Cactus Pear. Journal of Agricultural Science, v.11. n.14.

[13] Huerta, S. A. (1963). Par de folhas representativo del estado nutricional del cafeto. Cenicafé, 14: 11–127.

[14] Le Clerg, E.L. (1967). Significance of experimental design in plant breeding. In: FREY, K. J. Plant breeding symposium. Ames: Iowa State University, p. 243-313.

[15] Leonardo, F.A.P.; Pereira, W.E.; Silva, S.M.; Araujo, R.C.; Mendonça, R.M.N. (2014). Tamanho ótimo da parcela experimental de abacaxizeiro 'Vitória'. Revista Brasileira de Fruticultura, v.36, n.4, p. 909-916.

[16] Lima, A.E.; Sampaio Junior, H.G.; Castro, E.M.; Carvalho, S.P.; Silva, F.F.; Lima Junior, S.; Carvalho, A.M. (2018). Incidence and severity of coffee leaf rust, cercosporiosis and coffee leaf miner in coffee progenies. Coffee Science, 13:349 - 355.

[17] Malavolta, E. (1980). Elementos de nutrição mineral de plantas. São Paulo: Agronômica. Ceres, 251 p.

[18] Mammen, E.; Nandi, S. (2012). Bootstrap and resampling. In: Gentle, J.E.; Hardle, W.K.; Mori, Y. (Eds.). Handbook of computational statistics, springer handbooks of computational statistics. Heidelberg: Springer-Verlag. p. 499-527.

[19] Mills, H.A.; Jones Júnior, J.B. (1996). Plant Analysis Handbook II: a practical sampling, preparation, analysis and interpretation guide. 2. ed. Athens: MicroMacro, p. 422.

[20] Paranaiba, P.F.; Morais, A.R.; Ferreira, D.F.(2009). Tamanho ótimo de parcelas experimentais: proposição de métodos de estimação. Revista Brasileira de Biometria, v.27, n.2, p.255-268.

[21] Pereira, L.L.; Guarçoni, R.C.; Souza, G.S.; Brioschi Junior, D.; Moreira, T.R.; Caten, C.S.(2018). Propositions on the Optimal Number of Q-Graders and R-Graders. Journal of Food Quality, p.1-7.

[22] Prezotti, L.C. (2016). Sistema de recomendação de calagem e adubação. Available at: <https://incaper.es.gov.br/Media/incaper/DOCUMENTOS/ Recomendacao_calagem.zip>.

[23] Raij, B. van. (2011). Fertilidade do solo e manejo de nutrientes. Piracicaba: International Plant Nutrition Institute, p. 420.

[24] R CORE TEAM. (2021). *R:* A language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing. Available at: <https://www.R-project.org>.

[25] Ribeiro, I.J.A.; Bergamim Filho, A.; Carvalho, P.C.T. (1981). Avaliação da resistência horizontal a *Hemileia vastatrix* Berket Br. em cultivares de *Coffea arabica* L. em condições naturais de epidemia. Summa Phytophathologica, Piracicaba, 7:80-95.

[26] Ribeiro Júnior, J.I.; Melo, A.L.P. Guia prático para utilização do SAEG. Viçosa: Folha, 2008. 288p.

[27] Santos, F.S.; Souza, P.E.; Pozza, E.A.; Miranda, J.C.; Barreto, S.S.; Theodoro, V.C. (2008). Progresso da cercosporiose (*Cercospora coffeicola* Berkeley & Cooke) em cafeeiros sob cultivos orgânico e convencional. Summa Phytopatologica, v.34, p. 48-54.

[28] Silva, R.V.; Miranda, B.E.C. (2016). Monitoramento das doenças do cafeeiro. In: BRASIL. Cadernos de aulas práticas dos Institutos Federais: cafeicultura. MEC/Secretaria de Educação Profissional e Tecnológica, Brasília, DF, p.57-64.

[29] Souza, A.G.C.; Maffia, L.A.; Silva, F.F.; Mizubuti, E.S.G.; Teixeira, H. (2015). Atime analysis of brown eye spot progress in conventional and organic coffee production systems. Plant Pathology, v. 54, p.157-166.

[30] Ventura, J.A.; Costa, H.; Lima, I.M. (2017). Manejo das doenças do cafeeiro conilon. In: Ferrão, R.G.; Fonseca, A.F.A.; Ferrão, M.A.; De Muner, L.H. Café Conilon - 2ª ediçãoatualizada e ampliada 2ed. Vitória, ES. p. 435-493.

Factors associated with self-rated health in older adults receiving oral prosthetic rehabilitation

Lucianna Leite Pequeno[1], Paulo Leonardo Ponte Marques[2], Maria Vieira de Lima Saintrain[3], Ilana Nogueira Bezerra[4], Anya Pimentel Gomes Fernandes Vieira-Meyer[5], Sandy Kaena Soares de Freitas[6], José Manuel Peixoto Caldas[7]

[1]School of Dentistry, Universidade de Fortaleza (UNIFOR), Fortaleza, Ceará, Brazil
Email: lupequeno@unifor.br
[2]School of Dentistry, Universidade de Fortaleza (UNIFOR), Fortaleza, Ceará, Brazil
Email: paulomarques@unifor.br
[3]Public Health Graduate Program, Universidade de Fortaleza (UNIFOR), Fortaleza, Ceará, Brazil
Email: mvlsaintrain@yahoo.com.br
[4]School of Nutrition, Universidade Estadual do Ceará (UECE), Fortaleza, Ceará, Brazil
Email: ilana.bezerra@yahoo.com.br
[5]Family Health Master's Program, Fundação Oswaldo Cruz (FIOCRUZ), Eusébio, Ceará, Brazil
Email: anyavieira10@gmail.com
[6]Public Health GraduateProgram, Universidade de Fortaleza (UNIFOR), Fortaleza, Ceará, Brazil
Email: sandy_kaena@hotmail.com
[7]Interdisciplinary Center for Gender Studies. University of Lisbon & ISPUP/University of Porto.
Email: jcaldas@fpce.up.pt

Corresponding author
Maria Vieira de Lima Saintrain.
ORCID https://orcid.org/0000-0002-3370-3218
Rua Irmã Simas, 100 apt 201 Bloco A Varjota CEP 60.165-220 Fortaleza-CE, Brasil.
E-mail: mvlsaintrain@yahoo.com.br. Phone: +55 85 988039038.

Abstract— Objectives: To assess factors associated with self-perception of health in older adults submitted to oral prosthetic rehabilitation in order to contribute to a more contextualized planning of public policies, actions and health services aimed at healthy aging. Design: Analytical cross-sectional study. Setting: Dental specialty centers. Participants: 244 people aged 60 years and older enrolled for oral prosthetic rehabilitation. Intervention: Interviews, oral examination and anthropometric measurements. Measurements: A questionnaire assessed demographic and economic data, general health and oral health and self-perception of oral health-related quality of life was measured by the Geriatric Oral Health Assessment Index (GOHAI). Performance in instrumental activities of daily living was assessed by the Lawton and Brody scale, mood was assessed by the Geriatric Depression Scale and nutritional status was assessed by the Mini Nutritional Assessment. Results: The multivariate analysis showed that factors such as hospitalization in the previous year, diabetes and risk of malnutrition determined the negative self-

perception of general health and current health status compared with 12 months ago. Needing assistance to perform AIDL significantly influenced self-perception of general health while income and vision problems interfered with older adults' perception of their current health status compared with 12 months ago. Conclusion: Older adults who needed oral prosthetic rehabilitation exhibited a predominantly negative self-perception of oral health.

I.   INTRODUCTION

Population aging is a reality in Brazil, a country where older adults are people aged 60 years or older. This age group is prioritized in health services and there are even specific regulations that prioritize people aged over 80 years [1].

Healthy Aging is the process of development and maintenance of functional capacity that allows well-being at an advanced age [2]. According to the World Health Organization (WHO), health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity [3].

Self-perceived heath consists of people's perception of their health status taking into consideration the socioeconomic, cultural and historical context and is used to assess older adults' functional capacity [4,5]. Research on older adults' self-perceived health has presented contradictory results. Positive self-rated health can mean older adults' difficulty in performing a critical analysis of their own health while negative self-rated health can also be influenced by older adults' functional disability and mental health.

Studies emphasize that most older adults report a self-perception of good health despite the presence of chronic diseases. This finding indicates that this population group relates health to autonomy and independence, thus showing that the absence of diseases does not necessarily influence their self-perception of health [5-7].

Oral health is an integrating part of general health. Therefore, maintaining good oral health in older adults is key to ensuring healthy aging, especially because older adults are commonly submitted to curative and mutilating dental procedures. In Brazil, for instance, the rate of use of and need for dental prosthesis in 2010 was 78.2% and 68.7%, respectively [8].

Given that, public health policies should take into consideration the clinical and subjective needs of older adults based on their self-perception of health and the influence of oral health on the quality of life [9].

In view of the considerations outlined above, we raised the hypothesis that negative self-perception of health is influenced by sociodemographic conditions, general health, oral health, self-perception of oral health, functional capacity, mood, and nutritional status. Thus, the present study aimed to assess factors associated with self-perception of health in older adults submitted to oral prosthetic rehabilitation.

II.   METHODS

A cross-sectional study was carried out in two dental specialty centers (*Centros de Especialidades Odontológicas – CEOs*) located in the city of Fortaleza in Northeastern Brazil. The CEOs are reference secondary care centers for oral prosthetic rehabilitation of people served by Brazil's Unified Health System (*Sistema Único de Saúde – SUS*) [10].

The sample of 260 older adults was obtained using the formula for finite population considering a total of 257,715 older adults in the city of Fortaleza [11], an expected loss of 20%, an expected value of sample proportion of 83% of older adults who need dental prosthesis [8], a significance level of 5%, and a maximum permissible error of 5%.

Data were collected by previously trained researchers between December 2016 and April 2017. We collected sociodemographic information and general and oral health data through interviews held in private in the centers where the research took placeafter obtaining written informed consent from the participants.

Self-perception of general health was assessed by asking the following question: "How is your general health?". The dependent variable of the study was dichotomized into negative perception ("poor" category) and positive perception ("very good" and "fair" categories). Self-perception of current health status compared with 12 months ago was assessed by asking the following question: "How is your health now compared with 12 months ago?". The dependent variable was dichotomized into negative perception ("worse" category) and positive perception ("better" and "the same" categories) [12].

The need for oral prosthetic rehabilitation was assessed using a WHO instrument recommended by the 2010 SB-Brazil Survey [8,13]. Oral health-related quality of life was assessed by the Geriatric Oral Health

Assessment Index (GOHAI) [14]. Higher index values indicate better oral health and better self-perception of oral health-related quality of life. Values ranging 34-36 are considered high, values ranging 31-33 are considered moderate, and values below 30 are considered low [15].

Performance in Instrumental Activities of Daily Living (IADL) was assessed by the Lawton & Brody scale [16]. The scale assesses nine domains and the total score ranges 9-27 points. Individuals with scores of 19-27 points are classified as independent. Scores of 10-18 indicate assisted independence and scores of 1-9 points indicate dependence.

Nutritional status was assessed using the Mini Nutritional Assessment (MNA), which consists of 18 self-reported questions. Results are given based on the sum of the scores in each domain [17]. Scores of 24-30 points indicate normal nutritional status, scores of 17-23.5 points indicate risk of malnutrition, and scores below 17 points indicate malnutrition. Height (cm) and weight (kg) measurements were taken according to the World Health Organization protocol [18].

Mood was assessed using Geriatric Depression Scale (GDS). The short form of the GDS consists of 15 questions (GDS15) and its total score ranges 0-15. Scores of 0-5 are considered normal; 6-10 indicate mild depression; and 6-15 indicate severe depression [19].

This study was approved by a Research Ethics Committee (Approval No 1.699.965/2016). Data were presented using descriptive statistics and bivariate analyses were performed using either the Chi-squared test or Fisher's exact test. The strength of the associations was measured using prevalence ratios for independent variables with a significance level of 95%. Variables with a *p* value below 0.20 were analyzed using Poisson regression with robust error variance. The final model included the variables that presented significant associations at p<0.05.

III.   RESULTS

Participants were 244 older adults, which means there was a loss of 6.2%, which was lower than expected. There was a predominance of women (74.2%) and participants aged 60-69 years (62.3%). Age ranged 60-91 years and the mean age was 68.9 years (SD: 7.1). There were higher rates of Mixed-race Brazilians(49.6%), married participants (56.9%), participants who lived with their spouse (36.9%) or children (30.7%), unemployed participants (75.4%), participants with an income of up to two minimum wages (72.9%), and participants with one to eight years of study (54.5%). The majority (89.3%) used medication and there was a mean of 3.6 (SD: 3.1)

medications per older adult. In addition, 112 (45.9%) participants were physically active, 30 (12.3%) were smokers and 40 (16.4%) were drinkers.

Systemic diseases were reported by 208 (85.2%) participants and the main diseases were hypertension (68%), diabetes (29.1%) and osteoporosis (21.7%). History of falls was reported by 145 (59.4%) participants and 200 (81.9%) reported vision problems, 82 (33.6%) reported hearing problems and 20 (8.2%) reported speech problems. In all, 51 (20.9%) participants reported having a health insurance and 207 (84.8%) had used health services in the last year, 180 (73.7%) of whom used public health services. In addition, 165 (67.6%) participants said they had their health problems solved.

Dry mouth was reported by 108 (44.2%) participants. Additionally, 107 (43.9%) participants had difficulty chewing and swallowing food, 51 (20.9%) had problems with the taste of food, 18 (7.4%) needed assistance to eat, 170 (69.7%) were already using some type of dental prosthesis and needed to replace it, and 74 (30.3%) had never used dental prostheses.

Older adults who needed oral prosthetic rehabilitation exhibited a predominantly (52.1%) negative self-perception of oral health. A total of 235 (96.3%) participants had a good index of independence in IADL, 179 (73.4) presented normal nutritional status and 185 (75.8%) did not exhibit signs of depression. In addition, 56 (23%) older adults rated their general health as very good, 145 (59.4%) rated it as fair and 43 (17.6%) rated it as poor (CI: 13.1-23.0). As for self-perception of current health status compared with 12 months ago, 50 (20.5%) participants said their health was better, 141 (57.8%) said it was the same and 53 (21.7%) said it was worse (CI: 16.7-27.4).

Tables 1 to 3 present the bivariate analyses of the associations between the independent variables of the study and the results of older adults' self-perception of general health and current health status compared with 12 months ago.

Table 4 shows the final model for the two outcome variables. The multivariate analysis showed that factors such as hospitalization in the previous year, diabetes and risk of malnutrition determined the negative self-perception of general health and current health status compared with 12 months ago. Needing assistance to perform AIDL significantly influenced self-perception of general health while income and vision problems interfered with older adults' perception of their current health status compared with 12 months ago.

IV.   DISCUSSION

We certify that this work is novel and that its results can contribute to a better understanding of the factors that interfere with older adults' self-perception of health and the conditions perceived in a negative way, which may serve as an important strategy for developing public health policies, planning broader preventive actions and improving access to and quality of health services.

The present study stands out in the current scientific scenario as it was carried out with older adults in need of oral prosthetic rehabilitation treated in reference centers. Access to free oral health care may have contributed to older adults' positive self-perception of general health as poor access to health care services have been associated with older adults' negative self-perception of general health [20-22].

In fact, 82.4% of the older adults who needed oral prosthetic rehabilitation had a positive self-perception of general health. Moreover, 78.3% of the participants had a positive self-perception of current health status compared with 12 months ago. These rates are higher than those reported in the literature (41.9%-57.5%) [23-25]. However, some studies have reported rates ranging 65.0%-82.9% [5,12].

The rate of participants with a negative perception of general health (17.6%) and current health status compared with 12 months ago (21.7%) was lower than that reported (57.6%) by Medeiros et al. [20]. Studies have reported higher rates of negative perception of health among institutionalized older adults [12,26], old-old cohorts of older adults, individuals with functional decline and dependence, and individuals with history of hospitalizations and a higher burden of chronic diseases [12,27].

In the bivariate analysis, level of education, hospitalization, systemic diseases, diabetes, number of medications used, solution of health problems, nutritional risk and signs of depression were associated with negative self-perception of general health and current health status compared with 12 months ago, thus confirming the subjective and multidimensional aspects of the studied outcomes [25,27,28] as well as regional peculiarities and older adults' specific vulnerabilities [20].

The predominance of negative self-perception of oral health (52.1%) is probably associated with complete or partial edentulism. The prevalence rate of negative self-perception of general health was 89% higher among older adults with lower GOHAI scores. In the study by Zanesco et al [29], 19% of the older adults analyzed presented negative perceptions of oral health and were 1.92 times more likely to negatively perceive their general health.

In the final model, the variables that remained associated with negative self-perception of general health and current health status compared with 12 months ago were hospitalization in the previous year, diabetes and risk of malnutrition. Need for assistance to perform IADL influenced general health while income and vision problems had an impact on self-perception of current health status compared with 12 months ago.

A total of 30 (12.3%) older adults had been hospitalized in the previous twelve months. A higher rate was reported by Medeiros et al [20] and the 2013 National Health Survey [24] found that 90% of the interviewees had been hospitalized in the previous 12 months and that hospitalization was associated with older adults' increased likelihood of having a negative perception of health. In the present study, the prevalence of negative perception of general health was 95% higher among older adults who reported hospitalization. Moreover, hospitalization in the previous year increased by 2.1 times the prevalence of negative self-perception of current health status compared with 12 months ago.

Hospitalization can have a negative impact on the quality of physical and psychological aspects and may lead to a decrease in older adults' autonomy to perform daily activities. Hospitalization may have resulted from complications of chronic systemic diseases or from factors such as falls and malnutrition. Hospitalization is more prevalent and prolonged in older adults [30] and increases the incidence of malnutrition [31]. Researchers found that older patients who reported poor health had an increased risk of hospitalization, institutionalization and mortality when compared with those who reported very good health [32].

The fact that diabetic patients (29.1%) were more likely to have negative self-perceptions of general health (PR: 2.43) and current health status compared with 12 months ago (PR: 1.89) is corroborated by researchers who found a significant association between self-perceived health and diabetes [23] and other authors whose multivariate analysis revealed that having diabetes is associated with a negative perception of health [20].

Diabetes is one of the most prevalent diseases in older adults [33] and it may interfere with performance of daily activities due to the continuous use of medications and dietary restrictions, which seem to be more strongly associated with negative perception of health status than the disease itself [34]. Diabetes is also associated with functional disability, hypertension and higher rates of hospitalization and premature death in older adults [35]. It may be associated with xerostomia and oral infections such as periodontal disease]36] as chronic hyperglycemia

modifies vascular and cerebral metabolism [37]. Therefore, limitations and complications caused by diabetes may explain older adults' negative self-perception of health.

In our study, self-perception of health was also influenced by risk of malnutrition. In all, 60% the older adults who were at risk of malnutrition had a negative self-perception of current health status compared with 12 months ago and were 2.42 times more likely to have a negative perception of general health. The 26.6% rate of malnourished older adults found in our study is in accordance with the rates reported in the literature, with values ranging 15%-54.1% [38-41]. In contrast, the lowest rates of risk of malnutrition have been found among non-institutionalized older adults with positive perception of health [40]. The interviewees were people who would receive prostheses, therefore, the lack of these can influence their nutrition.

Malnutrition is more prevalent among hospitalized (31.2%-40%) and institutionalized (39.6%-60%) older adults [38-42]. Like Brazil, other countries have also exhibited similar rates, such as Indonesia (57%) [43] and India (52.5%) [44].

Changes in dietary intake and changes in nutrient absorption may lead to the risk of malnutrition, which is associated with older adults' frailty, which is included in a broad concept of functional impairment [40]. Functional capacity, on the other hand, includes older adults' potential to choose and perform daily life tasks independently. Functional capacity decreases with age and may be intensified by systemic diseases and other factors [45].

Need for assistance to perform IADL was presented by 3.7% of the participants. Changes in the ability to perform daily activities may be associated with malnutrition, cardiovascular diseases, cognitive impairment, and decreased muscle strength and physical performance [46].

Functional limitation is associated with older adults' increased chances of having a negative perception of health. Older adults without functional limitations were 7.76 times more likely to rate their health positively [23]. In our study, older adults who needed assistance to perform IADL were 2.23 times more likely to rate their general health in a negative way, which agrees with the findings reported by Zanesco et al [29].

Ability to perform daily activities strongly determines the health of older adults and has been little studied as an exposure variable. In addition, negative perception of health can worsen functional decline and increase dependence, hospitalization and mortality in older adults [12].

Low levels of income interfere negatively with healthy behavior, home environment and access to health services. People with low levels of income tend to seek health services less often and have poor access to medications. Therefore, they tend to have a poor adherence to treatment of systemic diseases [47].

Low levels of household income were associated with negative self-perception of health in 54.5% of the studies in a review [48]. In the present study, 73% of the older adults reported earning up to two minimum wages, a fact that was associated with a 5.06-fold increase in the chances of having a negative self-perception of current health status compared with 12 months ago in relation to those who reported an income of more than two minimum wages.

Vision problems were reported by 82% of the older adults in our study and were associated with a 3.03-fold increase in the chances of a having negative self-perception of current health status compared with 12 months ago. Visual impairment may be a consequence of older adults' less favorable health and socioeconomic conditions [49]. In addition, they have been reported as major complaints related to the health status of this population group [6] and have been associated with a negative self-perception of health [25,49]. However, it should be noted that it is not the vision problem itself that leads older adults to negatively rate their health, but the social and psychological consequences of such problem.

The present study has some limitations. First, its cross-sectional design, and as so it does not allow to establish proof of a causal relationship in the associations found, thus limiting the interpretation of the results. Second, the information collected through interviews may have been distorted due to memory issues that were not controlled in our study. Finally, self-perception of health is a subjective process that changes according to older adults' context of life and physical and emotional health. However, despite the limitations outlined, our study remains relevant as it aimed to study a growing population whose peculiarities need different planning and reorientation of public health policies.

V.   CONCLUSION

Older adults who needed oral prosthetic rehabilitation exhibited a predominantly negative self-perception of oral health.

Hospitalization in the previous year, diabetes, risk of malnutrition, need for assistance to perform IADL, income and vision problems were associated with older adults' negative self-perception of health. Knowing the

factors that interfere with older adults' self-perception of health and the conditions perceived in a negative way are an important strategy for developing public health policies, planning broader preventive actions and improving access to and quality of health services.

SPONSOR'S ROLE

Sponsors had no role in the design, methods, subject recruitment, data collections, analysis and preparation of paper.

REFERENCES

[1]. Brasil. Lei nº 13.466, de 12 de julho de 2017. Altera os arts. 3o, 15 e 71 da Lei no 10.741, de 1o de outubro de 2003, que dispõe sobre o Estatuto do Idoso e dá outras providências. Brasília, 2017.

[2]. World Health Organization. World Report On Ageing and Health. Geneva, Switzerland: World Health Organization, 2015.

[3]. World Health Organization. Constituição da Organização Mundial da Saúde. Geneva, Switzerland: World Health Organization, 1946.

[4]. Vilela EA, Martins AMEBL, Barreto SM, Vargas AMD, Ferreira RC. Association between self-rated oral appearance and the need for dental prostheses among elderly Brazilians. Braz Oral Res 2013;27:203-210. DOI: https://dx.doi.org/10.1590/S1806-83242013005000010

[5]. Borges AM, Santos G, Kummer JA, Fior L, Molin VD, Wibelinger LM. Autopercepção de saúde em idosos residentes em um município do interior do Rio Grande do Sul. Revbras geriatra gerontol 2014;17:79-86. DOI: http://dx.doi.org/10.1590/S1809-98232014000100009.

[6]. Güths JFS, Jacob MHVM, Santos AMPV, Arossi GA, Béria JU. Sociodemographic profile, family aspects, perception of health, functional capacity and depression in institutionalized elderly persons from the north coastal region of Rio Grande do Sul, Brazil. Revbrasgeriatrgerontol2017;20:175-185. DOI: http://dx.doi.org/10.1590/1981-22562017020.160058

[7]. Tomicki C, Cecchin L, Zanini SCC, Benedetti TRB, Leguisamo CP, Portella MR. Associação entre números de quedas e força muscular de idosos residentes em instituições de longa permanência. Revista Kairóz: Gerontologia 2017;20:101-116. DOI: https://doi.org/10.23925/2176-901X.2017v20i2p101-116.

[8]. Brasil. SB Brasil 2010 - Pesquisa nacional de saúde bucal: resultados principais. Brasília (DF): Ministério da Saúde, 2012.

[9]. Agostinho ACMG, Campos ML, Silveira JLGC. Edentulismo, uso de prótese e autopercepção de saúde bucal entre idosos. Rev. odontol. UNESP 2015;44:74-79. DOI: http://dx.doi.org/10.1590/1807-2577.1072.

[10]. Brasil. Ministério da Saúde - Cadastro Nacional dos Estabelecimentos de Saúde do Brasil - CNES. DATASUS - Departamento de Informática do SUS, 2015.

[11]. Brasil. Informações de Saúde (TABNET): Demográficas e Socioeconômicas (online). Ministério da Saúde. DATASUS - Departamento de Informática do SUS, 2015. Availableat: http://www2.datasus.gov.br/DATASUS/index.php?area=02 06&id=6942.Accessed January 25,2019.

[12]. Jerez-Roig J, Souza DLB, Andrade FLJP et al. Self-perceived health in institutionalized elderly. Ciêncsaúdecoletiva2016;21:3367-3375. DOI: http://dx.doi.org/10.1590/1413-812320152111.15562015.

[13]. World Health Organization. Oral health surveys: basic methods 4th ed..Geneva: ORH/EPID, 1997.

[14]. Atchison KA, Dolan TA. Development of the geriatric oral health assessment index. Journal of dental education1990;54:680-687.

[15]. Silva DD, Sousa MLR, Wada RS. Autopercepção e condições de saúde bucal em uma população de idosos. Cad. Saúde Pública 2005;21:1251-1259. DOI: http://dx.doi.org/10.1590/S0102-311X2005000400028.

[16]. Lawton MP, Brody EM. Assessment of older people: self-maintaining and instrumental activities of daily living. The gerontologist 1969;9:179-186. DOI:https://doi.org/10.1093/geront/9.3_Part_1.179

[17]. Guigoz Y, Vellas B, Garry PJ. Assessing the Nutritional Status of the Elderly: The Mini Nutritional Assessment as Part of the Geriatric Evaluation. Nutrition Reviews 1996;54:59-65. DOI: https://doi.org/10.1111/j.1753-4887.1996.tb03793.x

[18]. World Health Organization. Physical status: the use and interpretation of antropometry (online). Report of a WHO Expert Commitee. WHO Technical Report Series, 854. Geneve: WHO, 1995.

[19]. Yesavage JA, Sheikh JI. Geriatric Depression Scale (GDS): Recent evidence and development of a shorter version. Clinical Gerontologist 1986; 5:165-173. DOI: http://dx.doi.org/10.1300/J018v05n01_09

[20]. Medeiros SM, Silva LSR, Carneiro JA, Ramos GCF, Barbosa ATF, Caldeira AP. Factors associated with negative self-rated health among non-institutionalized elderly in Montes Claros, Brazil. Ciênc. Saúde Coletiva 2016; 21:3377-3386. DOI: http://dx.doi.org/10.1590/1413-812320152111.18752015.

[21]. Rosenkranz RR, Duncan MJ, Rosenkranz SK, Kolt GS. Active lifestyles related to excellent self-rated health and quality of life: cross sectional findings from 194,545 participants in The 45 and Up Study. BMC Public Health 2013;13:1071. DOI: 10.1186/1471-2458-13-1071.

[22]. Louvison MCP, Lebrão ML, Duarte YAO, Santos JLF, Malik AM, Almeida ES. Desigualdades no uso e acesso aos serviços de saúde entre idosos do município de São Paulo. Rev. Saúde Pública 2008;42:733-740. DOI: http://dx.doi.org/10.1590/S0034-89102008000400021.

[23]. Gomes MFS, Pereira SCL, Abreu MNS. Fatores associados à autopercepção de saúde dos idosos usuários dos restaurantes populares de Belo Horizonte. Ciênc. saúde coletiva 2018;23:4007-4019. DOI: http://dx.doi.org/10.1590/1413-812320182311.31072016.

[24]. Instituto Brasileiro de Geografia e Estatística. Pesquisa Nacional de Saúde 2013 - Percepção do estado de saúde, estilos de vida e doenças crônicas. Brasília: Ministério da Saúde, 2014. Availableat:

https://biblioteca.ibge.gov.br/visualizacao/livros/liv91110.pdf. AccessedDecember 20, 2018.

[25]. Silva RJS, Smith-Menezes A, Tribess S, Rómo-Perez V, Virtuoso JJS. Prevalência e fatores associados à percepção negativa da saúde em pessoas idosas no Brasil. Rev. bras. epidemiol. 2012;15:49-62. DOI: http://dx.doi.org/10.1590/S1415-790X2012000100005

[26]. Sereny MD, Gu D. Living arrangement concordance and its association with self-rated health among institutionalized and community-residing older adults in China. J Cross Cult Gerontol. 2011;26:239-59. DOI: 10.1007/s10823-011-9145-y.

[27]. Höfelmann DA, Garcia LP, Freitas LR. Self-rated health in Brazilian adults and elderly: data from the National Household Sample Survey 2008. Salud Publica Mex. 2014;56:603-11.

[28]. Aguilar-Palacio I, Carrera-Lasfuentes P, Rabanaque MJ. Saludpercibida y nivel educativo enEspaña: tendencias por comunidades autónomas y sexo (2001-2012). Gac Sanit. 2015;29:37–43. DOI: https://doi.org/10.1016/j.gaceta.2014.07.004

[29]. Zanesco C, Bordin D, Santos CB, Müller EV, Fadel CB. Factors determining the negative perception of the health of Brazilian elderly people. Rev. bras. geriatr. gerontol. 2018;21:283-292. DOI: http://dx.doi.org/10.1590/1981-22562018021.170210.

[30]. Zen D, Leite MT, Hildebrandt LM, Silva LAA, Sand ICPV. Policies of attention to the elderly according to the voice of the municipal managers of health. Rev. Gaúcha Enferm 2018;39:e62502. DOI: http://dx.doi.org/10.1590/1983-1447.2018.62502.

[31]. Poisson P, Laffond T, Campos S, Dupuis V, Bourdel-Marchasson I. Relationships between oral health, dysphagia and undernutrition in hospitalised elderly patients. Gerodontology2016;33:161-168. DOI: 10.1111/ger.12123.

[32]. Nielsen AB, Siersma V, Waldemar G, Waldorff FB. The predictive value of self-rated health in the presence of subjective memory complaints on permanent nursing home placement in elderly primary care patients over 4-year follow-up. Age Ageing 2014;43:50-57. DOI: 10.1093/ageing/aft131.

[33]. Prince MJ, Wu F, Guo Y et al. The burden of disease in older people and implications for health policy and practice. Lancet 2015;385:549-562. DOI: 10.1016/S0140-6736(14)61347-7.

[34]. Nützel A, Dahlhaus A, Fuchs A et al. Self-rated health in multimorbid older general practice patients: a cross-sectional study in Germany. BMC Fam Pract2014;15:1. DOI: 10.1186/1471-2296-15-1.

[35]. Borba AKOT, Marques APO, Ramos VP, Leal MCC, Arruda IKG, Ramos RSPS. Factors associated with elderly diabetic adherence to treatment in primary health care. Ciênc. saúde coletiva 2018;23:953-961. DOI: http://dx.doi.org/10.1590/1413-81232018233.03722016.

[36]. Cullinan MP, Seymour GJ. Periodontal disease and systemic illness: will the evidence ever be enough? Periodontol 2000 2013;62:271-286. DOI: 10.1111/prd.12007.

[37]. Huang DL, Chan KC, Young BA. Poor oral health and quality of life in older U.S. adults with diabetes mellitus. J Am Geriatr Soc. 2013;61:1782-1788. DOI:

10.1111/jgs.12452.

[38]. Wirth R, Streicher M, Smoliner C et al. The impact of weight loss and low BMI on mortality of nursing home residents - Results from the nutritionDay in nursing homes. ClinNutr2016;35:900-906. DOI: 10.1016/j.clnu.2015.06.003.

[39]. Hernández GA, Pontes TY, Goñi CI. Riesgo de malnutriciónen una poblaciónmayor de 75 años no institucionalizada conautonomía funcional. Nutr. Hosp. 2015;32:1184-1192. DOI: http://dx.doi.org/10.3305/nh.2015.32.3.9176.

[40]. Julio MPM, Clavero AE, Soler MLM. Nutritional status and factors associated with non-institutionalized people over 75 years of age. Rev. Bras. Enferm. 2018;71:1007-1012. DOI: http://dx.doi.org/10.1590/0034-7167-2017-0207.

[41]. Guerrero-García NB, Gómez-Lomelí ZM, Leal-Mora D, Loreto-Garibay O. Fragilidadenancianos y estado nutricional segúnel Mini Nutritional Assessment. Revista Médica del Instituto Mexicano del Seguro Social 2016;54:312-317.

[42]. Ferreira JD, Soares MJ, Lima CL, Ferreira TM, Oliveira P, Silva M. Evaluación nutricional por el Mini Nutritional Assessment: una herramienta para lasenfermeras. Eglobal2018;17:293-305. DOI: https://doi.org/10.6018/eglobal.17.3.290251

[43]. Adiatman M, Ueno M, Ohnuki M, Hakuta C, Shinada K, Kawaguchi Y. Functional tooth units and nutritional status of older people in care homes in Indonesia. Gerodontology2013;30:262-269. DOI: 10.1111/j.1741-2358.2012.00673.x.

[44]. Kshetrimayum N, Reddy CV, Siddhana S, Manjunath M, Rudraswamy S, Sulavai S. Oral health-related quality of life and nutritional status of institutionalized elderly population aged 60 years and above in Mysore City, India. Gerodontology2013;30:119-125. DOI: 10.1111/j.1741-2358.2012.00651.x.

[45]. Pereira LC, Figueiredo MLF, Beleza CMF, Andrade EMLR, Silva MJ, Pereir AFM. Fatores preditores para incapacidade funcional de idosos atendidos na atenção básica. Rev. Bras. Enferm. 2017;70:112-118. DOI: http://dx.doi.org/10.1590/0034-7167-2016-0046.

[46]. Tavares DMS, Dias FA, Ferreira PCS, Rodrigues LR, Gonçalves JRL, Ferreira LA. Morbidities and quality of life of urban elderly people with and without heart problems. Ciência, Cuidado e Saúde 2014;13:674-681. DOI: http://dx.doi.org/10.4025/cienccuidsaude.v13i4.19407

[47]. Muniz ECS, Goulart FC, Lazarini CA, Marin MJS. Analysis of medication use by elderly persons with supplemental health insurance plans. Rev. bras. geriatr. gerontol. 2017;20:374-386. DOI:http://dx.doi.org/10.1590/1981-22562017020.160111

[48]. Pagotto V, Bachion MM, Silveira EA. Autoavaliação da saúde por idosos brasileiros: revisão sistemática da literatura. Rev Panam Salud Publica. 2013;33:302–310.

[49]. Mantovani EP, Lucca SR, Neri AL. Negative self-rated health in the elderly in cities with different levels of economic well-being: data from FIBRA.Ciênc. saúdecoletiva 2015;20: 3653-3668. DOI: http://dx.doi.org/10.1590/1413-812320152012.20492014.

Supplementary table S1. Bivariate analysis of the associations of general health and current health status compared with 12 months ago with demographic and socioeconomic factors. Fortaleza, Ceará, Brazil, 2017.

Variables	General Health		PR (95%CI)	p value	Current Health Status Compared with 12 months ago		PR (95%CI)	p value
	Poor	Verygood / fair			Worse	Better / The same		
	n (%)	n (%)			n (%)	n (%)		
Age				0.647²				0.950¹
60-69 years	26 (17.1)	126 (82.9)	1.43 (0.47 - 4.36)		33 (21.7)	119 (78.3)	0.9 (0.42 - 1.93)	
70-79 years	14 (20.9)	53 (79.1)	1.74 (0.55 - 5.55)		14 (20.9)	53 (79.1)	0.87 (0.38 - 2.01)	
80 yearsandolder	3 (12)	22 (88)	1		6 (24)	19 (76)	1	
Gender				0.115¹				**0.044¹**
Men	7 (11.1)	56 (88.9)	1		8 (12.7)	55 (87.3)	1	
Women	36 (19.9)	145 (80.1)	1.79 (0.84 - 3.82)		45 (24.9)	136 (75.1)	1.96 (0.98 - 3.92)	
Race				0.194¹				0.150¹
White	19 (21.3)	70 (78.7)	1.61 (0.88 - 2.96)		21 (23.6)	68 (76.4)	1.36 (0.79 - 2.33)	
Black	8 (23.5)	26 (76.5)	1.78 (0.83 - 3.80)		11 (32.4)	23 (67.6)	1.86 (1 - 3.47)	
Mixedrace	16 (13.2)	105 (86.8)	1		21 (17.4)	100 (82.6)	1	
Marital status				0.506²				0.625²
Single	6 (14)	37 (86)	0.81 (0.35 - 1.85)		9 (20.9)	34 (79.1)	0.97 (0.5 - 1.88)	
Married	24 (17.3)	115 (82.7)	1		30 (21.6)	109 (78.4)	1	
Divorced	11 (25)	33 (75)	1.45 (0.77 - 2.71)		8 (18.2)	36 (81.8)	0.84 (0.42 - 1.7)	
Widowed	2 (11.1)	16 (88.9)	0.64 (0.17 - 2.5)		6 (33.3)	12 (66.7)	1.54 (0.75 - 3.19)	
Living alone				0.790¹				0.383¹
Yes	8 (19.0)	34 (81.0)	1.01 (0.55 - 2.20)		7 (16.7)	35 (83.3)	0.73 (0.36 - 1.51)	
No	35 (17.3)	167 (82.7)	1		46 (22.8)	156 (77.2)		
Working				**0.026¹**				0.071¹
Yes	5 (8.3)	55 (91.7)	1		8 (13.3)	52 (86.7)	1	
No	37 (21)	139 (79)	2.52 (1.04 - 6.12)		43 (24.4)	133 (75.6)	1.83 (0.91 - 3.67)	

Income			0.189[1]			<0.001[1]
Upto 2 wages	35 (19.7)	143 (80.3)	1.63 (0.77 - 3.47)	48 (27.0)	130 (73.0)	5.21 (1.69 - 16.11)
> 2 wages	7 (12.1)	51 (87.9)	1	3 (5.2)	55 (94.8)	
Education			**0.040[2]**			**0.049[2]**
0	3 (21.4)	11 (78.6)	2.12 (0.65 - 6.89)	4 (28.6)	10 (71.4)	2.12 (0.79 - 5.65)
1-8 years	30 (22.6)	103 (77.4)	2.23 (1.11 - 4.47)	35 (26.3)	98 (73.7)	1.95 (1.07 - 3.55)
> 8 years	9 (10.1)	80 (89.9)	1	12 (13.5)	77 (86.5)	1

[1] Chi-squared test; [2] Fisher's Exact test

Supplementary table S2. Bivariate analysis of the associations of general health and current health status compared with 12 months ago with systemic health and lifestyle variables. Fortaleza, Ceará, Brazil, 2017

Variables	General Health		PR (95%CI)	p value	Current Health Status Compared with 12 Months Ago		PR (95%CI)	p value
	Poor	VeryGood / Fair			Worse	The Same / Better		
	n (%)	n (%)			n (%)	n (%)		
Hospitalization in the previous year				**0.003[1]**				**0.010[1]**
Yes	11 (36.7)	19 (63.3)	2.45 (1.39 - 4.33)		12 (40)	18 (60)	2.09 (1.24 - 3.5)	
No	32 (15)	182 (85)	1		41 (19.2)	173 (80.8)	1	
Systemicdiseases				**0.003[1]**				**0.011[1]**
Yes	43 (20.7)	165 (79.3)	-		51 (24.5)	157 (75.5)	4.41 (1.12 - 17.33)	
No	0 (0)	36 (100)	-		2 (5.6)	34 (94.4)	1	
Diabetes mellitus				**<0.001[1]**				**0.003[1]**
Yes	23 (32.4)	48 (67.6)	2.8 (1.65 - 4.77)		24 (33.8)	47 (66.2)	2.02 (1.27 - 3.21)	
No	20 (11.6)	153 (88.4)	1		29 (16.8)	144 (83.2)	1	
Cardiovascular disorders				0.087[1]				**0.048[1]**
Yes	34 (20.5)	132 (79.5)	1		42 (25.3)	124 (74.7)	1.79 (0.98 - 3.29)	

No	9 (11.5)	69 (88.5)	0.56 (0.28 - 1.12)		11 (14.1)	67 (85.9)	1	
Osteoporosis				0.136[1]				**0.015[1]**
Yes	13 (24.5)	40 (75.5)	1.56 (0.88 - 2.78)		18 (34)	35 (66)	1.85 (1.15 - 3)	
No	30 (15.7)	161 (84.3)	1		35 (18.3)	156 (81.7)	1	
Nutritionaldefficiency				1.000[2]				0.522[2]
Yes	0 (0)	3 (100)	-		1 (33.3)	2 (66.7)	1.55 (0.31 - 7.79)	
No	43 (17.8)	198 (82.2)	-		52 (21.6)	189 (78.4)	1	
Use ofmedications				0.057[2]				**0.019[1]**
Yes	42 (19.3)	176 (80.7)	5.01 (0.72 - 34.89)		52 (23.9)	166 (76.1)	6.2 (0.89 - 43.01)	
No	1 (3.8)	25 (96.2)	1		1 (3.8)	25 (96.2)	1	
Numberofmedicationsused				**<0.001[1]**				**<0.001[1]**
Upto 3	15 (11.1)	120 (88.9)	1		21 (15.6)	114 (84.4)	1	
More than 3	27 (32.5)	56 (67.5)	2.93 (1.66 - 5.17)		31 (37.3)	52 (62.7)	2.4 (1.48 - 3.89)	
Historyoffalls				**0.027[1]**				0.154[1]
Yes	32 (22.1)	113 (77.9)	1.99 (1.05 - 3.75)		36 (24.8)	109 (75.2)	1.45 (0.86 - 2.42)	
No	11 (11.1)	88 (88.9)	1		17 (17.2)	82 (82.8)	1	
Vision problems				0.229[1]				**0.066[1]**
Yes	38 (19)	162 (81)	1.67 (0.7 - 4)		48 (24)	152 (76)	2.11 (0.89 - 5)	
No	5 (11.4)	39 (88.6)	1		5 (11.4)	39 (88.6)	1	
Hearingproblems				0.596[1]				0.176[1]
Yes	16 (19.5)	66 (80.5)	1.16 (0.67 - 2.03)		22 (26.8)	60 (73.2)	1.39 (0.86 - 2.25)	
No	27 (16.8)	134 (83.2)	1		31 (19.3)	130 (80.7)	1	
Speech problems				0.059[2]				1.000[2]
Yes	7 (35)	13 (65)	2.18 (1.12 - 4.25)		4 (20)	16 (80)	0.91 (0.37 - 2.27)	
No	36 (16.1)	188 (83.9)	1		49 (21.9)	175 (78.1)	1	
Smoking				0.381[1]				0.100[1]
Yes	7 (23.3)	23 (76.7)	1.39 (0.68 - 2.83)		10 (33.3)	20 (66.7)	1.66 (0.94 - 2.94)	

	General Health			Current Health Status Compared with 12 Months Ago		
No	36 (16.8)	178 (83.2)	1	43 (20.1)	171 (79.9)	1
Drinking			0.066[1]			0.260[1]
Yes	3 (7.5)	37 (92.5)	1	6 (15)	34 (85)	1
No	40 (19.6)	164 (80.4)	2.61 (0.85 - 8.04)	47 (23)	157 (77)	1.54 (0.7 - 3.35)
Physicalactivity			0.208[1]			0.919[1]
Yes	16 (14.3)	96 (85.7)	1	24 (21.4)	88 (78.6)	1
No	27 (20.5)	105 (79.5)	1.43 (0.81 - 2.52)	29 (22)	103 (78)	1.03 (0.64 - 1.65)
Healhinsurance			0.411[1]			0.240[1]
Yes	7 (13.7)	44 (86.3)	1	8 (15.7)	43 (84.3)	1
No	36 (18.7)	157 (81.3)	1.36 (0.64 - 2.87)	45 (23.3)	148 (76.7)	1.49 (0.75 - 2.95)
Used health services in the previous year			**0.034[1]**			0.189[1]
Yes	41 (19.8)	166 (80.2)	3.66 (0.93 - 14.5)	48 (23.2)	159 (76.8)	1.72 (0.73 - 4.02)
No	2 (5.4)	35 (94.6)	1	5 (13.5)	32 (86.5)	1
Service used			0.166[1]			**0.021[1]**
Public	38 (21.1)	142 (78.9)	1.9 (0.72 - 4.99)	47 (26.1)	133 (73.9)	3.13 (1.03 - 9.52)
Private/healthinsurance	4 (11.1)	32 (88.9)	1	3 (8.3)	33 (91.7)	1
Health problemwassolved			**<0.001[1]**			**0.015[1]**
Yes	22 (13.3)	143 (86.7)	1	32 (19.4)	133 (80.6)	1
No	20 (40)	30 (60)	3 (1.79 - 5.03)	18 (36)	32 (64)	1.86 (1.15 - 3.01)

[1] Chi-squared test; [2] Fisher's Exact test

Supplementary table S4. Multivariate analysis of the associations of general health and current health status compared with 12 months ago with variables included in the model. Fortaleza, Ceará, Brazil, 2017.

Variables in themodel	General Health		Current Health Status Compared with 12 Months Ago	
	Adjusted PR	p value	Adjusted PR	p value
Income				

Upto 2 wages	-	-	5.06 (1.67 - 15.34)	**0.004**
> 2 wages	-	-	1	
Hospitalization in the previous year				
Yes	2.1 (1.27 - 3.49)	**0.004**	1.95 (1.21 - 3.14)	**0.006**
No	1		1	
Diabetes mellitus				
Yes	2.43 (1.44 - 4.1)	**0.001**	1.89 (1.2 - 2.98)	**0.006**
No	1			
Vision problems				
Yes	-	-	3.03 (1.09 - 8.41)	**0.034**
No	-	-	1	
MNA				
Risk ofmalnutrition	2.42 (1.44 - 4.06)	**0.001**	1.6 (1 - 2.55)	**0.048**
Normal	1		1	
IADL				
Needingassistance	2.23 (1.16 - 4.27)	**0.016**	-	-
Independent	1		-	-

Supplementary table S3. Bivariate analysis of general health and current health status compared with 12 months ago with oral health variables, GOHAI, IADL, MNA and GDS. Fortaleza, Ceará, Brazil, 2017.

Variable	General Health		PR (95%CI)	p value	Current Health Status Compared with 12 Months Ago		PR (95%CI)	p value
	Poor	VeryGood / Fair			Poor	The Same / Better		
	n (%)	n (%)			n (%)	n (%)		
Drymouth				0.316[1]				**0.041[1]**
Yes	22 (20.4)	86 (79.6)	1.32 (0.77 - 2.27)		30 (27.8)	78 (72.2)	1.64 (1.02 - 2.66)	
No	21 (15.4)	115 (84.6)	1		23 (16.9)	113 (83.1)	1	

Difficulty chewing and swallowing food				**0.038[1]**				0.072[1]
Yes	25 (23.4)	82 (76.6)	1.78 (1.03 - 3.08)		29 (27.1)	78 (72.9)	1.55 (0.96 - 2.5)	
No	18 (13.1)	119 (86.9)	1		24 (17.5)	113 (82.5)	1	
Problems with the taste of food				0.097[1]				**0.008[1]**
Yes	13 (25.5)	38 (74.5)	1.64 (0.92 - 2.91)		18 (35.3)	33 (64.7)	1.95 (1.21 - 3.14)	
No	30 (15.5)	163 (84.5)	1		35 (18.1)	158 (81.9)	1	
Pain with no apparent reason				1.000[2]				0.574[1]
Yes	5 (18.5)	22 (81.5)	1.06 (0.46 - 2.46)		7 (25.9)	20 (74.1)	1.22 (0.62 - 2.43)	
No	38 (17.5)	179 (82.5)	1		46 (21.2)	171 (78.8)	1	
Assistancetoeat				0.532[2]				0.554[2]
Yes	4 (22.2)	14 (77.8)	1.29 (0.52 - 3.2)		5 (27.8)	13 (72.2)	1.31 (0.6 - 2.87)	
No	39 (17.3)	187 (82.7)	1		48 (21.2)	178 (78.8)	1	
Use ofprosthesis				0.140[1]				0.717[1]
Yes	34 (20.0)	136 (80.0)	1.64 (0.83 - 3.25)		38 (22.4)	132 (77.6)	1.10 (0.65 - 1.88)	
No	9 (12.2)	65 (87.8)	1		15 (20.3)	59 (79.7)	1	
GOHAI				**0.028[1]**				0.131[1]
Low	29 (22.8)	98 (77.2)	1.89 (1.05 - 3.40)		32 (25.2)	95 (74.8)	1.46 (0.89 - 2.41)	
Moderate/High	14 (12.1)	102 (87.9)	1		20 (17.2)	96 (82.8)	1	
IADL				0.054[2]				0.412[2]
Needingassistance	4 (44.4)	5 (55.6)	2.68 (1.22 - 5.87)		3 (33.3)	6 (66.7)	1.57 (0.60 - 4.08)	
Independent	39 (16.6)	196 (83.4)	1		50 (21.3)	185 (78.7)	1	
MNA				**<0.001[1]**				**0.002[1]**
Risk ofmalnutrition	22 (33.8)	43 (66.2)	2.88 (1.70 - 4.88)		23 (35.4)	42 (64.6)	2.11 (1.33 - 3.36)	
Normal	21 (11.7)	158 (88.3)	1		30 (16.8)	149 (83.2)	1	
GDS				**<0.001[1]**				**<0.001[1]**
Suspecteddepression	26 (44.1)	33 (55.9)	4.80 (2.80 - 8.20)		28 (47.5)	31 (52.5)	3.51 (2.23 - 5.52)	
No suspecteddepression	17 (9.2)	168 (90.8)	1		25 (13.5)	160 (86.5)	1	

[1] Chi-squared test; [2] Fisher's Exact test

Factors associated with self-rated health in older adults receiving oral prosthetic rehabilitation

Lucianna Leite Pequeno[1], Paulo Leonardo Ponte Marques[2], Maria Vieira de Lima Saintrain[3], Ilana Nogueira Bezerra[4], Anya Pimentel Gomes Fernandes Vieira-Meyer[5], Sandy Kaena Soares de Freitas[6], José Manuel Peixoto Caldas[7]

[1]School of Dentistry, Universidade de Fortaleza (UNIFOR), Fortaleza, Ceará, Brazil
Email: lupequeno@unifor.br
[2]School of Dentistry, Universidade de Fortaleza (UNIFOR), Fortaleza, Ceará, Brazil
Email: paulomarques@unifor.br
[3]Public Health Graduate Program, Universidade de Fortaleza (UNIFOR), Fortaleza, Ceará, Brazil
Email: mvlsaintrain@yahoo.com.br
[4]School of Nutrition, Universidade Estadual do Ceará (UECE), Fortaleza, Ceará, Brazil
Email: ilana.bezerra@yahoo.com.br
[5]Family Health Master's Program, Fundação Oswaldo Cruz (FIOCRUZ), Eusébio, Ceará, Brazil
Email: anyavieira10@gmail.com
[6]Public Health GraduateProgram, Universidade de Fortaleza (UNIFOR), Fortaleza, Ceará, Brazil
Email: sandy_kaena@hotmail.com
[7]Interdisciplinary Center for Gender Studies. University of Lisbon & ISPUP/University of Porto.
Email: jcaldas@fpce.up.pt

Corresponding author

Maria Vieira de Lima Saintrain.
ORCID https://orcid.org/**0000-0002-3370-3218**
Rua Irmã Simas, 100 apt 201 Bloco A Varjota CEP 60.165-220 Fortaleza-CE, Brasil.
E-mail: mvlsaintrain@yahoo.com.br. Phone: +55 85 988039038.

Abstract— Objectives: To assess factors associated with self-perception of health in older adults submitted to oral prosthetic rehabilitation in order to contribute to a more contextualized planning of public policies, actions and health services aimed at healthy aging. Design: Analytical cross-sectional study. Setting: Dental specialty centers. Participants: 244 people aged 60 years and older enrolled for oral prosthetic rehabilitation. Intervention: Interviews, oral examination and anthropometric measurements. Measurements: A questionnaire assessed demographic and economic data, general health and oral health and self-perception of oral health-related quality of life was measured by the Geriatric Oral Health Assessment Index (GOHAI). Performance in instrumental activities of daily living was assessed by the Lawton and Brody scale, mood was assessed by the Geriatric Depression Scale and nutritional status was assessed by the Mini Nutritional Assessment. Results: The multivariate analysis showed that factors such as hospitalization in the previous year, diabetes and risk of malnutrition determined the negative self-

perception of general health and current health status compared with 12 months ago. Needing assistance to perform AIDL significantly influenced self-perception of general health while income and vision problems interfered with older adults' perception of their current health status compared with 12 months ago. Conclusion: Older adults who needed oral prosthetic rehabilitation exhibited a predominantly negative self-perception of oral health.

I.   INTRODUCTION

Population aging is a reality in Brazil, a country where older adults are people aged 60 years or older. This age group is prioritized in health services and there are even specific regulations that prioritize people aged over 80 years [1].

Healthy Aging is the process of development and maintenance of functional capacity that allows well-being at an advanced age [2]. According to the World Health Organization (WHO), health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity [3].

Self-perceived heath consists of people's perception of their health status taking into consideration the socioeconomic, cultural and historical context and is used to assess older adults' functional capacity [4,5]. Research on older adults' self-perceived health has presented contradictory results. Positive self-rated health can mean older adults' difficulty in performing a critical analysis of their own health while negative self-rated health can also be influenced by older adults' functional disability and mental health.

Studies emphasize that most older adults report a self-perception of good health despite the presence of chronic diseases. This finding indicates that this population group relates health to autonomy and independence, thus showing that the absence of diseases does not necessarily influence their self-perception of health [5-7].

Oral health is an integrating part of general health. Therefore, maintaining good oral health in older adults is key to ensuring healthy aging, especially because older adults are commonly submitted to curative and mutilating dental procedures. In Brazil, for instance, the rate of use of and need for dental prosthesis in 2010 was 78.2% and 68.7%, respectively [8].

Given that, public health policies should take into consideration the clinical and subjective needs of older adults based on their self-perception of health and the influence of oral health on the quality of life [9].

In view of the considerations outlined above, we raised the hypothesis that negative self-perception of health is influenced by sociodemographic conditions, general health, oral health, self-perception of oral health, functional capacity, mood, and nutritional status. Thus, the present study aimed to assess factors associated with self-perception of health in older adults submitted to oral prosthetic rehabilitation.

II.   METHODS

A cross-sectional study was carried out in two dental specialty centers (*Centros de Especialidades Odontológicas – CEOs*) located in the city of Fortaleza in Northeastern Brazil. The CEOs are reference secondary care centers for oral prosthetic rehabilitation of people served by Brazil's Unified Health System (*Sistema Único de Saúde – SUS*) [10].

The sample of 260 older adults was obtained using the formula for finite population considering a total of 257,715 older adults in the city of Fortaleza [11], an expected loss of 20%, an expected value of sample proportion of 83% of older adults who need dental prosthesis [8], a significance level of 5%, and a maximum permissible error of 5%.

Data were collected by previously trained researchers between December 2016 and April 2017. We collected sociodemographic information and general and oral health data through interviews held in private in the centers where the research took placeafter obtaining written informed consent from the participants.

Self-perception of general health was assessed by asking the following question: "How is your general health?". The dependent variable of the study was dichotomized into negative perception ("poor" category) and positive perception ("very good" and "fair" categories). Self-perception of current health status compared with 12 months ago was assessed by asking the following question: "How is your health now compared with 12 months ago?". The dependent variable was dichotomized into negative perception ("worse" category) and positive perception ("better" and "the same" categories) [12].

The need for oral prosthetic rehabilitation was assessed using a WHO instrument recommended by the 2010 SB-Brazil Survey [8,13]. Oral health-related quality of life was assessed by the Geriatric Oral Health

Assessment Index (GOHAI) [14]. Higher index values indicate better oral health and better self-perception of oral health-related quality of life. Values ranging 34-36 are considered high, values ranging 31-33 are considered moderate, and values below 30 are considered low [15].

Performance in Instrumental Activities of Daily Living (IADL) was assessed by the Lawton & Brody scale [16]. The scale assesses nine domains and the total score ranges 9-27 points. Individuals with scores of 19-27 points are classified as independent. Scores of 10-18 indicate assisted independence and scores of 1-9 points indicate dependence.

Nutritional status was assessed using the Mini Nutritional Assessment (MNA), which consists of 18 self-reported questions. Results are given based on the sum of the scores in each domain [17]. Scores of 24-30 points indicate normal nutritional status, scores of 17-23.5 points indicate risk of malnutrition, and scores below 17 points indicate malnutrition. Height (cm) and weight (kg) measurements were taken according to the World Health Organization protocol [18].

Mood was assessed using Geriatric Depression Scale (GDS). The short form of the GDS consists of 15 questions (GDS15) and its total score ranges 0-15. Scores of 0-5 are considered normal; 6-10 indicate mild depression; and 6-15 indicate severe depression [19].

This study was approved by a Research Ethics Committee (Approval No 1.699.965/2016). Data were presented using descriptive statistics and bivariate analyses were performed using either the Chi-squared test or Fisher's exact test. The strength of the associations was measured using prevalence ratios for independent variables with a significance level of 95%. Variables with a *p* value below 0.20 were analyzed using Poisson regression with robust error variance. The final model included the variables that presented significant associations at p<0.05.

III.   RESULTS

Participants were 244 older adults, which means there was a loss of 6.2%, which was lower than expected. There was a predominance of women (74.2%) and participants aged 60-69 years (62.3%). Age ranged 60-91 years and the mean age was 68.9 years (SD: 7.1). There were higher rates of Mixed-race Brazilians(49.6%), married participants (56.9%), participants who lived with their spouse (36.9%) or children (30.7%), unemployed participants (75.4%), participants with an income of up to two minimum wages (72.9%), and participants with one to eight years of study (54.5%). The majority (89.3%) used medication and there was a mean of 3.6 (SD: 3.1)

medications per older adult. In addition, 112 (45.9%) participants were physically active, 30 (12.3%) were smokers and 40 (16.4%) were drinkers.

Systemic diseases were reported by 208 (85.2%) participants and the main diseases were hypertension (68%), diabetes (29.1%) and osteoporosis (21.7%). History of falls was reported by 145 (59.4%) participants and 200 (81.9%) reported vision problems, 82 (33.6%) reported hearing problems and 20 (8.2%) reported speech problems. In all, 51 (20.9%) participants reported having a health insurance and 207 (84.8%) had used health services in the last year, 180 (73.7%) of whom used public health services. In addition, 165 (67.6%) participants said they had their health problems solved.

Dry mouth was reported by 108 (44.2%) participants. Additionally, 107 (43.9%) participants had difficulty chewing and swallowing food, 51 (20.9%) had problems with the taste of food, 18 (7.4%) needed assistance to eat, 170 (69.7%) were already using some type of dental prosthesis and needed to replace it, and 74 (30.3%) had never used dental prostheses.

Older adults who needed oral prosthetic rehabilitation exhibited a predominantly (52.1%) negative self-perception of oral health. A total of 235 (96.3%) participants had a good index of independence in IADL, 179 (73.4) presented normal nutritional status and 185 (75.8%) did not exhibit signs of depression. In addition, 56 (23%) older adults rated their general health as very good, 145 (59.4%) rated it as fair and 43 (17.6%) rated it as poor (CI: 13.1-23.0). As for self-perception of current health status compared with 12 months ago, 50 (20.5%) participants said their health was better, 141 (57.8%) said it was the same and 53 (21.7%) said it was worse (CI: 16.7-27.4).

Tables 1 to 3 present the bivariate analyses of the associations between the independent variables of the study and the results of older adults' self-perception of general health and current health status compared with 12 months ago.

Table 4 shows the final model for the two outcome variables. The multivariate analysis showed that factors such as hospitalization in the previous year, diabetes and risk of malnutrition determined the negative self-perception of general health and current health status compared with 12 months ago. Needing assistance to perform AIDL significantly influenced self-perception of general health while income and vision problems interfered with older adults' perception of their current health status compared with 12 months ago.

IV. DISCUSSION

We certify that this work is novel and that its results can contribute to a better understanding of the factors that interfere with older adults' self-perception of health and the conditions perceived in a negative way, which may serve as an important strategy for developing public health policies, planning broader preventive actions and improving access to and quality of health services.

The present study stands out in the current scientific scenario as it was carried out with older adults in need of oral prosthetic rehabilitation treated in reference centers. Access to free oral health care may have contributed to older adults' positive self-perception of general health as poor access to health care services have been associated with older adults' negative self-perception of general health [20-22].

In fact, 82.4% of the older adults who needed oral prosthetic rehabilitation had a positive self-perception of general health. Moreover, 78.3% of the participants had a positive self-perception of current health status compared with 12 months ago. These rates are higher than those reported in the literature (41.9%-57.5%) [23-25]. However, some studies have reported rates ranging 65.0%-82.9% [5,12].

The rate of participants with a negative perception of general health (17.6%) and current health status compared with 12 months ago (21.7%) was lower than that reported (57.6%) by Medeiros et al. [20]. Studies have reported higher rates of negative perception of health among institutionalized older adults [12,26], old-old cohorts of older adults, individuals with functional decline and dependence, and individuals with history of hospitalizations and a higher burden of chronic diseases [12,27].

In the bivariate analysis, level of education, hospitalization, systemic diseases, diabetes, number of medications used, solution of health problems, nutritional risk and signs of depression were associated with negative self-perception of general health and current health status compared with 12 months ago, thus confirming the subjective and multidimensional aspects of the studied outcomes [25,27,28] as well as regional peculiarities and older adults' specific vulnerabilities [20].

The predominance of negative self-perception of oral health (52.1%) is probably associated with complete or partial edentulism. The prevalence rate of negative self-perception of general health was 89% higher among older adults with lower GOHAI scores. In the study by Zanesco et al [29], 19% of the older adults analyzed presented negative perceptions of oral health and were 1.92 times more likely to negatively perceive their general health.

In the final model, the variables that remained associated with negative self-perception of general health and current health status compared with 12 months ago were hospitalization in the previous year, diabetes and risk of malnutrition. Need for assistance to perform IADL influenced general health while income and vision problems had an impact on self-perception of current health status compared with 12 months ago.

A total of 30 (12.3%) older adults had been hospitalized in the previous twelve months. A higher rate was reported by Medeiros et al [20] and the 2013 National Health Survey [24] found that 90% of the interviewees had been hospitalized in the previous 12 months and that hospitalization was associated with older adults' increased likelihood of having a negative perception of health. In the present study, the prevalence of negative perception of general health was 95% higher among older adults who reported hospitalization. Moreover, hospitalization in the previous year increased by 2.1 times the prevalence of negative self-perception of current health status compared with 12 months ago.

Hospitalization can have a negative impact on the quality of physical and psychological aspects and may lead to a decrease in older adults' autonomy to perform daily activities. Hospitalization may have resulted from complications of chronic systemic diseases or from factors such as falls and malnutrition. Hospitalization is more prevalent and prolonged in older adults [30] and increases the incidence of malnutrition [31]. Researchers found that older patients who reported poor health had an increased risk of hospitalization, institutionalization and mortality when compared with those who reported very good health [32].

The fact that diabetic patients (29.1%) were more likely to have negative self-perceptions of general health (PR: 2.43) and current health status compared with 12 months ago (PR: 1.89) is corroborated by researchers who found a significant association between self-perceived health and diabetes [23] and other authors whose multivariate analysis revealed that having diabetes is associated with a negative perception of health [20].

Diabetes is one of the most prevalent diseases in older adults [33] and it may interfere with performance of daily activities due to the continuous use of medications and dietary restrictions, which seem to be more strongly associated with negative perception of health status than the disease itself [34]. Diabetes is also associated with functional disability, hypertension and higher rates of hospitalization and premature death in older adults [35]. It may be associated with xerostomia and oral infections such as periodontal disease]36] as chronic hyperglycemia

modifies vascular and cerebral metabolism [37]. Therefore, limitations and complications caused by diabetes may explain older adults' negative self-perception of health.

In our study, self-perception of health was also influenced by risk of malnutrition. In all, 60% the older adults who were at risk of malnutrition had a negative self-perception of current health status compared with 12 months ago and were 2.42 times more likely to have a negative perception of general health. The 26.6% rate of malnourished older adults found in our study is in accordance with the rates reported in the literature, with values ranging 15%-54.1% [38-41]. In contrast, the lowest rates of risk of malnutrition have been found among non-institutionalized older adults with positive perception of health [40]. The interviewees were people who would receive prostheses, therefore, the lack of these can influence their nutrition.

Malnutrition is more prevalent among hospitalized (31.2%-40%) and institutionalized (39.6%-60%) older adults [38-42]. Like Brazil, other countries have also exhibited similar rates, such as Indonesia (57%) [43] and India (52.5%) [44].

Changes in dietary intake and changes in nutrient absorption may lead to the risk of malnutrition, which is associated with older adults' frailty, which is included in a broad concept of functional impairment [40]. Functional capacity, on the other hand, includes older adults' potential to choose and perform daily life tasks independently. Functional capacity decreases with age and may be intensified by systemic diseases and other factors [45].

Need for assistance to perform IADL was presented by 3.7% of the participants. Changes in the ability to perform daily activities may be associated with malnutrition, cardiovascular diseases, cognitive impairment, and decreased muscle strength and physical performance [46].

Functional limitation is associated with older adults' increased chances of having a negative perception of health. Older adults without functional limitations were 7.76 times more likely to rate their health positively [23]. In our study, older adults who needed assistance to perform IADL were 2.23 times more likely to rate their general health in a negative way, which agrees with the findings reported by Zanesco et al [29].

Ability to perform daily activities strongly determines the health of older adults and has been little studied as an exposure variable. In addition, negative perception of health can worsen functional decline and increase dependence, hospitalization and mortality in older adults [12].

Low levels of income interfere negatively with healthy behavior, home environment and access to health services. People with low levels of income tend to seek health services less often and have poor access to medications. Therefore, they tend to have a poor adherence to treatment of systemic diseases [47].

Low levels of household income were associated with negative self-perception of health in 54.5% of the studies in a review [48]. In the present study, 73% of the older adults reported earning up to two minimum wages, a fact that was associated with a 5.06-fold increase in the chances of having a negative self-perception of current health status compared with 12 months ago in relation to those who reported an income of more than two minimum wages.

Vision problems were reported by 82% of the older adults in our study and were associated with a 3.03-fold increase in the chances of a having negative self-perception of current health status compared with 12 months ago. Visual impairment may be a consequence of older adults' less favorable health and socioeconomic conditions [49]. In addition, they have been reported as major complaints related to the health status of this population group [6] and have been associated with a negative self-perception of health [25,49]. However, it should be noted that it is not the vision problem itself that leads older adults to negatively rate their health, but the social and psychological consequences of such problem.

The present study has some limitations. First, its cross-sectional design, and as so it does not allow to establish proof of a causal relationship in the associations found, thus limiting the interpretation of the results. Second, the information collected through interviews may have been distorted due to memory issues that were not controlled in our study. Finally, self-perception of health is a subjective process that changes according to older adults' context of life and physical and emotional health. However, despite the limitations outlined, our study remains relevant as it aimed to study a growing population whose peculiarities need different planning and reorientation of public health policies.

V.   CONCLUSION

Older adults who needed oral prosthetic rehabilitation exhibited a predominantly negative self-perception of oral health.

Hospitalization in the previous year, diabetes, risk of malnutrition, need for assistance to perform IADL, income and vision problems were associated with older adults' negative self-perception of health. Knowing the

factors that interfere with older adults' self-perception of health and the conditions perceived in a negative way are an important strategy for developing public health policies, planning broader preventive actions and improving access to and quality of health services.

SPONSOR'S ROLE

Sponsors had no role in the design, methods, subject recruitment, data collections, analysis and preparation of paper.

REFERENCES

[1]. Brasil. Lei nº 13.466, de 12 de julho de 2017. Altera os arts. 3o, 15 e 71 da Lei no 10.741, de 1o de outubro de 2003, que dispõe sobre o Estatuto do Idoso e dá outras providências. Brasília, 2017.

[2]. World Health Organization. World Report On Ageing and Health. Geneva, Switzerland: World Health Organization, 2015.

[3]. World Health Organization. Constituição da Organização Mundial da Saúde. Geneva, Switzerland: World Health Organization, 1946.

[4]. Vilela EA, Martins AMEBL, Barreto SM, Vargas AMD, Ferreira RC. Association between self-rated oral appearance and the need for dental prostheses among elderly Brazilians. Braz Oral Res 2013;27:203-210. DOI: https://dx.doi.org/10.1590/S1806-83242013005000010

[5]. Borges AM, Santos G, Kummer JA, Fior L, Molin VD, Wibelinger LM. Autopercepção de saúde em idosos residentes em um município do interior do Rio Grande do Sul. Revbras geriatra gerontol 2014;17:79-86. DOI: http://dx.doi.org/10.1590/S1809-98232014000100009.

[6]. Güths JFS, Jacob MHVM, Santos AMPV, Arossi GA, Béria JU. Sociodemographic profile, family aspects, perception of health, functional capacity and depression in institutionalized elderly persons from the north coastal region of Rio Grande do Sul, Brazil. Revbrasgeriatrgerontol2017;20:175-185. DOI: http://dx.doi.org/10.1590/1981-22562017020.160058

[7]. Tomicki C, Cecchin L, Zanini SCC, Benedetti TRB, Leguisamo CP, Portella MR. Associação entre números de quedas e força muscular de idosos residentes em instituições de longa permanência. Revista Kairóz: Gerontologia 2017;20:101-116. DOI: https://doi.org/10.23925/2176-901X.2017v20i2p101-116.

[8]. Brasil. SB Brasil 2010 - Pesquisa nacional de saúde bucal: resultados principais. Brasília (DF): Ministério da Saúde, 2012.

[9]. Agostinho ACMG, Campos ML, Silveira JLGC. Edentulismo, uso de prótese e autopercepção de saúde bucal entre idosos. Rev. odontol. UNESP 2015;44:74-79. DOI: http://dx.doi.org/10.1590/1807-2577.1072.

[10]. Brasil. Ministério da Saúde - Cadastro Nacional dos Estabelecimentos de Saúde do Brasil - CNES. DATASUS - Departamento de Informática do SUS, 2015.

[11]. Brasil. Informações de Saúde (TABNET): Demográficas e Socioeconômicas (online). Ministério da Saúde. DATASUS - Departamento de Informática do SUS, 2015. Availableat: http://www2.datasus.gov.br/DATASUS/index.php?area=02 06&id=6942.Accessed January 25,2019.

[12]. Jerez-Roig J, Souza DLB, Andrade FLJP et al. Self-perceived health in institutionalized elderly. Ciêncsaúdecoletiva2016;21:3367-3375. DOI: http://dx.doi.org/10.1590/1413-812320152111.15562015.

[13]. World Health Organization. Oral health surveys: basic methods 4th ed..Geneva: ORH/EPID, 1997.

[14]. Atchison KA, Dolan TA. Development of the geriatric oral health assessment index. Journal of dental education1990;54:680-687.

[15]. Silva DD, Sousa MLR, Wada RS. Autopercepção e condições de saúde bucal em uma população de idosos. Cad. Saúde Pública 2005;21:1251-1259. DOI: http://dx.doi.org/10.1590/S0102-311X2005000400028.

[16]. Lawton MP, Brody EM. Assessment of older people: self-maintaining and instrumental activities of daily living. The gerontologist 1969;9:179-186. DOI:https://doi.org/10.1093/geront/9.3_Part_1.179

[17]. Guigoz Y, Vellas B, Garry PJ. Assessing the Nutritional Status of the Elderly: The Mini Nutritional Assessment as Part of the Geriatric Evaluation. Nutrition Reviews 1996;54:59-65. DOI: https://doi.org/10.1111/j.1753-4887.1996.tb03793.x

[18]. World Health Organization. Physical status: the use and interpretation of antropometry (online). Report of a WHO Expert Commitee. WHO Technical Report Series, 854. Geneve: WHO, 1995.

[19]. Yesavage JA, Sheikh JI. Geriatric Depression Scale (GDS): Recent evidence and development of a shorter version. Clinical Gerontologist 1986; 5:165-173. DOI: http://dx.doi.org/10.1300/J018v05n01_09

[20]. Medeiros SM, Silva LSR, Carneiro JA, Ramos GCF, Barbosa ATF, Caldeira AP. Factors associated with negative self-rated health among non-institutionalized elderly in Montes Claros, Brazil. Ciênc. Saúde Coletiva 2016; 21:3377-3386. DOI: http://dx.doi.org/10.1590/1413-812320152111.18752015.

[21]. Rosenkranz RR, Duncan MJ, Rosenkranz SK, Kolt GS. Active lifestyles related to excellent self-rated health and quality of life: cross sectional findings from 194,545 participants in The 45 and Up Study. BMC Public Health 2013;13:1071. DOI: 10.1186/1471-2458-13-1071.

[22]. Louvison MCP, Lebrão ML, Duarte YAO, Santos JLF, Malik AM, Almeida ES. Desigualdades no uso e acesso aos serviços de saúde entre idosos do município de São Paulo. Rev. Saúde Pública 2008;42:733-740. DOI: http://dx.doi.org/10.1590/S0034-89102008000400021.

[23]. Gomes MFS, Pereira SCL, Abreu MNS. Fatores associados à autopercepção de saúde dos idosos usuários dos restaurantes populares de Belo Horizonte. Ciênc. saúde coletiva 2018;23:4007-4019. DOI: http://dx.doi.org/10.1590/1413-812320182311.31072016.

[24]. Instituto Brasileiro de Geografia e Estatística. Pesquisa Nacional de Saúde 2013 - Percepção do estado de saúde, estilos de vida e doenças crônicas. Brasília: Ministério da Saúde, 2014. Availableat:

https://biblioteca.ibge.gov.br/visualizacao/livros/liv91110.pdf. AccessedDecember 20, 2018.

[25]. Silva RJS, Smith-Menezes A, Tribess S, Rómo-Perez V, Virtuoso JJS. Prevalência e fatores associados à percepção negativa da saúde em pessoas idosas no Brasil. Rev. bras. epidemiol. 2012;15:49-62. DOI: http://dx.doi.org/10.1590/S1415-790X2012000100005

[26]. Sereny MD, Gu D. Living arrangement concordance and its association with self-rated health among institutionalized and community-residing older adults in China. J Cross Cult Gerontol. 2011;26:239-59. DOI: 10.1007/s10823-011-9145-y.

[27]. Höfelmann DA, Garcia LP, Freitas LR. Self-rated health in Brazilian adults and elderly: data from the National Household Sample Survey 2008. Salud Publica Mex. 2014;56:603-11.

[28]. Aguilar-Palacio I, Carrera-Lasfuentes P, Rabanaque MJ. Saludpercibida y nivel educativo enEspaña: tendencias por comunidades autónomas y sexo (2001-2012). Gac Sanit. 2015;29:37–43. DOI: https://doi.org/10.1016/j.gaceta.2014.07.004

[29]. Zanesco C, Bordin D, Santos CB, Müller EV, Fadel CB. Factors determining the negative perception of the health of Brazilian elderly people. Rev. bras. geriatr. gerontol. 2018;21:283-292. DOI: http://dx.doi.org/10.1590/1981-22562018021.170210.

[30]. Zen D, Leite MT, Hildebrandt LM, Silva LAA, Sand ICPV. Policies of attention to the elderly according to the voice of the municipal managers of health. Rev. Gaúcha Enferm 2018;39:e62502. DOI: http://dx.doi.org/10.1590/1983-1447.2018.62502.

[31]. Poisson P, Laffond T, Campos S, Dupuis V, Bourdel-Marchasson I. Relationships between oral health, dysphagia and undernutrition in hospitalised elderly patients. Gerodontology2016;33:161-168. DOI: 10.1111/ger.12123.

[32]. Nielsen AB, Siersma V, Waldemar G, Waldorff FB. The predictive value of self-rated health in the presence of subjective memory complaints on permanent nursing home placement in elderly primary care patients over 4-year follow-up. Age Ageing 2014;43:50-57. DOI: 10.1093/ageing/aft131.

[33]. Prince MJ, Wu F, Guo Y et al. The burden of disease in older people and implications for health policy and practice. Lancet 2015;385:549-562. DOI: 10.1016/S0140-6736(14)61347-7.

[34]. Nützel A, Dahlhaus A, Fuchs A et al. Self-rated health in multimorbid older general practice patients: a cross-sectional study in Germany. BMC Fam Pract2014;15:1. DOI: 10.1186/1471-2296-15-1.

[35]. Borba AKOT, Marques APO, Ramos VP, Leal MCC, Arruda IKG, Ramos RSPS. Factors associated with elderly diabetic adherence to treatment in primary health care. Ciênc. saúde coletiva 2018;23:953-961. DOI: http://dx.doi.org/10.1590/1413-81232018233.03722016.

[36]. Cullinan MP, Seymour GJ. Periodontal disease and systemic illness: will the evidence ever be enough? Periodontol 2000 2013;62:271-286. DOI: 10.1111/prd.12007.

[37]. Huang DL, Chan KC, Young BA. Poor oral health and quality of life in older U.S. adults with diabetes mellitus. J Am Geriatr Soc. 2013;61:1782-1788. DOI: 10.1111/jgs.12452.

[38]. Wirth R, Streicher M, Smoliner C et al. The impact of weight loss and low BMI on mortality of nursing home residents - Results from the nutritionDay in nursing homes. ClinNutr2016;35:900-906. DOI: 10.1016/j.clnu.2015.06.003.

[39]. Hernández GA, Pontes TY, Goñi CI. Riesgo de malnutriciónen una poblaciónmayor de 75 años no institucionalizada conautonomía funcional. Nutr. Hosp. 2015;32:1184-1192. DOI: http://dx.doi.org/10.3305/nh.2015.32.3.9176.

[40]. Julio MPM, Clavero AE, Soler MLM. Nutritional status and factors associated with non-institutionalized people over 75 years of age. Rev. Bras. Enferm. 2018;71:1007-1012. DOI: http://dx.doi.org/10.1590/0034-7167-2017-0207.

[41]. Guerrero-García NB, Gómez-Lomelí ZM, Leal-Mora D, Loreto-Garibay O. Fragilidadenancianos y estado nutricional segúnel Mini Nutritional Assessment. Revista Médica del Instituto Mexicano del Seguro Social 2016;54:312-317.

[42]. Ferreira JD, Soares MJ, Lima CL, Ferreira TM, Oliveira P, Silva M. Evaluación nutricional por el Mini Nutritional Assessment: una herramienta para lasenfermeras. Eglobal2018;17:293-305. DOI: https://doi.org/10.6018/eglobal.17.3.290251

[43]. Adiatman M, Ueno M, Ohnuki M, Hakuta C, Shinada K, Kawaguchi Y. Functional tooth units and nutritional status of older people in care homes in Indonesia. Gerodontology2013;30:262-269. DOI: 10.1111/j.1741-2358.2012.00673.x.

[44]. Kshetrimayum N, Reddy CV, Siddhana S, Manjunath M, Rudraswamy S, Sulavai S. Oral health-related quality of life and nutritional status of institutionalized elderly population aged 60 years and above in Mysore City, India. Gerodontology2013;30:119-125. DOI: 10.1111/j.1741-2358.2012.00651.x.

[45]. Pereira LC, Figueiredo MLF, Beleza CMF, Andrade EMLR, Silva MJ, Pereir AFM. Fatores preditores para incapacidade funcional de idosos atendidos na atenção básica. Rev. Bras. Enferm. 2017;70:112-118. DOI: http://dx.doi.org/10.1590/0034-7167-2016-0046.

[46]. Tavares DMS, Dias FA, Ferreira PCS, Rodrigues LR, Gonçalves JRL, Ferreira LA. Morbidities and quality of life of urban elderly people with and without heart problems. Ciência, Cuidado e Saúde 2014;13:674-681. DOI: http://dx.doi.org/10.4025/cienccuidsaude.v13i4.19407

[47]. Muniz ECS, Goulart FC, Lazarini CA, Marin MJS. Analysis of medication use by elderly persons with supplemental health insurance plans. Rev. bras. geriatr. gerontol. 2017;20:374-386. DOI:http://dx.doi.org/10.1590/1981-22562017020.160111

[48]. Pagotto V, Bachion MM, Silveira EA. Autoavaliação da saúde por idosos brasileiros: revisão sistemática da literatura. Rev Panam Salud Publica. 2013;33:302–310.

[49]. Mantovani EP, Lucca SR, Neri AL. Negative self-rated health in the elderly in cities with different levels of economic well-being: data from FIBRA.Ciênc. saúdecoletiva 2015;20: 3653-3668. DOI: http://dx.doi.org/10.1590/1413-812320152012.20492014.

Supplementary table S1. Bivariate analysis of the associations of general health and current health status compared with 12 months ago with demographic and socioeconomic factors. Fortaleza, Ceará, Brazil, 2017.

Variables	General Health		PR (95%CI)	p value	Current Health Status Compared with 12 months ago		PR (95%CI)	p value
	Poor	Verygood / fair			Worse	Better / The same		
	n (%)	n (%)			n (%)	n (%)		
Age				0.647²				0.950¹
60-69 years	26 (17.1)	126 (82.9)	1.43 (0.47 - 4.36)		33 (21.7)	119 (78.3)	0.9 (0.42 - 1.93)	
70-79 years	14 (20.9)	53 (79.1)	1.74 (0.55 - 5.55)		14 (20.9)	53 (79.1)	0.87 (0.38 - 2.01)	
80 yearsandolder	3 (12)	22 (88)	1		6 (24)	19 (76)	1	
Gender				0.115¹				**0.044¹**
Men	7 (11.1)	56 (88.9)	1		8 (12.7)	55 (87.3)	1	
Women	36 (19.9)	145 (80.1)	1.79 (0.84 - 3.82)		45 (24.9)	136 (75.1)	1.96 (0.98 - 3.92)	
Race				0.194¹				0.150¹
White	19 (21.3)	70 (78.7)	1.61 (0.88 - 2.96)		21 (23.6)	68 (76.4)	1.36 (0.79 - 2.33)	
Black	8 (23.5)	26 (76.5)	1.78 (0.83 - 3.80)		11 (32.4)	23 (67.6)	1.86 (1 - 3.47)	
Mixedrace	16 (13.2)	105 (86.8)	1		21 (17.4)	100 (82.6)	1	
Marital status				0.506²				0.625²
Single	6 (14)	37 (86)	0.81 (0.35 - 1.85)		9 (20.9)	34 (79.1)	0.97 (0.5 - 1.88)	
Married	24 (17.3)	115 (82.7)	1		30 (21.6)	109 (78.4)	1	
Divorced	11 (25)	33 (75)	1.45 (0.77 - 2.71)		8 (18.2)	36 (81.8)	0.84 (0.42 - 1.7)	
Widowed	2 (11.1)	16 (88.9)	0.64 (0.17 - 2.5)		6 (33.3)	12 (66.7)	1.54 (0.75 - 3.19)	
Living alone				0.790¹				0.383¹
Yes	8 (19.0)	34 (81.0)	1.01 (0.55 - 2.20)		7 (16.7)	35 (83.3)	0.73 (0.36 - 1.51)	
No	35 (17.3)	167 (82.7)	1		46 (22.8)	156 (77.2)		
Working				**0.026¹**				0.071¹
Yes	5 (8.3)	55 (91.7)	1		8 (13.3)	52 (86.7)	1	
No	37 (21)	139 (79)	2.52 (1.04 - 6.12)		43 (24.4)	133 (75.6)	1.83 (0.91 - 3.67)	

Income				0.189[1]				<0.001[1]
Upto 2 wages	35 (19.7)	143 (80.3)	1.63 (0.77 - 3.47)		48 (27.0)	130 (73.0)	5.21 (1.69 - 16.11)	
> 2 wages	7 (12.1)	51 (87.9)	1		3 (5.2)	55 (94.8)		
Education				**0.040[2]**				**0.049[2]**
0	3 (21.4)	11 (78.6)	2.12 (0.65 - 6.89)		4 (28.6)	10 (71.4)	2.12 (0.79 - 5.65)	
1-8 years	30 (22.6)	103 (77.4)	2.23 (1.11 - 4.47)		35 (26.3)	98 (73.7)	1.95 (1.07 - 3.55)	
> 8 years	9 (10.1)	80 (89.9)	1		12 (13.5)	77 (86.5)	1	

[1] Chi-squared test; [2] Fisher's Exact test

Supplementary table S2. Bivariate analysis of the associations of general health and current health status compared with 12 months ago with systemic health and lifestyle variables. Fortaleza, Ceará, Brazil, 2017

Variables	General Health		PR (95%CI)	p value	Current Health Status Compared with 12 Months Ago		PR (95%CI)	p value
	Poor	VeryGood / Fair			Worse	The Same / Better		
	n (%)	n (%)			n (%)	n (%)		
Hospitalization in the previous year				**0.003[1]**				**0.010[1]**
Yes	11 (36.7)	19 (63.3)	2.45 (1.39 - 4.33)		12 (40)	18 (60)	2.09 (1.24 - 3.5)	
No	32 (15)	182 (85)	1		41 (19.2)	173 (80.8)	1	
Systemicdiseases				**0.003[1]**				**0.011[1]**
Yes	43 (20.7)	165 (79.3)	-		51 (24.5)	157 (75.5)	4.41 (1.12 - 17.33)	
No	0 (0)	36 (100)	-		2 (5.6)	34 (94.4)	1	
Diabetes mellitus				**<0.001[1]**				**0.003[1]**
Yes	23 (32.4)	48 (67.6)	2.8 (1.65 - 4.77)		24 (33.8)	47 (66.2)	2.02 (1.27 - 3.21)	
No	20 (11.6)	153 (88.4)	1		29 (16.8)	144 (83.2)	1	
Cardiovascular disorders				0.087[1]				**0.048[1]**
Yes	34 (20.5)	132 (79.5)	1		42 (25.3)	124 (74.7)	1.79 (0.98 - 3.29)	

No	9 (11.5)	69 (88.5)	0.56 (0.28 - 1.12)	11 (14.1)	67 (85.9)	1
Osteoporosis			0.136[1]			**0.015[1]**
Yes	13 (24.5)	40 (75.5)	1.56 (0.88 - 2.78)	18 (34)	35 (66)	1.85 (1.15 - 3)
No	30 (15.7)	161 (84.3)	1	35 (18.3)	156 (81.7)	1
Nutritionaldefficiency			1.000[2]			0.522[2]
Yes	0 (0)	3 (100)	-	1 (33.3)	2 (66.7)	1.55 (0.31 - 7.79)
No	43 (17.8)	198 (82.2)	-	52 (21.6)	189 (78.4)	1
Use ofmedications			0.057[2]			**0.019[1]**
Yes	42 (19.3)	176 (80.7)	5.01 (0.72 - 34.89)	52 (23.9)	166 (76.1)	6.2 (0.89 - 43.01)
No	1 (3.8)	25 (96.2)	1	1 (3.8)	25 (96.2)	1
Numberofmedicationsused			**<0.001[1]**			**<0.001[1]**
Upto 3	15 (11.1)	120 (88.9)	1	21 (15.6)	114 (84.4)	1
More than 3	27 (32.5)	56 (67.5)	2.93 (1.66 - 5.17)	31 (37.3)	52 (62.7)	2.4 (1.48 - 3.89)
Historyoffalls			**0.027[1]**			0.154[1]
Yes	32 (22.1)	113 (77.9)	1.99 (1.05 - 3.75)	36 (24.8)	109 (75.2)	1.45 (0.86 - 2.42)
No	11 (11.1)	88 (88.9)	1	17 (17.2)	82 (82.8)	1
Vision problems			0.229[1]			**0.066[1]**
Yes	38 (19)	162 (81)	1.67 (0.7 - 4)	48 (24)	152 (76)	2.11 (0.89 - 5)
No	5 (11.4)	39 (88.6)	1	5 (11.4)	39 (88.6)	1
Hearingproblems			0.596[1]			0.176[1]
Yes	16 (19.5)	66 (80.5)	1.16 (0.67 - 2.03)	22 (26.8)	60 (73.2)	1.39 (0.86 - 2.25)
No	27 (16.8)	134 (83.2)	1	31 (19.3)	130 (80.7)	1
Speech problems			0.059[2]			1.000[2]
Yes	7 (35)	13 (65)	2.18 (1.12 - 4.25)	4 (20)	16 (80)	0.91 (0.37 - 2.27)
No	36 (16.1)	188 (83.9)	1	49 (21.9)	175 (78.1)	1
Smoking			0.381[1]			0.100[1]
Yes	7 (23.3)	23 (76.7)	1.39 (0.68 - 2.83)	10 (33.3)	20 (66.7)	1.66 (0.94 - 2.94)

	General Health			Current Health Status Compared with 12 Months Ago		
No	36 (16.8)	178 (83.2)	1	43 (20.1)	171 (79.9)	1
Drinking			0.066¹			0.260¹
Yes	3 (7.5)	37 (92.5)	1	6 (15)	34 (85)	1
No	40 (19.6)	164 (80.4)	2.61 (0.85 - 8.04)	47 (23)	157 (77)	1.54 (0.7 - 3.35)
Physicalactivity			0.208¹			0.919¹
Yes	16 (14.3)	96 (85.7)	1	24 (21.4)	88 (78.6)	1
No	27 (20.5)	105 (79.5)	1.43 (0.81 - 2.52)	29 (22)	103 (78)	1.03 (0.64 - 1.65)
Healhinsurance			0.411¹			0.240¹
Yes	7 (13.7)	44 (86.3)	1	8 (15.7)	43 (84.3)	1
No	36 (18.7)	157 (81.3)	1.36 (0.64 - 2.87)	45 (23.3)	148 (76.7)	1.49 (0.75 - 2.95)
Used health services in the previous year			**0.034¹**			0.189¹
Yes	41 (19.8)	166 (80.2)	3.66 (0.93 - 14.5)	48 (23.2)	159 (76.8)	1.72 (0.73 - 4.02)
No	2 (5.4)	35 (94.6)	1	5 (13.5)	32 (86.5)	1
Service used			0.166¹			**0.021¹**
Public	38 (21.1)	142 (78.9)	1.9 (0.72 - 4.99)	47 (26.1)	133 (73.9)	3.13 (1.03 - 9.52)
Private/healthinsurance	4 (11.1)	32 (88.9)	1	3 (8.3)	33 (91.7)	1
Health problemwassolved			**<0.001¹**			**0.015¹**
Yes	22 (13.3)	143 (86.7)	1	32 (19.4)	133 (80.6)	1
No	20 (40)	30 (60)	3 (1.79 - 5.03)	18 (36)	32 (64)	1.86 (1.15 - 3.01)

¹ Chi-squared test; ² Fisher's Exact test

Supplementary table S4. Multivariate analysis of the associations of general health and current health status compared with 12 months ago with variables included in the model. Fortaleza, Ceará, Brazil, 2017.

Variables in themodel	General Health		Current Health Status Compared with 12 Months Ago	
	Adjusted PR	p value	Adjusted PR	p value
Income				

Upto 2 wages	-	-	5.06 (1.67 - 15.34)	**0.004**
> 2 wages	-	-	1	
Hospitalization in the previous year				
Yes	2.1 (1.27 - 3.49)	**0.004**	1.95 (1.21 - 3.14)	**0.006**
No	1		1	
Diabetes mellitus				
Yes	2.43 (1.44 - 4.1)	**0.001**	1.89 (1.2 - 2.98)	**0.006**
No	1			
Vision problems				
Yes	-	-	3.03 (1.09 - 8.41)	**0.034**
No	-	-	1	
MNA				
Risk ofmalnutrition	2.42 (1.44 - 4.06)	**0.001**	1.6 (1 - 2.55)	**0.048**
Normal	1		1	
IADL				
Needingassistance	2.23 (1.16 - 4.27)	**0.016**	-	-
Independent	1		-	-

Supplementary table S3. Bivariate analysis of general health and current health status compared with 12 months ago with oral health variables, GOHAI, IADL, MNA and GDS. Fortaleza, Ceará, Brazil, 2017.

Variable	General Health		PR (95%CI)	p value	Current Health Status Compared with 12 Months Ago		PR (95%CI)	p value
	Poor	VeryGood / Fair			Poor	The Same / Better		
	n (%)	n (%)			n (%)	n (%)		
Drymouth				0.316[1]				**0.041[1]**
Yes	22 (20.4)	86 (79.6)	1.32 (0.77 - 2.27)		30 (27.8)	78 (72.2)	1.64 (1.02 - 2.66)	
No	21 (15.4)	115 (84.6)	1		23 (16.9)	113 (83.1)	1	

Difficulty chewing and swallowing food				**0.038¹**			0.072¹
Yes	25 (23.4)	82 (76.6)	1.78 (1.03 - 3.08)		29 (27.1)	78 (72.9)	1.55 (0.96 - 2.5)
No	18 (13.1)	119 (86.9)	1		24 (17.5)	113 (82.5)	1
Problems with the taste of food				0.097¹			**0.008¹**
Yes	13 (25.5)	38 (74.5)	1.64 (0.92 - 2.91)		18 (35.3)	33 (64.7)	1.95 (1.21 - 3.14)
No	30 (15.5)	163 (84.5)	1		35 (18.1)	158 (81.9)	1
Pain with no apparent reason				1.000²			0.574¹
Yes	5 (18.5)	22 (81.5)	1.06 (0.46 - 2.46)		7 (25.9)	20 (74.1)	1.22 (0.62 - 2.43)
No	38 (17.5)	179 (82.5)	1		46 (21.2)	171 (78.8)	1
Assistancetoeat				0.532²			0.554²
Yes	4 (22.2)	14 (77.8)	1.29 (0.52 - 3.2)		5 (27.8)	13 (72.2)	1.31 (0.6 - 2.87)
No	39 (17.3)	187 (82.7)	1		48 (21.2)	178 (78.8)	1
Use ofprosthesis				0.140¹			0.717¹
Yes	34 (20.0)	136 (80.0)	1.64 (0.83 - 3.25)		38 (22.4)	132 (77.6)	1.10 (0.65 - 1.88)
No	9 (12.2)	65 (87.8)	1		15 (20.3)	59 (79.7)	1
GOHAI				**0.028¹**			0.131¹
Low	29 (22.8)	98 (77.2)	1.89 (1.05 - 3.40)		32 (25.2)	95 (74.8)	1.46 (0.89 - 2.41)
Moderate/High	14 (12.1)	102 (87.9)	1		20 (17.2)	96 (82.8)	1
IADL				0.054²			0.412²
Needingassistance	4 (44.4)	5 (55.6)	2.68 (1.22 - 5.87)		3 (33.3)	6 (66.7)	1.57 (0.60 - 4.08)
Independent	39 (16.6)	196 (83.4)	1		50 (21.3)	185 (78.7)	1
MNA				**<0.001¹**			**0.002¹**
Risk ofmalnutrition	22 (33.8)	43 (66.2)	2.88 (1.70 - 4.88)		23 (35.4)	42 (64.6)	2.11 (1.33 - 3.36)
Normal	21 (11.7)	158 (88.3)	1		30 (16.8)	149 (83.2)	1
GDS				**<0.001¹**			**<0.001¹**
Suspecteddepression	26 (44.1)	33 (55.9)	4.80 (2.80 - 8.20)		28 (47.5)	31 (52.5)	3.51 (2.23 - 5.52)
No suspecteddepression	17 (9.2)	168 (90.8)	1		25 (13.5)	160 (86.5)	1

¹ Chi-squared test; ² Fisher's Exact test

Differential Manifestations of Resilience in Brazilian University Professors in the Health Area

Maria Regina Teixeira Ferreira Capelo[1*], Christina César Praça Brasil[2], António José de Olim Marote Quintal[3], Noémi Serrano-Díaz[4], Raimunda Magalhães Silva[5], Elci Alcione Almeida Santos[6], Mirna Albuquerque Frota[7]

[1]CLEPUL, Polo of University of Madeira, Portugal
Email: m.regina.capelo@gmail.com
[2]University of Fortaleza, Ceará, Brasil
[3]University of Madeira, Portugal
[4]University of Cádiz, Spain
[5]University of Fortaleza, Ceará, Brasil
[6]University of Madeira, Portugal
[7]University of Fortaleza, Ceará, Brasil
*Corresponding author

Abstract— Human resilience can be understood as resilience, positive adaptation and overcoming hostile, adverse and/or traumatic situations. This competence is increasingly required of university teachers who are faced with challenges of great magnitude in the workplace. The present study seeks to assess differential manifestations of the resilience of Brazilian university professors. 189 university professors from a private health university in Ceará, Brazil, who answered the Wagnild and Young resilience questionnaire, participated in this research. Results indicate gender differences in assessing self-esteem and personal competence in favor of women; differences in age and seniority indicate that teachers aged fifty-six and over and with eleven or more years of teaching service have higher levels of self-esteem and acceptance of life than younger professors and less experienced; differences in training favor postdoctoral teachers. The results are relevant to the knowledge of this professional group and may contribute to the design of a future cognitive and behavioral training program aimed at promoting resilience in university teachers.

I. INTRODUÇÃO

A universidade como instituição geradora de conhecimento e formadora de profissionais com elevadas competências e independência cognitiva, necessita de um corpo docente capaz de lidar com os potenciais fatores de stresse criados pela macro globalização, que põem em risco a saúde mental e a qualidade de vida laboral dos indivíduos (Favero & Marques, 2017; Olivares-Faúndez & Villalta Paucar, 2015; Yang, 2017). Neste sentido, diversas pesquisas relatam que uma exposição continuada do indivíduo a fontes de stresse pode gerar adoecimento e sofrimento humano (Carloto, 2014; Carloto & Câmara, 2017; García et al., 2016; Lima Filha & Morais, 2018; Olivares-Faúndez & Villalta Paucar, 2015). Mas, apesar do stresse fazer parte da vida de todos os dias (Vaz Serra, 2011), a literatura tem salientado que este problema tende a tornar-se mais significativo quando associado ao trabalho (Gomes et al., 2006).

Num quadro laboral complexo, também se posicionam os professores universitários que, no seu quotidiano, se vêm confrontados com o surgimento de relevantes transformações de grande magnitude e diversidade, obrigados a vivenciar cada vez mais situações adversas e hostis, geradoras de stresse e mal-estar (Baptista et al., 2019; Carlotto & Câmara, 2017; García et al., 2016; Olivares-Faúndez & Villalta Paucar, 2015; Souto et al., 2018).

Essas problemáticas envolvem a carga horária e atribuições excessivas, em que o trabalho real vai além do trabalho prescrito, pouco tempo de descanso, tarefas rotineiras, pouco uso das capacidades criativas, escassa ou nenhuma autonomia e de poder de decisão, falta de comunicação e de apoio dos colegas e de superiores hierárquicos, incerteza em relação ao futuro, conflitos, demasiadas responsabilidades, insegurança no trabalho, falta de oportunidades de crescimento, de progresso ou de ascensão na carreira, más condições físicas, dificuldades de concentração e mau humor (Grotberg, 2006), denunciando que o stresse laboral, hoje, é mais premente do que aquele que viveram gerações precedentes.

Embora se possa considerar que qualquer pessoa está vulnerável ao stresse (Vaz Serra, 2011) e que experimentar demasiado stresse em períodos prolongados pode desencadear adoecimento e sofrimento humano (Carloto, 2014; Lima Filha & Morais, 2018; Pasqualotto & Löhr, 2015; Olivares-Faúndez & Villalta Paucar, 2015), também é evidente que as caraterísticas pessoais podem influenciar de forma significativa o grau em que uma pessoa pode resistir ou fazer frente aos stressores que vivencia no trabalho (Otero-López et al., 2014). Porém, a natureza desgastante da docência universitária pode ser harmonizada pela capacidade de o profissional resistir ou enfrentar as fontes de stresse que vivencia em contexto laboral (Brandão et al., 2011; Otero-López et al., 2015; Olivares-Faúndez & Villalta Paucar, 2015; Otero-López et al., 2014). Uma dessas caraterísticas é a resiliência.

O vocábulo resiliência tem vindo a ser usado, mais frequentemente, associado a múltiplos domínios e áreas do funcionamento humano. Do latim *resiliens*, resiliência significa "pular de volta", regressar a um estado anterior, saltar para trás, voltar e recuar (Brandão et al., 2011; Pinheiro, 2004), remete para a ideia de elasticidade e capacidade de recuperação.

Sintetizando, resiliência consiste na capacidade de adaptação, adaptação positiva, recuperação, resistência e superação (Martins et al., 2012), isto é, conseguir um desenvolvimento bem-sucedido apesar das circunstâncias muito adversas experienciadas (Becoña, 2006), enfatizada como o produto de um processo dinâmico entre fatores protetores e de risco ou como um mecanismo de defesa (Davydov et al., 2010; Ribeiro et al., 2011), que permite às pessoas prosperarem perante as adversidades que ocorrem na vida, tal como no contexto laboral (You-De et al., 2019).

O sentido teórico obtido leva a inferir que a promoção de uma resiliência individual e coletiva crescente pode imprimir efeitos no tratamento e na prevenção da saúde mental, devendo ser potenciada a partir da família, da escola, da universidade, da organização de trabalho e da comunidade (Becoña, 2006; Brandão et al., 2011; Davydov et al., 2010; Fiorentino, 2008; Fontaines & Urdanteta, 2009). Neste âmbito, constatando escassez de literatura, este estudo pretende procura aferir as manifestações diferenciais da resiliência de professores universitários brasileiros, a partir das suas próprias representações, em função das variáveis sociodemográficas sexo, estado civil, idade, antiguidade, horário, formação pós-graduada e religião.

II. MÉTODO

2.1. Participantes

Participaram no estudo 189 professores universitários, sendo 56 homens (29,50%) e 133 mulheres (70,40%), dos quais, 43 (22,60%) solteiros(as) ou com companheiro(a) e 145 (76,30%) casados (as) ou com companheiro(a). A média de idade é de 44,75 (DP = 9,94) e situa-se entre os 27 e os 77 anos. Destes, 31 com idade igual ou inferior a 35 anos (16,40%), 75 com idades compreendidas entre os 36 e 45 anos (39,70%), 55 no escalão 46 e 55 anos (29,10%) e 28 com idade igual ou superior a 55 anos (14,80%). Quanto ao nível de formação verifica-se que 4 (2,1%) são especialistas, 95 (50,30%) mestres, 68 (36%), doutor, 22 (11,60) pós-doutores. Foram agregados na mesma categoria os especialistas e mestres, o que perfaz o número de 99 (52,40%) docentes. Noventa e um docentes (50%) indicam tempo de serviço igual ou menor de 10 anos, 48 com tempo de serviço no intervalo compreendido entre 11 e 20 anos (23,60%) e 43 com mais de vinte e um anos de serviço (23,60%) e 8 não assinalaram este item (4,20%). A grande maioria (72,40%) refere professar a religião católica (123), 18 (10,60%) espíritas, 21 (12,40) outras religiões (por exemplo, evangelho de cristo, batista, evangélica) e 8 (4,70%) agnósticos ou ateus. Como critério de inclusão foi considerado ser professor universitário de cursos de graduação na área da saúde. A amostra representativa conta com 36% de professores universitário de um universo de 530 (Peduzzi et al., 1996) que lecionam numa universidade privada do Ceará, Brasil.

2.2. Instrumento

Os participantes responderam a um questionário de dados sociodemográficos e profissionais construído para o efeito e à escala de resiliência de Wagnild e Young (1993). A escala de resiliência é um instrumento multidimensional, projetado para medir o grau de cada dimensão da resiliência, constituída por 25 itens, mensurados numa escala de *Likert* compreendida entre 1 (discordo totalmente) e 7 (concordo totalmente). A análise fatorial obtida por Taranu (2011) usada no presente estudo, avalia o nível de resiliência individual nas dimensões "valorização de si próprio", "competência pessoal" e "aceitação da vida" como caraterísticas positivas da personalidade que contribuem para a adaptação do individuo perante eventos adversos do quotidiano. A pontuação total varia entre 25 e 175 pontos, sendo os valores altos indicadores de elevada resiliência.

2.3. Procedimento

O estudo descritivo, transversal e inferencial realizou-se após aprovação do Comité de Ética (2.988.258) e assinatura do termo de consentimento livre e esclarecido dos participantes. Dos 300 questionários distribuídos resultou uma amostra final de 189 questionários válidos, constituindo uma taxa de participação de cerca de 63%. Os dados recolhidos foram processados no programa informático *SPSS – Statistical Package for Social Science*, versão 20.0. Procedeu-se à análise exploratória de dados para se poder decidir, com segurança, a que tipo de testes estatísticos – paramétricos *versus* não paramétricos – se deveria recorrer (Martins, 2011) e tentar alcançar respostas para o objetivo de investigação pré-definido. A normalidade da distribuição foi testada a partir da prova de *Kolmogorov-Smirnov* e *Shapiro-Wilk*, com correção de significância *Liliefors* para um nível de significância convencional ($p < 0,05$). Indicações relativas à normalidade das variâncias foram encontradas na dimensão "valorização de si próprio" (*Kolmogorov-Smirnov*, $p = 0,012$; *Shapiro-Wilk*, $p = 0,000$), na dimensão "competência pessoal" (*Kolmogorov-Smirnov*, $p = 0,000$; *Shapiro-Wilk*, $p = 0,000$), na dimensão "aceitação da vida" (*Kolmogorov-Smirnov*, $p = 0,011$; *Shapiro-Wilk*, $p = 0,116$) e na dimensão "score total" (*Kolmogorov-Smirnov*, $p = 0,047$; *Shapiro-Wilk*, $p = 0,012$). A análise exploratória de dados apontou resultados estatisticamente significativos e outros não significativos e por opção considerou-se estarem cumpridos os pressupostos subjacentes à utilização de testes paramétricos (Martins, 2011). Estimou-se a fiabilidade em cada uma das dimensões da escala de resiliência através do coeficiente de consistência interna *alpha* de *Cronbach*. Os índices de confiabilidade da escala, na presente amostra, foram $\alpha = 0,731$ para o *score* total, α

$= 0,696$ para a valorização de si próprio, $\alpha = 0,822$ para a competência pessoal e $\alpha = 0,828$ para a aceitação da vida. A proporção de variabilidade nas respostas que resulta de diferenças nos inquiridos varia entre o fraco e o bom, sendo por isso, a sua fiabilidade admissível (Pestana & Gageiro, 2005). No tratamento estatístico dos dados assumiu-se um a*lpha* = 0,05 como valor crítico de significância dos resultados dos testes.

Tendo em consideração o objetivo do estudo, a análise dos dados versou sobre a utilização dos testes de diferenças. Usou-se o *Test T* de *Student, design* inter-sujeitos, com correção de *Levene*, para comparação de dois grupos independentes e a análise de variância (*ANOVA) Unifatorial (One-Way Analysis of Variance, F),* design inter-sujeitos, para três ou mais grupos independentes e teste Post Hoc de Tukey (Hill e Hill, 2008; Martins, 2011; Pestana & Gageiro, 2005) porque os resultados permitem fazer inferências.

Em todas as fases do processo de investigação foram adotados de modo rigoroso os procedimentos éticos na pesquisa com seres humanos, a referenciação da forma mais correta possível, a colaboração graciosa e voluntária, garantindo o anonimato e a confidencialidade dos dados obtidos.

III. RESULTADOS

Os resultados diferenciais que se apresenta reportam, apenas, àqueles que se revelaram estatisticamente significativos ($p < 0,05$).

A diferenciação, a partir do *Test T* de *Student*, em função do sexo, indicou que as mulheres relatam níveis mais elevados do que os homens nas dimensões "valorização de si próprio" [$t(187) = -2,40$, $p = 0,017$] e "competência pessoal" [$t(187) = -2,27$, $p = 0,024$] (Tabela 1). Há grande discrepância entre o número de homens e mulheres participantes, pelo que se pressupõe que numa população mais homogénea os resultados poderiam ser diferentes.

Table.1: Distribuição da resiliência de professores universitários em função do sexo

Dimensões	Sexo	N	M	DP	t	df	p
Valorização de si próprio	Masculino	56	77,03	7,15	-2,407	187	0,017
	Feminino	133	**79,74**	7,02			
Competência pessoal	Masculino	56	35,64	3,82	-2,272	187	0,024
	Feminino	133	**36,95**	3,54			

Fonte: elaboração dos autores.

Os resultados diferenciais em função de ser casado(a) / com companheiro(a) ou solteiro(a) / sem companheiro(a) não sugerem diferenças estatisticamente significativas relativamente às dimensões da escala - valorização de si próprio - [$t(186) = 0,451$, $p = 0,653$],

competência pessoal - [$t(186) = -0,280$, $p = 0,780$] e aceitação da vida - [$t(186) = 1,781$, $p = 0,077$].

A diferenciação em função da idade, a partir da prova *ANOVA*, mostra que há diferenças significativas ao nível da "valorização de si próprio" [$F(3,189 – 4 = 4,102)$] (Tabela 2).

Table.2: Distribuição da resiliência de professores universitários em função da idade

Dimensões	Idade	N	M	DP	P	df	F	ANOVA Sig
Valorização de si próprio	≤ 35	31	76,19	7,53	0,015	3	4,102	0,008
	≥ 56	28	**81,71**	5,52				
Aceitação da vida	≤ 35	31	24,90	4,14	0,001	3	6,369	0,000
	≥ 56	28	**29,68**	4,54				
	≥ 56	28	**29,68**	4,54	0,003	3		
	36-45	75	27,43	5,44				

Fonte: Elaboração dos autores.

O teste *Post-Hoc* de *Tukey* revelou que os professores universitários mais velhos, isto é, com idade igual ou superior a 56 anos relatam maior valorização de si próprios do que os professores mais jovens, com idade igual ou menor do que 35 anos ($p = 0,015$). Há diferenças significativas ao nível da perceção da "aceitação da vida", [$F(3,189 – 4 = 6,369)$], sendo os professores universitários mais velhos, com idade igual ou superior a 56 anos a relatar maior "aceitação da vida" do que os professores os universitários com idade igual ou menor do que 35 anos ($p = 0,001$) e do que os que se encontram no escalão etário entre 36 e 45 anos ($p = 0,003$).

As provas não revelaram diferenças estatisticamente significativas em função do horário de trabalho dos professores universitários, nas três dimensões da escala, nomeadamente, valorização de si próprio, [$F(3,188 – 4 = 2,661; p = 0,050)$], competência pessoal, [$F(3,188 – 4 = 0,759; p = 0,518)$] e aceitação da vida, [$F(3,188 – 4 = 1,278; p = 0,283)$].

Table.3: Distribuição da resiliência de professores universitários em função da antiguidade

Dimensões	Anos	N	M	DP	p	df	F	ANOVA Sig.
Valorização de si próprio	≤ 10	91	76,81	7,06	0,001	2	8,745	0,000
	11-20	48	**81,50**	5,83				
	≤ 10	91	76,81	7,06	0,010			
	≥ 21	43	**80,60**	7,80				
Competência pessoal	≤ 10	91	35,89	3,58	0,012	2	4,213	0,016
	11-20	48	**37,77**	3,46				
Aceitação da vida	≤ 10	91	138,35	11,72	0,026	2	4,506	0,012
	≥ 21	43	**145,19**	15,27				

Fonte: Elaboração dos autores.

Em função da antiguidade, os resultados estatísticos sugerem diferenças significativas na dimensão "valorização de si próprio", [$F(2,189 – 3 = 8,745)$], sendo os professores universitários com mais tempo de serviço, ou seja, no escalão etário compreendido entre os 11 e os 20 anos ($p = 0,001$) e com 21 anos ou mais de antiguidade docente ($p = 0,010$), a pontuarem mais alto do que os

apresentam professores com 10 anos ou menos de experiência docente (Tabela 3).

Há diferenças significativas na dimensão "competência pessoal", [$F(2,189 – 3 = 4,213)$] com o teste *Post Hoc* de *Tukey* a indicar que os professores universitários com idades compreendidas entre os 11 e os 20 anos relatam maior "competência pessoal" do que os menos experientes ($p = 0,026$). Relativamente à "aceitação da vida", [$F(2,189 – 3 = 4,213)$], nota-se que os professores com 10 ou menos anos de experiência docente apresentam níveis de "aceitação da vida" mais baixos do que o grupo etário entre os 11 e 20 anos ($p = 0,001$) e o grupo com 21 ou mais anos de antiguidade docente ($p = 0,011$).

A análise de variância revela diferenciação estatisticamente significativa na resiliência em função da formação académica dos professores universitários (Tabela 4). Na dimensão "valorização de si próprio", [$F(2,189 – 3 = 5,366)$], observou-se que os professores universitários pós-doutorados apresentam médias mais elevadas do que os pares sem doutoramento ($p = 0,008$) e com doutoramento ($p = 0,005$). Os níveis médios da dimensão "competência pessoal", [$F(2,189 – 3 = 5,111)$], sugerem que os professores universitários pós-doutorados percecionam uma maior competência pessoal do que os colegas sem doutoramento ($p = 0,007$) e com doutoramento ($p = 0,009$). Em relação à dimensão "aceitação da vida", [$F(2,189 – 3 = 10,507)$], verifica-se que os professores universitários pós-doutorados percecionam uma maior aceitação da vida do que os colegas sem doutoramento ($p = 0,038$) e com doutoramento ($p = 0,000$), sendo de sublinhar que, neste domínio, os professores universitários com doutoramento relatam menor aceitação da vida do que os colegas sem doutoramento ($p = 0,008$) e com pós-doutoramento ($p = 0,000$).

Table.4: Distribuição da resiliência de professores universitários em função da formação académica

Dimensões	Nível	N	M	DP	p	df	F	ANOVA Sig.
Valorização de si próprio	n/Doutor	99	78,51	7,34	0,008	2	5,366	0,005
	Pos-Doc	22	**83,50**	4,4				
	Doutor	68	78,09	7,12	0,005			
	Pos-Doc	22	**83,50**	4,40				
Competência pessoal	n/Doutor	99	36,28	3,76	0,007	2	5,111	0,007
	Pos-Doc	22	**38,86**	2,47				
	Doutor	68	36,23	3,62	0,009			
	Pos-Doc	22	**38,86**	2,47				
Aceitação da vida	n/Doutor	99	**27,29**	5,08	0,008	2	10,507	0,000
	Doutor	68	25,10	4,14				
	n/Doutor	99	27,29	5,08	0,038			
	Pos-Doc	22	**29,95**	3,10				
	Doutor	68	25,10	4,14	0,000			
	Pos-Doc	22	**29,95**	3,10				

Fonte: Elaboração dos autores.

Quanto às médias das categorias da escala de resiliência em função da religião os resultados não aventam quaisquer diferenças estatisticamente

significativas: valorização de si próprio, [$F(3,169 - 3 = 1,206$; $p = 0,309$], competência pessoal, [$F(3,169 - 3 = 1,176$; $p = 0,320$] e aceitação da vida, [$F(3,169 - 3 = 0,812$; $p = 0,489$].

IV. DISCUSSÃO

Os resultados obtidos denunciam as manifestações diferenciais numa amostra representativa de professores universitários de uma universidade privada, no Ceará, Brasil, que leciona cursos do domínio da saúde coletiva, tendo em consideração as dimensões da escala de resiliência de Wagnild e Young (1993), adaptada para o português por Taranu (2011) – "valorização de si próprio", "aceitação da vida" e "competência pessoal" e as variáveis sócio demográficas e profissionais "sexo", "conjugalidade", "idade", "horário de trabalho", "antiguidade docente", "nível de formação académica" e "religião". Apenas foram considerados os resultados estatisticamente significativos ($p < 0,05$).

Uma primeira análise respeita às diferenças de sexo, tendo se verificado que as professoras apresentam níveis significativamente mais elevados nas dimensões valorização de si próprio e competência pessoal do que os professores. O estudo de Taranu (2011), por sua vez, encontrou diferença em função do sexo, na dimensão aceitação da vida. O resultado obtido parece apoiar estereótipos sociais que atribuem à mulher um autoconceito elevado, mas que não foi objeto deste estudo e, ainda, um papel mais proativo na superação dos dissabores da vida. Esta evidência leva a pressupor que a resiliência como capacidade de adaptação, resistência e superação (Martins *et al*, 2012) é uma caraterística tipicamente feminina (Fontaines & Urdanteta, 2009), crucial num mundo onde se exige cada vez mais tarefas e competências às mulheres. Este pressuposto não sugere que as professoras sejam invulneráveis perante adversidades significativas da vida, mas que recorrem a habilidades psicológicas de recuperação e a mecanismos de *coping* flexíveis para se adaptarem, resistirem, superarem dificuldades e construírem novos caminhos (Martins *et al*, 2012).

A investigação evidenciou ausência de diferenças na escala de resiliência em função da conjugalidade, isto é, viver com cônjuge ou viver só. Estudos da resiliência centrados na família (Yunes, 2003) definem as famílias resilientes como aquelas que perante catástrofes e crises não esperadas resistem às adversidades e adaptam-se positivamente às situações No entanto, o conceito de família, bem como o tipo de conjugalidade tem vindo a mudar, obrigando os indivíduos a optarem por se integrarem em novos modelos e a recorrerem a novas

formas de adaptação positiva e de superação das adversidades (Carnut & Faquim, 2014).

A adaptação positiva ocorre a partir de aspetos saudáveis do indivíduo na interação com o meio, tais como o otimismo e que funcionam como mediadores do impacto gerado pelos stressores (Ribeiro *et al*, 2011; Martins *et al*, 2012; Otero-López *et al*, 2014), contudo, o fator apoio emocional destaca-se como muito importante no estudo sobre estratégias de conciliação trabalho-família de professores universitários numa capital do Nordeste brasileiro (Silveira & Bendassolib, 2018). A resiliência pode ser explicada num contexto académico andragógico conforme enfatizam Alvarez (2018), Fiorentino (2008), Fontaines e Urdanteta (2009) e Ortega, (2014), conexa com diversos fatores como capacidade de resolução de problemas, género feminino considerado uma variável protetora (Suárez, 1993), vínculos afetivos externos com pessoas significativas fora da família, aspetos saudáveis do grupo familiar (Yunes, 2003), temperamento, relações interpessoais e diferentes caraterísticas, designadamente, introspeção, independência, capacidade de se relacionar, iniciativa, humor, criatividade e moral.

Na diferenciação em função da idade não sobressaiu a dimensão competência pessoal conforme assinalou o estudo de Capelo e colaboradores (2015). Esta evidência merece um estudo mais aprofundado, mas sugere que os professores universitários participantes neste estudo, tanto do sexo masculino como feminino, detém a perceção de níveis de competência pessoal idênticos.

Relativamente à valorização de si próprio, aceitação da vida e resiliência total, o estudo demonstra que os docentes universitários mais velhos relatam níveis significativamente mais elevados do que os mais jovens. Por sua vez, a pesquisa de Taranu (2011) também assinalou diferenciação na aceitação da vida, com os participantes mais velhos a apresentarem níveis superiores de resiliência nesta dimensão, enquanto o estudo de Capelo e colaboradores (2015) revela que os participantes com idade igual ou superior a 51 anos, indiciam níveis significativamente mais elevados de competência pessoal do que os participantes que se encontram no escalão etário entre os 31 e os 40 anos.

A análise diferencial evidenciou que os resultados da antiguidade vão no mesmo sentido que os resultados da idade, sugerindo que os professores mais experientes se percecionam mais resilientes e mais capazes de dar novos significados aos problemas. Os professores universitários deste estudo menos experientes, com menor tempo de serviço docente (menor ou igual a dez anos), apresentaram níveis de valorização de si próprio, de competência pessoal e de aceitação da vida, inferiores aos professores com

maior antiguidade docente. De facto, os resultados espelham um olhar mais positivo dos professores universitários em final de carreira, vindo a sua expressão a corroborar a teoria que define a resiliência como um processo dinâmico, que obriga a sucessivos padrões de adaptação, recuperação e superação ao longo da vida (Brandão et al., 2011; Martins *et al*, 2012). Na verdade, os docentes mais velhos experienciaram, treinaram, melhoraram as suas estratégias de enfrentamento e superaram situações traumáticas, merecendo um estudo mais aprofundado sobre este grupo profissional.

A expressão dos participantes sobre o horário laboral não indiciou diferenças estatisticamente significativas entre eles em qualquer dimensão da escala de resiliência. A resiliência denota-se como um estado psicológico, como uma caraterística da personalidade que depende de aspetos individuais e ambientais (Yang, 2017), podendo ser vista como um mecanismo de defesa (Davydov et al., 2010), que permite às pessoas prosperar perante as adversidades (Becoña, 2003). Este resultado permite deduzir que variáveis intrínsecas ou extrínsecas não consideradas neste estudo, como por exemplo o otimismo, a elevação, a motivação, a satisfação, a interação professor/aluno, as gratificações pelo trabalho realizado, a socialização, a partilha, a compaixão, entre outras, poderão concorrer para que os resultados não evidenciem diferenciação entre os professores universitários, em função da componente horário de trabalho.

As diferenças em função da formação académica mostram que os professores universitários Pós-doutorados relatam maior resiliência, maior valorização de si próprio e maior competência pessoal do que os doutorados e do que os não doutores. Quanto à aceitação da vida, são os docentes doutorados que relatam níveis mais baixos de resiliência quando comparados com os não doutorados e os pós-doutorados. O pressuposto é que ao elevar o nível de formação do professor universitário, isso afetará a sua resiliência, bem como a forma como lida com as demandas diárias da sua profissão. Conforme assevera Ortega (2014), a resiliência é uma capacidade e não um atributo de personalidade, passível de ser promovida e fomentada. Logo, o fortalecimento do comportamento resiliente e estimulação das habilidades sociais devem ser tidos em conta na formação de futuros professores que irão passar a vivenciar níveis de stresse elevado na sua profissão (Pasqualotto & Löhr, 2015) num quadro laboral complexo, cada vez mais dominado pelo macro da globalização (Baptista et al., 2019; Carlotto & Câmara, 2017; García et al., 2016; Olivares-Faúndez & Villalta Paucar, 2015; Souto et al., 2018; Yang, 2017).

Neste estudo não emergiram diferenças estatisticamente significativas entre a prática religiosa e as variáveis sócio demográficas e profissionais, indiciando que, caso exista alguma diferença tendencial, a mesma não tem significado psicológico nesta população. Contudo, considera-se conveniente integrar esta variável em estudos futuros a fim de se confirmar se, na verdade, a prática de religião ou a conexão espiritual influenciam a adaptação psicossocial do indivíduo perante eventos da vida quotidiana (Capelo et al., 2015).

V. CONCLUSÃO

Conclui-se que as manifestações diferenciais dos atributos valorização de si próprio, competência pessoal e aceitação da vida parece terem sido comprovadas através dos resultados da resiliência dos professores universitários brasileiros, evidenciadas nesta pesquisa, em relação ao sexo, à idade, à antiguidade e à formação académica. Contudo, apesar da escassez de literatura no contraste ou corroboração dos resultados, crê-se que esta pesquisa concede subsídios para o conhecimento de um grupo profissional insuficientemente estudado, crucial para a formação de novas gerações e para o desenvolvimento sociomoral e económico de qualquer país. Por tudo isso, considera-se de suma importância a realização de novas investigações que ajudem a compreender o fenómeno e facilitem o delineamento de estratégias de treino cognitivo e comportamental dirigido à prevenção dos riscos psicossociais e à promoção da resiliência nos professores universitários e na população em geral.

REFERÊNCIAS

[1] Alvarez, M. A. (2018). Nuevas perspectivas de resiliência em el entorno de la docência universitária. *Revista Internacional de Investigación y Formación Educativa,* 1-20. https://www.ensj.edu.mx/wp-content/uploads/2019/01/4.-Nuevas-perspectivas-de-resiliencia.pdf

[2] Baptista, M. N., Soares, T. F. P., Raad, A. J., & Santos, L. M. (2019). Burnout, estresse, depressão e suporte laboral em professores universitários. *Revista Psicologia: Organização e Trabalho,* 19(1), 564-570. http://dx.doi.org/10.17652/rpot/2019.1.15417

[3] Becoña, E. (2006). Resiliência: definición, características y utilidade del concepto. *Revista de Psicopatología Clínica*, 11(3), 125-146. ISSN 1136-5420/06

[4]   Brandão, J. M., Mahfoud, M., & Gianordoli-Nascimento, I. F. (2011). A construção do conceito de resiliência em psicologia: discutindo as origens. *Paidéia,* 21(49), 263-271. https://www.scielo.br/j/paideia/a/X8smHqGPJnV9jWTCYTmTmrx/?format=pdf&lang=pt

[5]   Carlotto, M. S. (2014). Prevenção da Síndrome de Burnout em professores: um relato de experiência. *Mudanças – Psicologia da Saúde,* 1(22), 31-39. https://www.metodista.br/revistas/revistas-metodista/index.php/MUD/article/view/4782/4383

[6]   Carlotto, M. S., & Câmara, S. G. (2017). Riscos psicossociais associados à síndrome de burnout em professores universitários. *Avances em Psicología Latinoamericana,* 35(3), 447-457. http://dx.doi.org/10.12804/10.12804/revistas.urosario.edu.co/apl/a.4036

[7]   Carnut, L., & Faquim, J. (2014). Conceitos de família e a tipologia familiar: aspectos teóricos para o trabalho da equipa de saúde bucal na estratégia de saúde de família. *J Manag Prim Health Care,* 6(1), 82-70. https://jmphc.com.br/jmphc/article/view/198

[8]   Capelo, M. R. T. F., Pocinho, M., & Rodrigues, S. (2015). O sentido da vida quotidiana: religião, resiliência e espiritualidade. In José Eduardo Franco e João Paulo Oliveira e Costa (Dir.). *Diocese do Funchal. A Primeira diocese Global. História, Cultura e Espiritualidades,* II, Funchal: Diocese do Funchal, pp. 883-896.

[9]   Davydov, D. M., Stewart, R., Ritchie, K., & Chaudieu, I. (2010). Resilience and mental health. *Clinical Psychology Review,* 30, 479-495. https://doi.org/10.1016/j.cpr.2010.03.003

[10] Favero, A. A., & Marques. M. (2017). Docência universitária numa perspetiva de formação interdisciplinar. *Revista de Ciências Humanas – Educação,* 18(30), 37-53. ISSN 1981-9250**.**

[11] Fiorentino, M. T. (2008). La construcción de la resiliência en el mejoramiento de la calidad de vida y la salud. *Suma Psicológica,* 15(1), 95-114. ISSN: 0121-4381.

[12] Fontaines, T., & Urdanteta, G. (2009). Aptitud resiliente de los docentes en ambientes universitarios. *Revista de Artes y Humanidades ÚNICA,* 10(1), 163-180. ISSN: 1317-102X.

[13] García, M. M., Iglesias, S., Saletab, M., & Romaya, J. (2016). Riesgos psicosociais em el professorado de enseñanza universitária: diagnóstico y prevención. *Journal of Work and Organizational Psychology,* 32, 173-182. ISSN 2174-0534.

[14] Gomes, A., Silva, M. J., Mourisco, S., Silva, S., Mota. A., & Montenegro, N. (2006). Problemas e desafios no exercício da atividade docente: Um estudo sobre o stresse, "burnout", saúde física e satisfação profissional em professores do ensino secundário. *Revista Portuguesa de Educação,* 19(1), 67-93. ISSN: 0871-9187.

[15] Grotberg, E. H. (2006). *La resiliência em el mundo de hoy: como superar las adversidades.* Barcelona: Gedisa.

[16] Hill, M. M.; Hill, A. (2008). *Investigação por Questionário.* Lisboa: Edições Sílabo.

[17] Lima Filha, C. N. M. B., & Morais, A. N. (2018). Prevalência e fatores de risco do burnout nos docentes universitários. *Revista contemporânea de educação,* 13(27), 453-471. https://doi.org/10.20500/rce.v13i26.12277

[18] Martins, C. (2011). *Manual de análise de dados quantitativos com recurso ao IBM SPSS.* Braga: Psiquilibrios Edições.

[19] Martins, M. C. F., Onça, S. S., Emílio, E. R., & Siqueira, M. M. M. (2012). Resiliência: uma breve revisão teórica do conceito. In Rezende, M. M. e Heleno, M. G. V. *Psicologia e Promoção da Saúde em Cenários Contemporâneos.* São Paulo: Vetor Editora, pp. 97-156.

[20] Olivares-Faúndez, V., & Villalta Paucar, M. A. (2015). Burnout y resiliência em professores universitários. In Lorena Godoy e Elisa Ansoleaga (Ed.), *Um campo en tensión o tensión entre campos.* Santiago de Chile: Ril Editores, 307-318.

[21] Ortega, J. (2014). Estrés y evaluación psicológica: um acercamiento teórico relacionado al concepto de resiliência. *Anuario de Investigaciones,* XXI, 297-302. https://www.redalyc.org/pdf/3691/369139994030.pdf

[22] Otero-López, J. M., Villardfrancos, E., Castro, C., & Santiago, M. J. (2014). Stress, positive personal variables and burnout: A path analytic approach. *European Journal of Education and Psychology,* 7(2) 95-106. https://doi.org/10.30552/ejep.v7i2.105

[23] Pasqualotto, R. A., & Löhr, S. S. (2015). Habilidades sociais e resiliência em futuros professores. *Psicologia Argumento,* 33(80),310-320. http://dx.doi.org/10.7213/psicol.argum.33.080.AO07.

[24] Peduzzi, P., Concato, J., Kemper, E., Holford, T. R., & Feinstein, A. R. (1996). A simulation study of the number of events per variable in logistic regression analysis. *Journal Clinical Epidemiology,* 49(12), 1373-1370. https://doi.org/10.1016/s0895-4356(96)00236-3.

[25] Pestana, M. H., & Gageiro, J. N. (2005). *Análise de dados para ciências Sociais.* Lisboa: Edições Sílabo.

[26] Pinheiro, D. P. N. (2004). A resiliência em discussão. *Psicologia em Estudo,* 9(1) 67-75. https://doi.org/10.1590/S1413-73722004000100009

[27] Ribeiro, A. C. A., Mattos, B. M., Antonelli, C. S., Canêo, L. C., & Goulart Júnior, E. (2011). Resiliência no Trabalho Contemporâneo: Promoção e/ou Desgaste da Saúde Mental. *Psicologia em Estudo,* 16(4), 623-633. https://www.scielo.br/j/pe/a/prVsx9C8B4Z564mKMCgnzng/?format=pdf&lang=pt

[28] Silveira, S. S., & Bendassollib, P. F. (2018). Estratégias de conciliação trabalho-família de professores universitários em uma capital do Nordeste brasileiro. Revista Organização e Trabalho, 18(3), 422-429. http://dx.doi.org/10.17652/rpot/2018.3.14299

[29] Souto, I, Pereira, A., Brito, E., Sancho, L., & Jardim, J. (2018). Psychosocial Risk Factors and Distress in Higher Education Teachers. *The European Proceedings of Social & Behavioural Sciences. Future Academy,* 127-140. ISSN: 2357-1330.

[30] Suárez, O. E. (1993). *Resiliencia o capacidad de sobreponerse a la adversidade. Medicina y Sociedad.* Buenos Aires: Paidós.

[31] Taranu, O. (2011). *Estudo da Relação entre Resiliência e Espiritualidade numa amostra portuguesa.* Dissertação de Mestrado. Lisboa: Universidade de Lisboa. https://repositorio.ul.pt/handle/10451/4338

[32] Vaz Serra, A. (2011). *O Stress na vida de todos os dias.* Lisboa: Adriano Vaz Serra.

[33] Wagnild, G. M., & Young, H. M. (1993). Development and Psychometric Evaluation of the Resilience Scale. *Journal of Nursing Measurement,* 1(2), 165-177. PMID: 7850498.

[34] Yang, J. C-C. (2017). A Study of Factors Affecting University Professors' Research Output: Perspectives of Taiwanese Professors. *Journal of College Teaching & Learning*, 14(1), 11-20. https://doi.org/10.19030/tlc.v14i1.9968

[35] You-De, D., Wen.Long, Z, & Tzung-Chen, H. (2019). Engage or quit? The moderating role of abusive supervision between resilience, intention to leave and work engagement. *Tourism Management,* 70, 69-77. https://doi.org/10.1016/j.tourman.2018.07.014

[36] Yunes, M. A. M. (2003). Psicologia positiva e resiliência: o foco no indivíduo e na família. *Psicologia em Estudo,* 8(esp), 75-84. https://doi.org/10.1590/S1413-73722003000300010

Spatial Analysis of Hospitalized Dengue Patients in Cabanatuan City: Demographics and Risk

Ronald S. Santos[1], Gilbert M. Tumibay, Ph.D.[2]

[1]Angeles University Foundation, Angeles City, Philippines
Email: santos.ronald@neust.edu.ph, santos.ronald@auf.edu.ph
2Angeles University Foundation, Angeles City, Philippines
Email : gibo.tumibay@gmail,com

Abstract— This study employed spatial pattern analysis of a prospective dengue epidemic in one of the cities in Nueva Ecija Philippines – Cabanatuan City. It aims to give strategic information for the dengue management effort in the face of constrained capacity. The researchers examined the demographic pattern of dengue cases to add to the knowledge needed for successful policy-making. Weekly records of dengue cases from multiple Disease Reporting Units (DRU) in Cabanatuan City were gathered as the database. This includes barangay, sex, age, and DRU types from January 2014 to December 2018. Each recorded dengue fever patient's barangay was geocoded to map and clustered. This research found a substantial correlation between reported incidents and particular demographic groupings among male, age 10-14, mostly admitted in a government hospitals and weeks 28 to 42 where the virus transmission is high. Furthermore, the dynamic growth of the aggregation of disease incidence (hotspots) for dengue patients in Cabanatuan City was displayed using spatial analysis utilizing geographic information system (GIS). It is hoped that the research results shall provide strategic information for dengue control program planning and design.

I. INTRODUCTION

Mosquito had been a well-known transmitter of disease. The most dangerous is the malaria which according to World Health Organization's (WHO) latest world malaria report, there were an estimated 241 million malaria cases and 627,000 malaria deaths worldwide in 2020 [1] [2] [3]. Despite the fact that mosquitoes are responsible for many malaria deaths, there were more dengue cases around the world, and there is no specific treatment for dengue/severe dengue [4] [5]. But early identification of illness development associated with severe dengue, and availability to adequate medical care decreases mortality rates of severe dengue to below 1 percent. But if not treated, this may lead to severe dengue - the Dengue Hemorrhagic Fever (DHF). This disease could cost one's life. Modelling estimates show that 400 million dengue virus infections occur each year, with 96 million of these manifesting clinically [6]. According to another study on the prevalence of dengue, 3.9 billion people are at risk of infection with dengue viruses. Despite the fact that there is a risk of infection in 129 countries, Asia bears 70% of the actual burden [7].

Dengue is an acute viral infection transmitted through a bite of a dengue-carrying mosquito. It has four (4)

virus types: DENV 1, DENV 2, DENV 3 and DENV 4. Dengue mosquitoes are usually in dark places and they breed in clear stagnant water. The metamorphosis from larvae to mosquito usually takes 10-12 days. Dengue carrying mosquitoes are "day biters" and frequents 2 hours before the sun sets. Humans are infected with the virus by the bites of infected female mosquitos, typically the Aedes aegypti mosquito. Other Aedes species can also operate as vectors, although their contribution is secondary to that of Aedes aegypti. Dengue can be life threatening when not managed early. Persons experiencing any of these symptoms: high fever, skin flushing, bleeding, nausea and vomiting must seek immediate medical attention [8].

In 2019, 27 countries reported 4,363 cases of dengue, of which 4,020 were confirmed. The number of cases in 2019 was almost double that for 2018, reflecting the intense circulation of the virus on a global scale. "Dengue is endemic primarily in urban and semi-urban tropical or subtropical regions of the world." [9] [10] This means that it is frequently available case in that specific area. According to Bilal Tariq 2007, Dengue mosquito-borne disease is becoming a serious public health problem worldwide, especially in tropical and subtropical areas, and dengue fever is among the main mosquito-borne diseases in addition to malaria [11].

The dengue virus replicates in the mosquito midgut after feeding on a DENV-infected individual before spreading to secondary tissues such as the salivary glands [12] [13]. When the ambient temperature is between 25 and 28°C, the extrinsic incubation period (EIP) takes roughly 8-12 days [14]. Variations in the extrinsic incubation period are determined not only by ambient temperature, but also by a variety of parameters such as the amplitude of daily temperature swings, virus genotype, and starting viral concentration. Once infected, the mosquito may transmit virus for the remainder of its life [15] [16].

As regards the transmission of the virus, mosquito vectors are the principal method of transmission between people. However, there is evidence of the possibility of maternal transfer (from a pregnant mother to her baby). While vertical transmission rates appear to be modest, the risk of vertical transmission appears to be associated with the time of the dengue infection during pregnancy. When a mother has a DENV infection while pregnant, her infants may experience pre-term delivery, low birthweight, and fetal distress [17] [18].

On the other hand, only a few cases of transmission by blood products, organ donation, and transfusions have been documented. Transovarial transmission of the virus within mosquitoes has also been documented. While the majority of dengue infections are asymptomatic or have moderate symptoms, it can sometimes produce a severe, flu-like sickness that affects newborns, young children, and adults but rarely results in death. After an incubation period of 4–10 days following a bite from an infected mosquito, symptoms normally last for 2–7 days [19]. WHO classified dengue fever into two categories: mild dengue (with or without warning signals) and severe dengue. The categorization of dengue with or without warning signals is intended to assist health practitioners in triaging patients for hospital admission, guaranteeing close surveillance, and reducing the risk of developing more severe dengue.

The overall worrisome increase in dengue case counts over the last two decades can be attributed in part to a shift in national methods for recording and reporting incidents to Department of Health and the WHO. Hence, the need for a systematic reporting of dengue illness cases. When effective vector control methods are in place, dengue prevention and management can be done properly. In addition, vector control efforts can significantly improve if long-term community engagement will be established [20].

Between 2014 – 2018, the highest cases of dengue in the whole province of Nueva Ecija were recorded in Cabanatuan City [21]. But due to lack of effective monitoring method the incidence estimates or reporting may be erroneous since there is no mechanism available to closely monitor these incidences; hence, this study.

This study aims to use spatial analysis to identify the dengue-affected barangays in Cabanatuan City particularly in the year 2014 – 2018. In addition, it is also hoped that through this study, medical health practitioners will be able to characterize and identify the profile of dengue-prone individuals in the city.

II. OBJECTIVES

With the use of Spatial Analysis, the researchers aim to identify the barangays in Cabanatuan City where highest number of dengue cases are recorded in the last 5 years, 2014 -2018. With these data, they can identify statistically significant spatial clusters of high value phenomena and put red alert status on barangays where dengue outbreaks are identified. This will help them in developing a more efficient health policies and possible intervention that can help prevent or limit the number of dengue cases in the city. Likewise, this study will characterize demographic data of people affected by Dengue Fever.

III. LITERATURE REVIEW

According to the Bill Gate's Informatics (2014), the deadliest animal is the mosquito. This is from the point

of view on the data gather on the number of people that were killed by an animal per year. There are about 600,000 recorded deaths brought about by the virus transferred by mosquito. Such diseases are malaria, dengue, yellow fever or Japanese encephalitis, Zika virus, chikungunya and west nile to name a few. There are more than 2,500 species of mosquitoes thriving in every region of the world except Antarctica [22].

Malaria cases are brought by anopheles' mosquitoes. For dengue virus Aedes Aegypti and Aedes Albopictus mosquitoes are the assailant. The former are more aggressive and only female bites because they need it to lay their eggs [23].

From the article of Rachel Nuwer (2014), she stated that "…mosquitoes kill more humans than humans' murderers do". Many people would assume the creature that they most afraid with would be snake, wild animals like lion or tiger or right out in the amazon - the crocodile or anacondas. But data show that the recorded 475,000 people being murdered by other people from car accident to robbery was topped by 725,000 number of deaths caused by mosquito virus [24] [25].

Fig.1. Mosquito (Aedes Aegypti)

Fig.2. Bill Gates Infographics [8]

On the other hand, the article written by Miguel Prudencio in 2020 dubbed as "In fairness to Mosquitoes" reported that it is not the mosquitoes that kill people directly; but it was the multiple diseases that they transmit. He further states that a mosquito bite may include pain, itchiness and discomfort but no deaths were being reported. He also emphasizes that data on human-to-human transmission of fatal infections such as TB, AIDS, coronavirus diseases 2019 (COVID-19), and other infectious illnesses should be added to the list of murderers, and it would almost certainly be the unchallenged leader in any list of killers [26].

In the Philippines, the compendium of dengue monthly report of the Department of Health (DOH) from 2014-2018, show that the highest dengue cases reported was in the year 2016 where 1,021 out of 208,805 cases are reported as morbidity. The Table 1 below shows the complete information of the reported dengue cases. It is also noteworthy to mention, that in Region III where the research locale is situated, highest dengue cases for 2 years, 2015 and 2018, were recorded. While it ranked 2nd in the year 2014 and 2017 [27].

Table 1. Dengue cases and deaths in the Philippines

Region	2014		2015		2016		2017		2018	
	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths
Philippines	121,580	465	87,411	272	208,805	1,021	152,224	811	127,478	655
I	6,985	18	7,702	24	8,139	20	8,206	23	9,988	38
II	3,854	17	7,799	11	3,869	11	5,306	34	6,701	18
III	14,471	19	12,035	9	19,642	65	24,865	82	19,307	61
IV-A	15,111	30	11,893	48	23,331	110	22,318	104	16,005	92
IV-B	2,591	15	1,933	6	3,935	20	2,735	14	4,761	36
V	2,329	11	952	3	2,419	17	3,190	26	2,033	23
VI	8,489	27	4,360	11	25,836	88	10,302	86	9,551	67
VII	6,566	26	4,042	19	26,318	232	13,735	119	7,584	39
VIII	5,239	21	916	4	5,280	28	4,285	24	4,219	26
IX	6,755	28	4,625	14	6,911	37	4,607	27	3,493	28
X	11,752	65	5,550	27	17,080	70	6,671	24	11,223	71
XI	8,561	44	2,670	10	11,667	94	3,551	25	3,371	15
XII	7,247	40	5,599	16	17,937	77	9,432	37	5,383	26
BARMM	1,501	10	720	8	2,364	30	454	2	1,601	18
CAR	2,582	7	4,837	4	10,397	22	3,991	13	4,332	7
Caraga	8,618	43	2,664	14	7,879	40	2,679	13	3,450	13
NCR	8,929	44	9,114	44	15,801	60	25,897	158	14,476	77

In addition to the significant information presented above, the Philippine Health Agenda of 2016 – 2022 recognizes that dengue is one of the prevalent communicable diseases in the country as shown in figure 3 below [28].
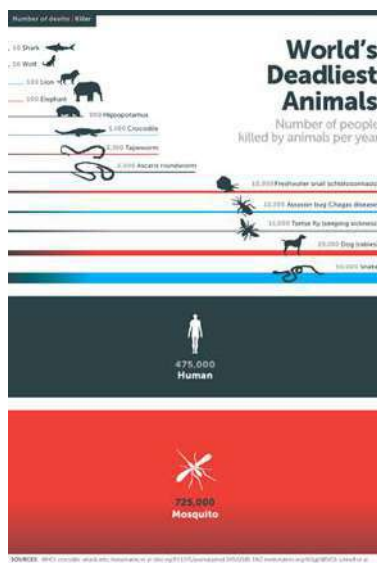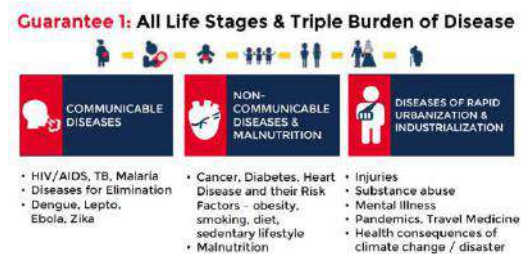

Fig.3. Department of Health Agenda of 2016-2022

IV. METHODS

Using the shapefile of the Map of the Philippines,

downloaded from namria website, together with their respective codes, the data were joined via barangay name. This done to map the counts of the admitted dengue patients.

From the dengue case per barangay, the researchers inserted additional column to append the barangay code on the shapefile of the barangay boundary in the Philippines. These codes were later on combined polygon shapefile available in the namria website. Typically, it is done by joining a table of data to a dataset by a field value found in both tables. In this case, the barangay code is utilized. The researchers made used of barangay Campo Tinio, as an example. They coded this barangay as PH034903022. Upon successful join, with no usual error, like the name of barangay San Juan Pob. (Acofa) and Aduas Centro (Aduas) to San Joan Pob. (ACCFA) and Aduas Centro shows in Figure below. In symbology, graduated color can be assigned to the polygon, like red for most extreme value to blue for a lesser value and clear or white for no value. Assignment of colors was based on count of attributes that fall inside the polygon or its equivalent value.

Fig.4. Shows the joined data via barangay code in ArcMap

The researchers also labelled the he names of the barangays occupying the top three (3) range per year so that the names would not overlap and that the value or count of the incidence will be shown up in the label inside the parenthesis.

In addition, the dengue case data were also processed in a geo-spatial program called ArcMap. This is performed to identify and classify the data that were collected. These data include the frequency of admitted patients, gender mostly prone to the dengue virus (DENV), age bracket reported to have high admission to hospitals, and weeks with notably high count of DENV reflected on the 5-year data the researchers had analyzed.

Locale of the Study

Cabanatuan City is a first-class city in the

Philippines situated in the province of Nueva Ecija. It has a population of 327,325 people, making it the most populous city in the province and the fifth-most populous city in the whole Central Luzon [29].

According to the 2020 census, Cabanatuan, is a first-class component city comprising of 89 barangays, with its own charter granted by Republic Act No. 526, and serves as Nueva Ecija's principal commercial, educational, medical, and entertainment center. (Cabanatuan LGU City Official Website, n.d.). It is also recognized as the business capital of the province. And dubbed as the "Tricycle capital of the Philippines" were 30,000 registered motorized tricycles and has become the source of livelihood of over 10,000 families [30].
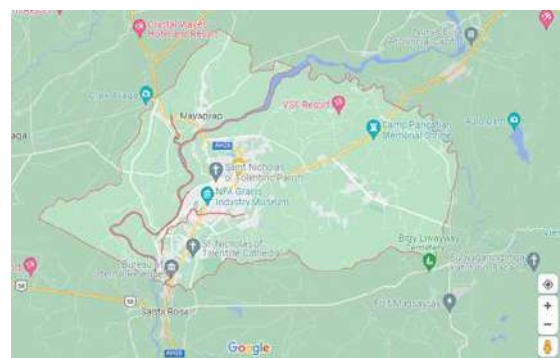
Fig.5. Locator Map [31]

Figure 5 above shows the location map of Nueva Ecija highlighting the research locale, the city of Cabanatuan.

Data Source

Data gathered on weekly monitoring report of admitted patients diagnosed with Dengue Fever (DF) from January 2014 to December 2018 (5-year dengue data) were obtained from Cabanatuan City Health Office sourced from the 89 barangays in Cabanatuan City. Data show that there were 4,532 reported DF cases in this city for that period alone. The report also includes the demographic data of DF infection categorized by gender, age group, and the Disease Reporting Unit (DRU). The DRU Category was classified as follows: hospital; City Health Office (CHO); City Epidemiological and Surveillance Unit (CESU); or Rural Health Unit (RHU) where DF infected patients were admitted.

To plot the collected data, the researchers made use of the ArcMap application. The ArcMap is the centerpiece of Esri's ArcGIS family of geospatial processing products, and it is primarily used to view, modify, produce, and analyze geographic data [32]. The 4,532 dengue cases of admitted patients are plotted per year. It enables the researchers to examine data inside a data collection,

represent features, and generate maps accordingly.

Data Models in GIS

Spatial Analysis

This research uses spatial analysis often known as locational analysis. It is a sort of geographical analysis that aims to explain patterns of human behavior and its spatial expression in terms of mathematics and geometry. It aims to explain patterns of human behavior and its spatial expression in terms of mathematics and geometry.
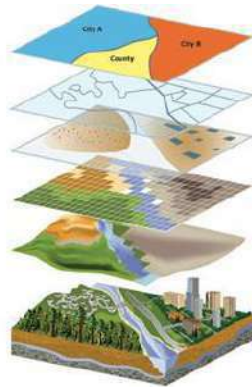
Fig.6. Vector and Raster Data in GIS [33]

On the data sets of dengue cases

Table 2 shows the distributed admitted patients of dengue virus in Cabanatuan City. They were subdivided per year from 2014 to 2018 and distributed per barangay around the City of Cabanatuan.

Statistical Analysis of Data

GIS software was used to evaluate and analyze the spatial data collected for this study.

The barangay shapefiles were obtained from the namria website. They are in the vector data storage format for recording geographic features' position, shape, and attributes. These information were obtained via the Philippine Integrated Disease Surveillance and Response (PIDSR) program utilized at the City Health Office and is monitored by the Provincial Health Office.

ArcGIS 10.6 (also known as ArcGIS Desktop), an Esri GIS software, was used to map the dengue cases of admitted patients from 2014 to 2018.

V.   RESULTS AND DISCUSSION

Dengue has been a very important public health problem in the Philippines. In 2019, there had been a report of 8 deaths in Nueva Ecija; two each in San Jose City and

Pantabangan; one each in Cabanatuan City, Gapan City, Cabiao and Gabaldon. With the growing dengue cases with 1,576 as of July 10, 2020, Cabanatuan had the most number with 171 [34].

ARCMAP on dengue cases

In 2014, with the dengue cases with a value greater than 7 were highlighted. The researchers were able to easily identify that the barangay Magsaysay district had around 33 dengue cases throughout the aforementioned year. On the other hand, it was seen in the map that in 2015 barangay Caalibangbangan (84), Campo Tinio (61) and Magsaysay District (54) were the areas with the highest number of hospitalized patients. The map showing the 2016 data reveals that barangay Macatbong has 31 dengue cases indicated by a red color.

In 2017, the map depicts the following data: barangay Caalibangbangan (22), Aduas Norte (23), Bagong Sikat (26), Bantug Norte (24), Suamcab Norte (19), Bangad (22), Campo Tinio (24) and Barrera District (Pob) (20). And in 2018, the map shows whopping 127 dengue patients admitted were from barangay San Juan Pob. (Accfa). This report calls the attention of the medical experts to investigate the matter and to devise ways to determine the classification/s of mosquitos infesting the residents of the said barangay and determine the causes of such huge increase of reported cases.

Figure 7 in the next page shows the resulting map created in ArcMap from the admitted patients with dengue cases in Cabanatuan City between January 2014 to December 2018.

On the 22nd August 2018, the Epidemiology Bureau (EB) of the DOH received an Event-based Surveillance and Response (ESR) report on Dengue Outbreak in 36 cases in Barangay San Juan ACCFA, Cabanatuan City, Nueva Ecija. On 3rd September of the same year, the Field Epidemiology Training Program (FETP) team was sent to the area with the following objectives: 1) to verify the diagnosis; 2) to determine the existence of an outbreak; 3) to identify the source and mode of transmission; 4) to identify risk factors; and 5) to recommend control and preventive measures [35].

Figure 8 shows the distribution of dengue cases per gender. It shows that in year 2016, most of the dengue case admitted where male and that female are impervious.
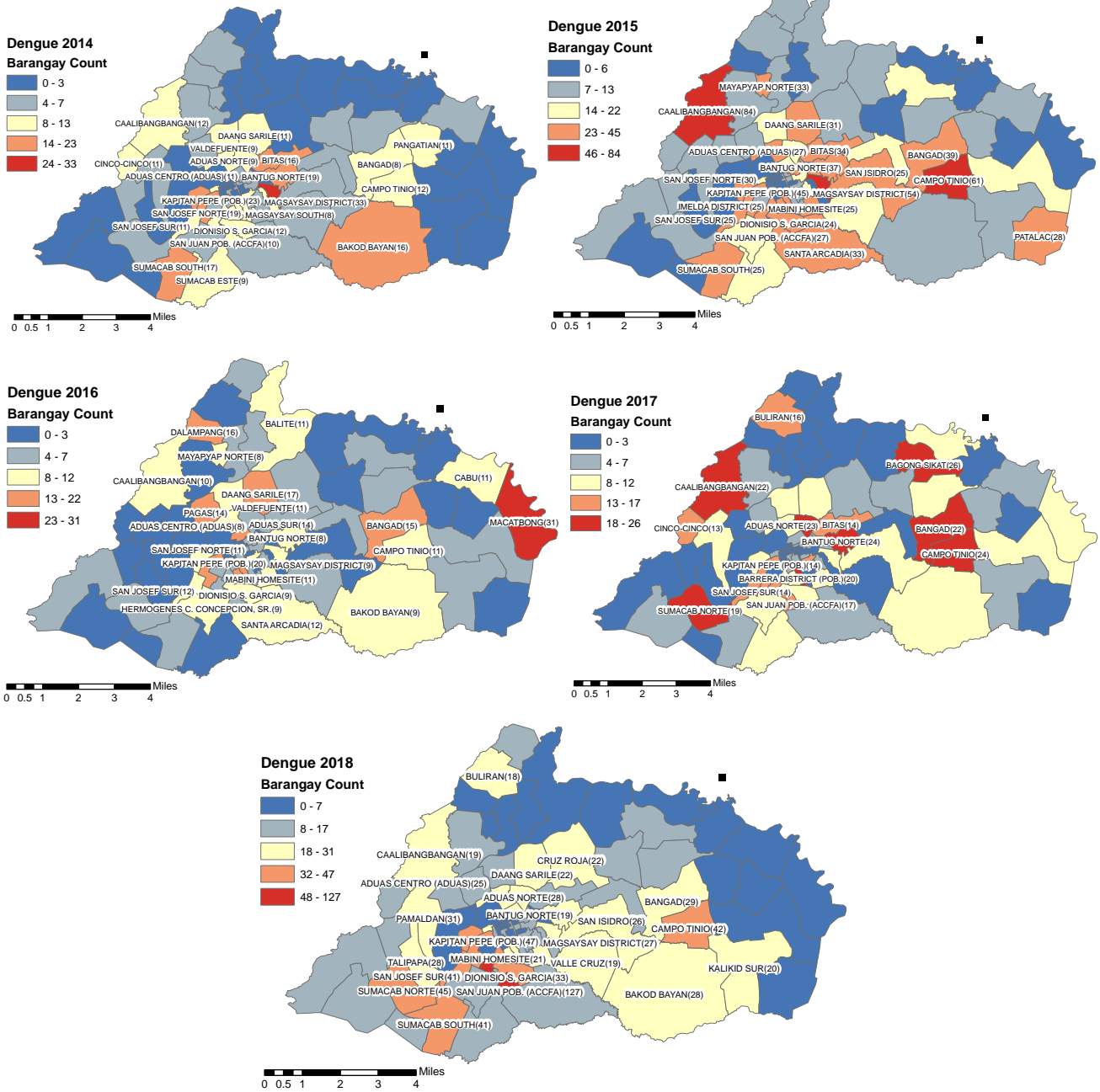
Fig.7. Dengue Cases for the year 2014 to 2018
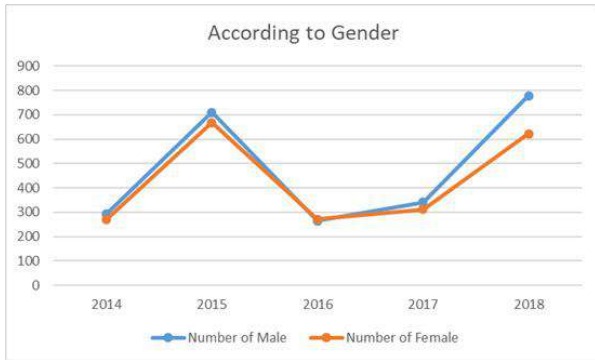
Fig.8. Graph categorized the patients by gender

Figure 9 shows the distribution of dengue cases as regards age. Findings show that most dengue case admitted in the year 2018 are between ages 10-14 years old, 314 patients. This was followed by the age bracket 15-19 in 2015 at 255 cases. Generally, the graph shows that individuals belonging to 5-24 years old are prone to DENV infections.
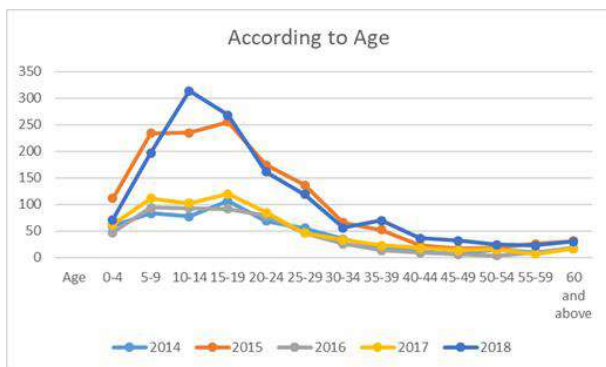
Fig.9. Graph categorized the patients by age bracket

Figure 10 shows the distribution of DRU all over Cabanatuan City. These DRUs include the following health units: City Health Office, rural health office situated in some barangays, and private hospitals such as Wesleyan University General Hospitals and Cardiovascular Center, Nueva Ecija Good Samaritan Health Care System Inc, Premiere Medical Center, Immaculate Conception Medical Center of Central Luzon Inc, Nueva Ecija Doctors Hospital Inc. Government hospitals were included, these are: E.L. Joson Memorial Hospital, Dr. Paulino J. Garcia Memorial Research and Medical Center and M.V. Gallego Cabanatuan City General Hospital.

The graph shows that the health centers or units with highest admission rate is the Government DRU.
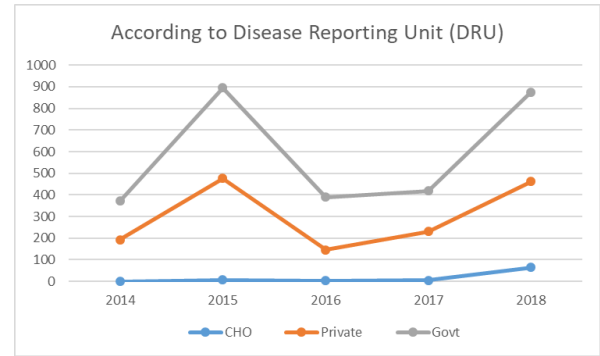
Fig.10. Graph showing the Dengue Case categorized by DRU

Figure 11 presents the dengue cases admitted in different health facilities distributed on a weekly basis. Data shows that dengue cases shoot up from week 28 to week 42. This occurs between the months of July to October. This is the period where rainy season is expected to commence.
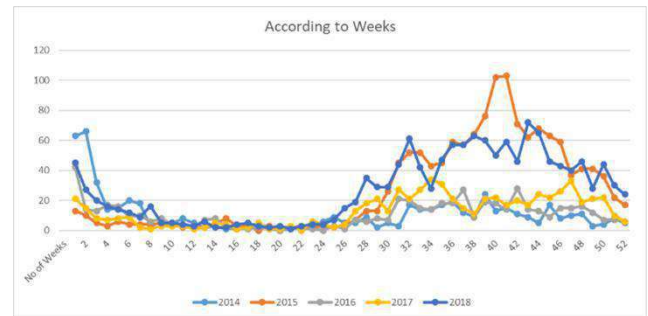
Fig.11. Graph showing the distribution of dengue patients according to weeks

VI. CONCLUSION AND RECOMMENDATIONS

Using a ranking method and choosing the top 10 barangays per year from 2014 to 2108, Barangay Kapitan Pepe (Pob.) and Campo Tinio showed up 4 times in a consecutive manner. While Barangay Bantug Norte, Calibangbangan and Bangad showed up 3 times. It is noteworthy to mention that barangay Bangad also appeared in 3 consecutive years namely 2015 to 2017.

The highest cases being recorded is at Barangay San Juan Pob. (ACCFA) with 127 admitted patients in year 2018 alone. Capturing of mosquitoes were done to test the virus outbreak in the locality. City Health Office officials attest that reason for the outbreak was due to the frequent tropical storm during that year and since the barangay is in a low-lying area, uncollected garbage and accumulated waters on container are some of the possible causes of mosquito reproduction. This also calls for a close monitoring of the situation. Netting mosquito to check what type they are and identifying which among the barangays needed the control and prevention the most.

In terms of Demographic information, results indicated that majority of the Dengue cases are males except for 2016 where the female were more susceptible. As regards, age bracket patients from 10 to14 years old is at 314 followed by those belonging to 15-19 with 255 in the year 2018 and 2015, respectively. Additionally, most of the dengue patients decided to be admitted to public hospitals. The occurrence of dengue cases accrues in weeks 28 to 42 which can be explained by the start of the rainy season.

The use of GIS in determining Dengue Cases was proven to be effective, hence, the results from the study can be a reliable and relevant information that can be used in order to strictly implement the health policies for dengue cases, prevention of dengue outbreaks, health care interventions, budget allocation and the effective implementations of heath programs in the different barangays in the city of Cabanatuan.

The Philippine government must continue to implement, evaluate and improve the dengue response plan at the regional, provincial, and municipal levels (WHO-ROP, 2019). This must be done to: conduct daily dengue epidemiology analysis at the barangay level, notify any cluster of dengue cases to DOH/EB for appropriate follow up, advocate for community and school-based health education campaigns and clean-up drives, ensure supply of sufficient insecticides for vector control, and work closely with LGUs, the DOH has directed all regional health offices and the MOH-BARMM to activate their disaster risk reduction and management councils, lead in the 4 a.m. daily habit and ensure its institutionalization and implementation down to the community level, collaborate with PhilHealth on the dengue benefit package and point-of-service enrolment, and strengthen its information campaign, including through social media.

At the national level, the Philippine government, through the DOH, must continue to implement the following measures (WHO-ROP, 2019): coordination of response efforts with CHDs via the Task Force for Prevention, Control, and Response to Dengue Outbreak, sustained disease surveillance, sustained advocacy campaigns, hospital preparedness for surge capacity, leadership of the NDRMMC's Health Cluster, and mobilization of human resources, logistics, and funds to affected regions.

The researchers also recommend that this spatial analysis be done regularly to help detect and monitor the occurrence of dengue in the different barangays covered in this study.

ACKNOWLEDGEMENTS

CONFLICT OF INTEREST

The authors declare no conflict of interest regarding the publication of this paper.

REFERENCES

[1]. M. Assefa, L. Golassa, Andargie Abate, "Five-Year Trend of Malaria Prevalence in Mojo Town, Central Ethiopia: Shifting Burden of the Disease and Its Implication for Malaria Elimination A Retrospective Study," Dovepress, no. 5, p. 455–464, 2022. DOI: 10.2147/IDR.S348203

[2]. A. D. Mbouna, E. Efon, D. F. Achu, L. Andre, A. M. Dikande, Sharlot Fosah, "Influences of Rainfall and Temperature on Malaria Endemicity in Cameroon: Emphasis on Bonaberi District," Journal of Geoscience and Environment Protection, no. 10, pp. 46-66, 2022. DOI: 10.4236/gep.2022.103004

[3]. F. Ntoumi, N. Kapata, P. Lungu, L. A. Mucheleng'anga, J. Chakaya, J. Tembo, C. Himwaze, R. Ansumana, D. Asogun, S. Mfinanga, P. Nyasulu, P. Mwaba, D. Y.-Manu, Pascalina Chanda-Kapata, "Tuberculosis, HIV/AIDS and Malaria Health Services in sub-Saharan Africa – A Situation Analysis of the Disruptions and Impact of the COVID-19 Pandemic," International Journal of Infectious Diseases, 17 March 2022. DOI: https://doi.org/10.1016/j.ijid.2022.03.

[4]. A. W.-Smith, M. Scott Halstead, "Severe dengue in travellers: pathogenesis, risk and clinical management," International Society of Travel Medicine, pp. 1-15, 2019. DOI: 10.1093/jtm/taz062

[5]. L. C. Ng, S. Lam, D. Teo, "Is dengue a threat to the blood supply?," Transfusion Medicine, no. 19, pp. 66-77, 2009. DOI: 10.1111/j.1365-3148.2009.00916.x

[6]. A. Z. Zaidi, Bilal Tariq, "Geo-statistical Dengue Risk Model Case Study of Lahore Dengue Outbreak 2011," Journal of Space Technology, pp. 48-54, 2015.

[7]. D. V. Net, "Welcome to Dengue Virus Net," 2020. [Online]. Available: http://www.denguevirusnet.com/.

[8]. "https://www.makatimed.net.ph/," 26 April 2021. [Online]. Available: https://www.makatimed.net.ph/blogs/malaria-vs-dengue-how-are-they-different/#:~:text=According%20to%20the%20World%20Health,of%20malaria%20worldwide%20in%202019. [Accessed 22 February 2022].

[9]. V. Saravanabavan, D. Balaji, "A geo medical analysis of dengue cases in Madurai city-Tamilnadu India," GeoJournal, no. 85, pp. 979-994, 2019. DOI:10.1007/s10708-019-10006-4

[10]. M. B. Quam, a. A. W.-Smith, Natasha Evelyn Anne Murray, "Epidemiology of dengue: past, present and future prospects," Clinical Epidemiology, no. 5, pp. 299-309, 2013. DOI: 10.2147/CLEP.S34440

[11]. T. McVicar, B. Basso, "https://www.semanticscholar.org," 2007. [Online]. Available:

https://www.semanticscholar.org/paper/Chapter-12-Remote-sensing-and-GIS-applications-in-Basso-McVicar/174df6b0762b7cc72948bbaf10c5db2480be02ed. [Accessed 13 August 2020].

[12]. J. L. Ramirez, G. Dimopoulos, Shuzhen Sim, "Dengue Virus Infection of the Aedes aegypti Salivary Gland and Chemosensory Apparatus Induces Genes that Modulate Infection and Blood-Feeding Behavior," PLoS Pathogens, vol. 8, no. 3, p. e1002631, 2012. DOI: 10.1371/journal.ppat.1002631

[13]. L. Lambrechts, Vincent Raquin, "Dengue virus replicates and accumulates in Aedes aegypti salivary glands," Virology, vol. 507, pp. 75-81, 2017. DOI: 10.1016/j.virol.2017.04.009

[14]. M. A. Johansson, Miranda Chan, "The Incubation Periods of Dengue Viruses," 30 November 2012. [Online]. Available: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0050972. [Accessed 27 March 2022]. https://doi.org/10.1371/journal.pone.0050972.

[15]. E. McDermott, J. Kopanke, M. Stenglein, J. Lee, C. Mathiason, M. Carpenter, K. Reed, T. A. Perkins, Christie Mayo, "Ecological Dynamics Impacting Bluetongue Virus Transmission in North America," Frontiers in Veterinary Science, vol. 7, p. 186, 2020. https://doi.org/10.3389/fvets.2020.00186.

[16]. A. M. Carrasco, Y. Dong, C. M. Sgrò, HY Yixin, "The effect of temperature on Wolbachia-mediated dengue virus blocking in Aedes aegypti," The American Journal of Tropical Medicine and Hygiene, vol. 94, no. 4, pp. 812-819, 2016. DOI: 10.4269/ajtmh.15-0801.

[17]. N. Dad, S. Buhmaid, Varsha Mulik, "Dengue in Pregnancy: Review article," European Journal of Obstetrics & Gynecology and Reproductive Biology, vol. 261, pp. 205-210, June 2021. DOI: 10.1016/j.ejogrb.2021.04.035.

[18]. J. M. Nelson, M. Fischer, J. E. Staples, M. P. Karwowski, P. Mead, J. Villanueva, C. M. Renquist, A. A. Minta, D. J. Jamieson, M. A. Honein, C. A. Moore, S. A. Rasmussen, Katherine E. Fleming-Dutra, "Update: Interim Guidelines for Health Care Providers Caring for Infants and Children with Possible Zika Virus Infection-United States, February 2016," Morbidity and Mortality Weekly Report, vol. 65, no. 7, pp. 182-187, February 2016. DOI:10.15585/mmwr.mm6507e1er.

[19]. R.-B. Tang, Hui-Lan Chen, "Why Zika virus infection has become a public health concern?," Journal of the Chinese Medical Association, vol. 79, no. 4, pp. 174-178, April 2016. DOI: 10.1016/j.jcma.2016.03.001.

[20]. S. Donegan, J. McCall, Leigh R. Bowman, "Is Dengue Vector Control Deficient in Effectiveness or Evidence?: Systematic Review and Meta-analysis," PLoS Neglected Tropical Diseases, vol. 10, no. 3, p. e0004551, 2016. DOI: 10.1371/journal.pntd.0004551.

[21]. S. A. Gosuico, "https://journal.com.ph," 12 August 2020. [Online]. Available: https://journal.com.ph/news/provincial/8-dengue-deaths-listed-ecija.

[22]. B. Gates, "https://www.gatesnotes.com," 25 April 2014. [Online]. Available: https://www.gatesnotes.com/health/most-lethal-animal-mosquito-week. [Accessed 24 February 2022].

[23]. P. Dang, Urban Pest Control, Boston, MA: CAB International, 2018.

[24]. R. Nuwer, "https://www.smithsonianmag.com/," 30 April 2014. [Online]. Available: https://www.smithsonianmag.com/smart-news/mosquitoes-kill-more-humans-human-murderers-do-180951272/. [Accessed 22 February 2022].

[25]. D. Tregde, Jason Puckett, "https://www.king5.com/," 31 July 2018. [Online]. Available: https://www.king5.com/article/news/local/verify/verify-are-mosquitoes-really-the-deadliest-animals-on-earth/507-578093577. [Accessed 22 February 2022].

[26]. M. Prudencio, "In fairness to mosquito," Trends in Parasitology, vol. 36, no. 11, pp. 876-877, 2020. DOI: 10.1016/j.pt.2020.08.003

[27]. Health, Department of, "https://doh.gov.ph/," 2015-2019. [Online]. [Accessed 22 February 2022].

[28]. "https://doh.gov.ph/," 15 September 2016. [Online]. Available: https://doh.gov.ph/sites/default/files/publications/Philippine%20Health%20Agenda_Dec1_1.pdf. [Accessed 22 February 2022].

[29]. "https://www.philatlas.com/," 2022. [Online]. Available: https://www.philatlas.com/luzon/r03/nueva-ecija/cabanatuan.html. [Accessed 22 February 2022].

[30]. M. P. Pascual, M. D. Santos, A. F. Ortiz, A. G. Gabriel, T. L. S. Mangahas, Felipe E. Balaria, "Sustainability of E-Trike as Alternative Mode of Public Transportation System: The Case of Cabanatuan City, Philippines," Open Journal of Civil Engineering, vol. 7, no. 3, pp. 362-377, 2017. DOI: 10.4236/ojce.2017.73025.

[31]. "Google Map," [Online]. Available: https://www.google.com.ph/maps/place/Cabanatuan+City,+Nueva+Ecija/@15.5000569,120.9109837,12z/data=!3m1!4b1!4m5!3m4!1s0x33972921652f4ccb:0x3ddca086bad37111!8m2!3d15.4865047!4d120.973393?hl=en&authuser=0. [Accessed 23 February 2022].

[32]. "https://desktop.arcgis.com/," 2021. [Online]. Available: https://desktop.arcgis.com/en/arcmap/latest/map/main/what-is-arcmap-.htm. [Accessed 22 February 2022].

[33]. "https://www.esri.com/," [Online]. Available: https://www.esri.com/arcgis-blog/products/product/analytics/how-to-perform-spatial-analysis/. [Accessed 22 February 2022].

[34]. T. N. E. Reporter, "https://m.facebook.com/TheNuevaEcijaReporter/," 25 July 2019. [Online]. Available: https://m.facebook.com/TheNuevaEcijaReporter/posts/2783277178409940. [Accessed 22 February 2022].

[35]. M. N. Sucaldito, A. De Guzman, H. Hizon, E. M. Cañal, M. I. R. Iturralde, Ferchito Avelino, "Preliminary Report on the Dengue Outbreak in Barangay San Juan ACCFA, Cabanatuan City, Nueva Ecija, June 8 – September 5, 2018," Department of Health, Cabanatuan City, 2018.

Table 2. Dengue Case distributed by year and per barangay (2014-2018)

Barangay	Dengue Cases					
	2014	2015	2016	2017	2018	Total
1. Aduas Centro	11	27	8	9	25	80
2. Aduas Norte	9	17	6	23	28	83
3. Aduas Sur	7	16	14	6	22	65
4. Bagong Buhay	0	0	1	0	2	3
5. Bagong Sikat	0	16	4	26	11	57
6. Bakero	4	8	4	9	9	34
7. Bakod Bayan	16	12	9	12	28	77
8. Balite	3	10	11	2	2	28
9. Bangad	8	39	15	22	29	113
10. Bantug Bulalo	2	24	3	5	7	41
11. Bantug Norte	19	37	8	24	19	107
12. Barlis	2	7	6	2	1	18
13. Barrera District (Pob.)	11	29	22	20	21	103
14. Bernardo District (Pob.)	7	1	4	6	3	21
15. Bitas	16	34	4	14	16	84
16. Bonifacio District (Pob.)	10	14	5	6	24	59
17. Buliran	5	10	2	16	18	51
18. Caalibangbangan	12	84	10	22	19	147
19. Cabu	6	12	11	5	5	39
20. Calawagan (Kalawagan)	1	5	2	10	7	25
21. Campo Tinio	12	61	11	24	42	150
22. Caridad	4	8	2	1	10	25
23. Caudillo	2	4	0	1	7	14
24. Cinco-Cinco	11	9	2	13	10	45
25. City Supermarket (Pob.)	0	2	0	0	0	2
26. Communal	1	0	1	1	2	5
27. Cruz Roja	2	12	7	4	22	47
28. Daang Sarile	11	31	17	11	22	92
29. Dalampang	5	6	16	1	4	32
30. Dicarma (Pob.)	9	7	8	14	9	47
31. Dimasalang (Pob.)	3	6	5	5	5	24
32. Dionisio S. Garcia	12	24	9	8	33	86
33. Fatima (Pob.)	0	4	0	2	4	10
34. General Luna (Pob.)	7	11	7	3	14	42
35. Hermogenes C. Concepcion, Sr.	7	20	9	11	11	58
36. Ibabao Bana	6	7	2	3	17	35
37. Imelda District	13	25	4	11	37	90
38. Isla (Pob.)	3	2	1	0	6	12
39. Kalikid Norte	3	15	7	12	1	38
40. Kalikid Sur	3	8	5	6	20	42
41. Kapitan Pepe (Pob.)	23	45	20	14	47	149
42. Lagare	4	6	3	6	12	31
43. Lourdes (Matungal-tungal)	5	20	6	0	12	43
44. M.S. Garcia	10	32	17	9	29	97
45. Mabini Extension	6	22	5	7	16	56
46. Mabini Homesite	7	25	11	11	21	75
47. Macatbong	2	3	31	11	4	51

48. Magsaysay District	33	54	9	9	27	132
49. Magsaysay South	8	0	0	3	15	26
50. Maria Theresa	2	4	1	5	1	13
51. Matadero (Pob.)	2	4	2	3	6	17
52. Mayapyap Norte	7	33	8	3	6	57
53. Mayapyap Sur	5	13	3	6	14	41
54. Melojavilla (Pob.)	1	0	0	1	6	8
55. Nabao (Pob.)	0	6	1	4	4	15
56. Obrero	2	8	2	2	5	19
57. Padre Burgos (Pob.)	4	13	0	3	3	23
58. Padre Crisostomo	8	7	6	3	14	38
59. Pagas	5	7	14	7	11	44
60. Palagay	2	7	5	2	9	25
61. Pamaldan	7	12	3	11	31	64
62. Pangatian	11	10	3	4	6	34
63. Patalac	0	28	2	1	4	35
64. Polilio	2	4	1	7	12	26
65. Pula	2	12	6	1	15	36
66. Quezon District (Pob.)	7	14	4	2	10	37
67. Rizdelis (Pob.)	2	6	2	2	4	16
68. Samon	0	12	0	1	8	21
69. San Isidro	7	25	3	10	26	71
70. San Josef Norte	19	30	11	12	33	105
71. San Josef Sur	11	25	12	14	41	103
72. San Juan Pob. (Accfa)	10	27	6	17	127	187
73. San Roque Norte	3	7	5	3	9	27
74. San Roque Sur	1	4	3	11	13	32
75. Sanbermicristi (Pob.)	6	3	1	6	8	24
76. Sangitan	4	26	4	4	9	47
77. Sangitan East	2	11	3	4	5	25
78. Santa Arcadia	7	33	12	4	16	72
79. Santo Niño	2	3	2	3	10	20
80. Sapang	1	1	7	0	4	13
81. Sumacab Este	9	18	3	11	17	58
82. Sumacab Norte	7	12	5	19	45	88
83. Sumacab South	17	25	4	7	41	94
84. Talipapa	2	3	0	1	28	34
85. Valdefuente	9	19	11	8	10	57
86. Valle Cruz	6	15	7	2	19	50
87. Vijandre District (Pob.)	1	5	2	1	9	18
88. Villa Ofelia-Caridad	5	8	5	4	2	24
89. Zulueta District (Pob.)	4	7	4	3	5	23
TOTAL	*563*	*1, 378*	*537*	*653*	*1,401*	*4,532*

Prevalence of death and ICU admission in individuals hospitalized at a University Hospital in Amazonas: Cross-sectional study

Janaína de Oliveira Castro[1], Tiago de Almeida Araújo[2], Tatiane Lima Aguiar[3], Elizete de Almeida Araújo[4]

[1]Federal University of Amazonas, Faculty of Medicine, Manaus, Amazonas, Brazil. castrooojanaina@gmail.com

[2]Federal University of Amazonas, Faculty of Physical Education and Physiotherapy, Manaus, Amazonas, Brazil. tiagodealmeidaaraujo@gmail.com

[3]Federal University of Amazonas, Faculty of Medicine and Getúlio Vargas University Hospital, Manaus, Amazonas, Brazil. tatiane@ufam.edu.br

[4] Federal University of Amazonas, Getúlio Vargas University Hospital, Amazonas, Brazil. elizetemanaus@ufam.edu.br

*Corresponding Author

Janaína de Oliveira e Castro – castrooojanaina@gmail.com

Abstract— Objective: To estimate the prevalence of intensive care admission and deaths among inpatients suspected to have COVID-19 in Hospital Universitário Getúlio Vargas (HUGV). Methods: Cross-sectional study with secondary data from discharged patients or deaths of those that had positive RT-PCR for COVID-19. Prevalence ratio and Confidence Interval were calculated using Poisson Regression. Results: The study included 87 individuals. Men (65,5%), elderly ≥ 60 years (47%) and multimorbidity (46%). Women had less association with admission to intensive care (PR= 0.75%; 95%CI: 0.41-1.36) and deaths (PR= 0.57; 95%CI: 0.24-1.34). The time of hospitalization was death protecting factor. Conclusion: Men had a more severe outcome and contributed to higher mortality. Adequate medical records are necessary for a better understanding of suspected cases and to support the most appropriate health policies.

I. INTRODUCTION

The new coronavirus, SARS-CoV-2, the etiological agent of coronavirus disease (COVID-19), was initially discovered in December 2019 by Chinese authorities, thus identifying a new virus. Highly contagious, it quickly spread to all continents, being declared a pandemic by the World Health Organization (WHO) in March 2020 [1].

Currently with several variants, it is responsible for about 395 million cases of contamination and more than 5.7 million deaths worldwide.[2] The pandemic also had a negative influence on socioeconomic factors, due to the need of social distancing in order to reduce the transmission rates of the virus, such a prolonged action resulted in increased levels of poverty and unemployment in several regions of the world. [3].

In Brazil, the first diagnosed and confirmed case of COVID-19 took place at the end of February 2020, at Hospital Israelita Albert Einstein in the state of São Paulo [4]. The contamination soon spread to the country's regions, capitals, and municipalities, in part due to the lack of adequate policies to contain the virus. As of mid-March

2022, Brazil had more than 26,473,273 confirmed cases and 657,998 deaths caused by the new coronavirus [2].

Amazonas, with an estimated population of 3,483,985 [5], was one of the brazilian states most affected by the coronavirus pandemic. The first wave of COVID-19, peaked in May 2020, causing a meltdown on the funeral system which did not expect such demand. After 6 months, a second wave was even more serious, this time resulting in a complete collapse of the public and private health system due to lack of hospital beds, Intensive Care Unit (ICU), and lack of oxygen in hospitals. Until mid-February 2022, Amazonas had 549,076 confirmed cases of COVID-19 and 14,024 deaths [6].

Because it is a disease of severity and lethality that is constantly evolving, there is a need for a systematic search for knowledge about its epidemiology and its negative outcomes in the population in different contexts. In this sense, this study aimed to estimate the prevalence of hospitalization in the ICU and death in individuals hospitalized with suspected COVID-19 at the Hospital Universitário Getúlio Vargas (HUGV) in Manaus, Amazonas, Brazil.

II.   METHOD

2.1 Study design and context

This is a cross-sectional study with data from electronic medical records of individuals suspected of having COVID-19 hospitalized at Hospital Universitário Getúlio Vargas, in Manaus, Amazonas. HUGV is a tertiary hospital that acted as a backup in the care of individuals suspected of having COVID-19, receiving patients previously treated by other health units. Data from this study are part of a multicenter study "Artificial intelligence algorithms to predict outcomes related to covid-19", carried out through a partnership with the Faculty of Public Health of the University of São Paulo (FSP/USP) and the Laboratory of Big Data and Predictive Analysis in Health (LABDAPS), of the State of São Paulo. HUGV was one of the partner centers to carry out the initial phase of data collection.

2.2 Participants

Individuals who had already been discharged or died, who underwent a positive RT-PCR test for COVID-19, were included in the study. Individuals whose clinical information was not found in the electronic medical record, within the 24-hour window before and after the RT-PCR, were excluded.

2.3 Data collect

A preliminary list containing 144 records of suspected COVID-19 hospitalizations was obtained for screening participants. After selection, data from participants were collected anonymously from March to August 2020, through the Management Application for University Hospitals. At this stage, the medical prescription and hospitalization modules were used. Clinical data collection was performed based on a 24-hour window before or after the RT-PCR test was performed, since it was the main objective of the Project "Artificial intelligence algorithms to predict outcomes related to covid-19".

2.4 Variables

Study outcomes were ICU admission and death from COVID-19, dichotomized (yes or no). The demographic variables collected were categorized: sex (male and female); age group (16 to 29 years, 30 to 59 years and ≥60 years); race/skin color (white, brown and undeclared); education (higher education, high school, elementary school, elementary school or less and undeclared). Clinical variables were: temperature, O_2 saturation, systolic blood pressure, diastolic blood pressure, mean blood pressure, heart rate and respiratory rate; use of vasoactive drugs; dialysis; mechanical ventilation and chronic diseases (hypertension, diabetes, vascular disease, chronic obstructive pulmonary disease - COPD, chronic renal failure, bronchial asthma and asthmatic bronchitis, heart disease, hypercholesterolemia, lupus, stroke, and cancer). Multimorbidity was categorized into (no disease, one disease, and two or more diseases per individual); hospitalization, was categorized into (1 to 5 days, 6 to 15 days, 10 to 35 days and 36 or more) of hospitalization.

2.5 Statistical analyses

Initially, the descriptive statistics of the variables measured in the study were obtained by calculating their frequency and stratification by ICU admission and death. In this step, eventual differences among the proportions were identified by Pearson's χ^2 calculation. Subsequently, bivariate analyses were performed between all independent and dependent variables to calculate the prevalence ratio (PR) and confidence intervals 95% (CIs), using Poisson regression [7]. The difference in mean and 95% CI of clinical variables stratified by sex was obtained by the t-test. Data analysis was carried out Stata V.14.2 (Stata).

2.6 Ethical considerations

The project "Artificial intelligence algorithms to predict outcomes related to covid-19", was approved by the Research Ethics Committee of the Faculty of Public Health USP/SP with CAAE 32872920.4.1001.5421. Through an amendment to the project, the participation of the Hospital

Universitario Getúlio Vargas was approved, through opinion 4,202,536.

III.   III. RESULT

3.1 Participant characteristics

Table 1 shows the demographic and clinical characteristics of the individuals. Of the 144 records of individuals hospitalized for suspected COVID-19, 87 individuals who performed PCR-RT were included in the study. The sample consisted of 65,5% male, elderly ≥ 60 years old (47.1%), brown skin color (92%), had high school education (29.9%), multimorbidity (two or more diseases) was identified in 46% of the records, hospitalization for 36 days or more (18.4%), about half of

the individuals required vasoactive drugs and mechanical ventilation was required in 49.4% of the hospitalized individuals.

3.2 Prevalence of ICU admission and death

The prevalence of ICU admission was 60.9%. More than half of the individuals who required ICU admission were male (66.7%), elderly ≥60 years (65.8%), with higher education (69.2%) and 62.5% had multimorbidity.

Prevalence of death was 34.5% and was more frequent in males (40.3%) compared to females (23.3%), individuals aged between 30 and 59 years (37%) had a higher frequency of mortality as well as those without any preexisting comorbidities (42.8%) (Table 1).

Table 1 Demographic and clinical characteristics of COVID-19 patients, stratified by ICU admission and death at HUGV. Manaus- Amazonas, 2020.

Variable	n	%	Prevalence %			
			ICU	p-value[a]	Death	p-value[a]
Total	87		60,9		34,5	
Sex				0,130		0,112
Male	57	65,5	66,7		40,3	
Female	30	34,5	50,0		23,3	
Age groups (years)				0,464		0,833
16 to 29	11	12,6	45,4		27,3	
30 to 59	35	40,2	60,0		37,1	
≥60	41	47,1	65,8		34,1	
Race/Color				0,332		0,709
White	5	5,7	80,0		20,0	
Brown	80	92,0	58,7		35,0	
Not reported [b]	2	2,3	100		50,0	
Education				0,569		0,135
Higher education	13	14,9	69,2		15,4	
High school	26	29,9	65,4		50,0	
Elementary school	15	17,2	66,7		40,0	
Less than elementary school	20	22,9	45,0		20,0	
Not reported [b]	13	14,9	61,5		38,5	
Multimorbidity				0,918		0,644
None	21	24,1	57,1		42,8	
1 disease	26	30,0	61,5		30,7	
2 or more diseases	40	46,0	62,5		32,5	
Length of hospital stay (days)				0,157		0.406
1 to 5	17	19,0	47,0		47,0	

	n	%		p-value		p-value
6 to 15	30	34,5	53,3		26,7	
10 to 35	24	27,6	66,7		29,2	
36 or more	16	18,4	81,2		43,7	
Use of Mechanical ventilation	43	49,4	93,0	<0,001	62,8	<0,001
Use of vasoactive drugs	40	46,0	90,0	<0,001	67,5	<0,001
Use of dialysis	27	31,0	74,0	0,064	57,2	0,002

[a] Pearson's chi-square test; [b] there was no record in the medical report

3.3 Factors associated with ICU admission and death

In the bivariate analysis (Table 2), women had a lower association with ICU admission (RP=0.75; 95%CI:0.41-1.36) and death (RP=0.57; 95%CI:0.24-1.34). Elderly people ≥ 60 years (PR=1.44; 95%CI: 0.55-3.76) were more associated with ICU compared to young people aged 16 to 29 years. The presence of two or more chronic diseases (PR=1.09; 95%CI:0.54-2.17) and 36 days or more of hospitalization (PR=1.72; 95%CI:0.71-4.16) had a greater association with ICU admission, respectively, compared with those who had no disease and 1 to 5 days of hospitalization.

Regarding the outcome of death, individuals aged 30 to 59 years were more associated (PR=1.36; 95%CI: 0.38-4.77) than those aged ≥ 60 years (PR=1.25; IC95%:0.35-4.35). Individuals who used mechanical ventilation (RR=9.20; 95%CI: 2.79-30.35), vasoactive drugs (RR=10.57; 95%CI:3.20-34.85) and dialysis (RR=2.40; 95%CI: 1.17-4.93) were more associated with negative outcomes. Duration of hospitalization of 36 days or more had a lower association with death than 1 to 5 days of hospitalization.

Table 2 Prevalence Ratio of factors associated with ICU and death, in patients of COVID-19, hospitalized at HUGV. Manaus- Amazonas, 2020

Variables	n	%	Prevalence%			
			ICU	p-value[a]	Death	p-value[a]
Total	87		60,9		34,5	
Sex				0,130		0,112
Male	57	65,5	66,7		40,3	
Female	30	34,5	50,0		23,3	
Age groups (years)				0,464		0,833
16 to 29	11	12,6	45,4		27,3	
30 to 59	35	40,2	60,0		37,1	
≥60	41	47,1	65,8		34,1	
Race/Color				0,332		0,709
White	5	5,7	80,0		20,0	
Brown	80	92,0	58,7		35,0	
Not reported [b]	2	2,3	100		50,0	
Education				0,569		0,135
Higher education	13	14,9	69,2		15,4	
High school	26	29,9	65,4		50,0	
Elementary school	15	17,2	66,7		40,0	
Less than elementary school	20	22,9	45,0		20,0	
Not reported [b]	13	14,9	61,5		38,5	

Multimorbidity				0,918		0,644
None	21	24,1	57,1		42,8	
1 disease	26	30,0	61,5		30,7	
2 or more diseases	40	46,0	62,5		32,5	
Length of hospital stay (days)				0,157		0.406
1 to 5	17	19,0	47,0		47,0	
6 to 15	30	34,5	53,3		26,7	
10 to 35	24	27,6	66,7		29,2	
36 or more	16	18,4	81,2		43,7	
Use of Mechanical ventilation	43	49,4	93,0	<0,001	62,8	<0,001
Use of vasoactive drugs	40	46,0	90,0	<0,001	67,5	<0,001
Use of dialysis	27	31,0	74,0	0,064	57,2	0,002

[a] Pearson's chi-square test; [b] there was no record in the medical report

3.4 Mean clinical parameters stratified by sex

In Table 3, the mean difference stratified by sex, shows that men in comparison to women presented on average higher heart rates (93.49 ± 18.54), respiratory rate (25.00 ± 8.00), more use of vasoactive drugs (0.54 ± 0.50), use of dialysis (0.36 ± 0.48), mechanical ventilation (0.56 ± 0.50), and ICU admission (0.66 ± 0.47). While women had higher mean O2 saturation (95.00 ± 6.25), longer hospital stay (23.56 ±28.43 days), and higher mean presence of some chronic diseases (1.73 ± 0.94).

Table 3 Mean of clinical parameters stratified by sex in COVID-19 patients hospitalized at HUGV. Manaus- Amazonas, 2020.

Variables	Mean ± SD (CI95%)	
	Women	**Men**
Heart rate	83,73 ± 23,79 (74,11 – 93,34)	93,49 ± 18,54 (88,27 – 98,70)
Respiratory rate	21,60 ± 5,73 (19,12 – 24,08)	25,00 ± 8,00 (22,70 – 27,29)
Systolic pressure	130,25 ± 22,78 (120,62 –139,87)	129,26 ± 31,30 (120,27 – 138,25)
Diastolic pressure	78,37 ± 16,59 (71,36 – 85,38)	76,85 ± 16,97 (71,98 – 81,73)
MAP	76,51 ± 41,66 (60,96 – 92,07)	81,07 ± 37,05 (71,24 – 90,90)
O$_2$ Saturation	95,00 ± 6,25 (92,22 – 97,77)	93,29 ± 10,01 (90,38 – 96,19)
Use of vasoactive drugs	0,30 ± 0,46 (0,12 – 0,47)	0,54 ± 0,50 (0,41 – 0,67)
Use of dialysis	0,23 ± 0,43 (0,07 – 0,39)	0,36 ± 0,48 (0,23 – 0,49)
Use of Mechanical ventilation	0,36 ± 0,49 (0,18 – 0,54)	0,56 ± 0,50 (0,42 – 0,69)
ICU admission	0,50 ± 0,50 (0,31 – 0,68)	0,66 ± 0,47 (0,54 – 0,79)
Days of hospitalization	23,56 ±28,43 (12,94 - 34,18)	22,36 ± 26,57(15,31 - 29,41)
Presence of some chronic disease	1,73 ± 0,94 (1,38 – 2,08)	1,36 ± 1,33 (1,01 – 1,72)

SD: Standard Deviation; CI$_{95\%}$: 95% confidence interval, MAP: mean blood pressure

IV. DISCUSSION

This is an observational study with electronic medical record data from March to August 2020, during the first wave of COVID-19 in Manaus, Amazonas. The results of the study reveal that 34.5% of hospitalized individuals died and 60.9% were admitted to the ICU. Of the 87 hospitalized individuals, 65.5% were male and had worse negative clinical outcomes

We identified a relatively high frequency of mortality and hospitalization in ICU compared to national data. A longitudinal cohort conducted in Brazil using secondary data from 398,063 medical reimbursement authorization records classified as COVID-19 hospitalization, describes a 21.7% death rate and a 26.07% rate of ICU admissions, and 55.5% of the hospitalizations of males.[8] A retrospective study of 250,000 COVID-19 admissions in the country also shows that the northern region outperformed the other Brazilian regions in hospital death rate (50%), and in the hospitalization of males (60%) [9].

Other studies conducted with similar outcomes in individuals hospitalized in the states of Rio de Janeiro, Espírito Santo and Bahia also support that men, age over 60 years, and the presence of multimorbidity were conditions more associated with a higher risk of ICU admissions and deaths [10]–[12].

In other Contexts such as China the mortality frequency ranged from 1.4% to 4.3% in the year 2020 (13,14), in Seattle and New York in the United States, a mortality frequency of 33% and 39% respectively was identified [13], [14], in Mexico, there was a variation of 1% to 20% in mortality rates between health institutions [15], in Italy, in the Lombardy region, the overall hospital mortality rate was 53.4% in one of the worst pandemic moments in that country [16], while in the region of Aragon in Spain, a mortality rate of 3.84 deaths per 100,000 people per day in the year 2020 has been identified [17].

A higher frequency of negative COVID-19 outcomes, such as ICU admission and deaths in males, elderly (60 years and older), and presence of multimorbidity is supported by strong evidence that reinforces our findings. A meta-analysis carried out in 2020 showed that males, advanced age, presence of chronic diseases were considered risk factors for death among patients with COVID-19 [18].

Two systematic reviews conducted in 2020, including more than 350,000 individuals, found that men had a higher risk of developing the outcomes of death and ICU admission compared to women [19], [20], as well as individuals who have some chronic health condition.

Studies conducted in 2020, in European countries such as, (Spain, Italy, England, Belgium, Greece, Denmark and the Netherlands) showed a male to female ratio for death in confirmed cases of COVID-19 equal to or greater than 1.7 [21]. Suggesting that women may be less likely to develop severe complications of COVID-19 leading to death [22].

The reasons for lower lethality from COVID-19 in women are still uncertain. Previous studies report that women have a greater perception of their health status, and they seek more health care services [23], This can help women identify the symptoms of the disease and seek assistance more quickly. While men tend to seek health services at a more advanced stage of the disease, when in general therapeutic supports for care are more limited.

There are also studies that suggest that the difference in lethality between men and women may be related to sexual dimorphism, which plays a central role in the genetic and hormonal regulation of immune responses, mainly in the regulation of Angiotensin Converting Enzyme 2 (ACE2), which is the main receptor used by SARS-CoV-2 to enter cells [24].

We identified an average time of two days more in the hospital and almost twice as many chronic diseases in women when compared to men, but these factors apparently did not contribute to greater severity or lethality in women. While in men, more severe outcomes were identified, such as changes in heart rate, respiratory rate, use of mechanical ventilation and vasoactive drugs.

A meta-analysis conducted in 2021, demonstrated that oxygen saturation lower than 93% is associated with more severe outcomes in patients with COVID-19, [24] A mean oxygen saturation of (93.29 ± 10.01) in men was observed in our study, which was lower than the mean observed in women (95.00 ± 6.25), which may justify the presence of more reserved outcomes for that group.

Our study detected that the risk of death was nine times higher in individuals on mechanical ventilation, when compared to those who did not use mechanical ventilation, as well as those who used vasoactive drugs had a ten-time increased risk of death compared to those who did not need to receive vasoactive drugs during hospitalization. In Brazil, mortality rates ranging from 59.5% to 82.98% were observed in patients on mechanical ventilation [25], [26], and in developed countries, the mortality rate was 45%, and that points to a meta-analysis including data from 23 countries [27]. The use of vasoactive drugs was also associated with mortality in patients with COVID-19 [28].

The difficulties in obtaining this data were significant, mainly due to the need to search for the information in the electronic medical record where access is restricted to the

hospital's employees, the release of data by the competent sectors and the academic unavailability, as there was no legal support for the access of students to the hospital premises, out of respect to state decrees since the state of Amazonas was in lockdown. And the restricted time of the researcher to access the electronic medical records.

The pandemic has imposed great challenges to all of us, including conducting research. The very structure and team of the hospital where this study was conducted, as it had to adapt physical spaces, personnel, equipment, and supplies to become a back-up hospital in facing COVID-19 in the state of Amazonas.

Other limitations to this research are those common to the cross-sectional study design, which are due to the non-probabilistic design and the use of secondary data, with the possibility TL of registration errors, missing data, and incomplete information. The information on comorbidities was self-reported, and some patients' hospitalization time for diagnosis was limited, often considering only the family member's information and this may favor overestimation or underestimation of some diseases.

The records can be related to more severe patients because it is a back-up hospital, which received patients only by transfer. In any way this study points out similarity with previous research and provides a support to identify the profile of individuals hospitalized with suspected COVID-19 in Amazonas, and outline strategies for supportive public policies in the study region.

V.   CONCLUSION

The new coronavirus has imposed great challenges to the population of Amazonas, as well as to its authorities. In this study, more than half of the hospitalized individuals suspected of COVID-19, required ICU admission and more than a third died. Men had more severe outcomes and contributed to higher mortality, according to the electronic medical records of the researched hospital. Adequate reporting and recording in medical records are of great importance for a better understanding of suspected cases of COVID-19, as well as providing high quality studies to evaluate and inform health policies in the region.

AUTHOR CONTRIBUTIONS

Araújo MEA, contributed to the study design, analysis and writing of the manuscript. Castro JO, Araújo TA and Aguiar TL contributed to the writing of the manuscript and review. All authors have approved the final version of the manuscript and are responsible for the integrity and accuracy of the article.

REFERENCES

[1] A. DG *et al.*, "Current Status of Epidemiology, Diagnosis, Therapeutics, and Vaccines for Novel Coronavirus Disease 2019 (COVID-19)," *J. Microbiol. Biotechnol.*, vol. 30, no. 3, pp. 313–324, 2020, doi: 10.4014/JMB.2003.03011.

[2] WHO, "WHO Coronavirus (COVID-19) Dashboard | WHO Coronavirus (COVID-19) Dashboard With Vaccination Data," Feb. 07, 2022. https://covid19.who.int/ (accessed Feb. 07, 2022).

[3] A. Martin, M. Markhvida, S. Hallegatte, and B. Walsh, "Socio-Economic Impacts of COVID-19 on Household Consumption and Poverty," *Econ. Disasters Clim. Chang. 2020 43*, vol. 4, no. 3, pp. 453–479, Jul. 2020, doi: 10.1007/S41885-020-00070-3.

[4] V. D. Teich *et al.*, "Epidemiologic and clinical features of patients with COVID-19 in Brazil," *Einstein (Sao Paulo).*, vol. 18, p. eAO6022, 2020, doi: 10.31744/EINSTEIN_JOURNAL/2020AO6022.

[5] IBGE, "Brasil. Instituto Brasileiro de Geografia e Estatistica (IBGE). Censo demográfico de 2010.," 2010. .

[6] FVS, "Fundação de Vigilância em Saúde do Amazonas. Centro de Informações Estratégicas em Vigilância em Saúde do Amazonas (CIEVS/FVS-AM)BOLETIM DIÁRIO COVID-19 NO AMAZONAS," Feb. 2022. Accessed: Feb. 07, 2022. [Online]. Available: https://www.fvs.am.gov.br/media/publicacao/07_02_22_BOLETIM_DIARIO_DE_CASOS_COVID-19.pdf.

[7] A. J. Barros and V. N. Hirakata, "Alternatives for logistic regression in cross-sectional studies: an empirical comparison of models that directly estimate the prevalence ratio," *BMC Med. Res. Methodol. 2003 31*, vol. 3, no. 1, pp. 1–13, Oct. 2003, doi: 10.1186/1471-2288-3-21.

[8] I. R. Zimmermann *et al.*, "Trends in COVID-19 case-fatality rates in Brazilian public hospitals: A longitudinal cohort of 398,063 hospital admissions from 1st March to 3rd October 2020," *PLoS One*, vol. 16, no. 7, p. e0254633, Jul. 2021, doi: 10.1371/JOURNAL.PONE.0254633.

[9] R. OT *et al.*, "Characterisation of the first 250,000 hospital admissions for COVID-19 in Brazil: a retrospective analysis of nationwide data," *Lancet. Respir. Med.*, vol. 9, no. 4, pp. 407–418, Apr. 2021, doi: 10.1016/S2213-2600(20)30560-9.

[10] C. C. Escosteguy, T. de A. Eleuterio, A. G. L. Pereira, M. R. V. E. Marques, A. D. Brandão, and J. P. M. Batista, "COVID-19: estudo seccional de casos suspeitos internados em um hospital federal do Rio de Janeiro e fatores associados ao óbito hospitalar," *Epidemiol. e Serviços Saúde*, vol. 30, no. 1, p. e2020750, 2021, doi: 10.1590/S1679-49742021000100023.

[11] C. L. T. de Andrade, C. C. de A. Pereira, M. Martins, S. M. L. Lima, and M. C. Portela, "COVID-19 hospitalizations in Brazil's Unified Health System (SUS)," *PLoS One*, vol. 15, no. 12, p. e0243126, Dec. 2020, doi: 10.1371/JOURNAL.PONE.0243126.

[12] M. KC, V. ACBC, S. ASS, M. WD, B. VG, and M. ELN, "COVID-19 hospitalization and death and relationship with social determinants of health and morbidities in Espírito

Santo State, Brazil: a cross-sectional study," *Epidemiol. e Serv. saude Rev. do Sist. Unico Saude do Bras.*, vol. 30, no. 3, pp. 1–11, 2021, doi: 10.1590/S1679-49742021000300004.

[13] B. FS *et al.*, "Clinical Features and Outcomes of 105 Hospitalized Patients With COVID-19 in Seattle, Washington," *Clin. Infect. Dis.*, vol. 71, no. 16, pp. 2167–2173, Oct. 2020, doi: 10.1093/CID/CIAA632.

[14] M. J. Cummings *et al.*, "Epidemiology, clinical course, and outcomes of critically ill adults with COVID-19 in New York City: a prospective cohort study," *Lancet (London, England)*, vol. 395, no. 10239, p. 1763, Jun. 2020, doi: 10.1016/S0140-6736(20)31189-2.

[15] H. Najera and A. G. Ortega-Avila, "Health and Institutional Risk Factors of COVID-19 Mortality in Mexico, 2020," *Am. J. Prev. Med.*, vol. 60, no. 4, pp. 471–477, Apr. 2021, doi: 10.1016/J.AMEPRE.2020.10.015.

[16] G. Grasselli *et al.*, "Risk Factors Associated With Mortality Among Patients With COVID-19 in Intensive Care Units in Lombardy, Italy," *JAMA Intern. Med.*, vol. 180, no. 10, p. 1, Oct. 2020, doi: 10.1001/JAMAINTERNMED.2020.3539.

[17] B. Poblador-Plou *et al.*, "Baseline Chronic Comorbidity and Mortality in Laboratory-Confirmed COVID-19 Cases: Results from the PRECOVID Study in Spain," *Int. J. Environ. Res. Public Heal. 2020, Vol. 17, Page 5171*, vol. 17, no. 14, p. 5171, Jul. 2020, doi: 10.3390/IJERPH17145171.

[18] F. M. Noor and M. M. Islam, "Prevalence and Associated Risk Factors of Mortality Among COVID-19 Patients: A Meta-Analysis," *J. Community Health*, vol. 45, no. 6, p. 1, Dec. 2020, doi: 10.1007/S10900-020-00920-X.

[19] J. Li *et al.*, "Epidemiology of COVID-19: A systematic review and meta-analysis of clinical characteristics, risk factors, and outcomes," *J. Med. Virol.*, vol. 93, no. 3, pp. 1449–1458, Mar. 2021, doi: 10.1002/JMV.26424.

[20] X. Fang *et al.*, "Epidemiological, comorbidity factors with severity and prognosis of COVID-19: a systematic review and meta-analysis," *Aging (Albany NY)*, vol. 12, no. 13, p. 12493, 2020, doi: 10.18632/AGING.103579.

[21] C. Penna, V. Mercurio, C. G. Tocchetti, | Pasquale Pagliaro, and C. G. Tocchetti, "Sex-related differences in COVID-19 lethality," 2020, doi: 10.1111/bph.15207.

[22] C. Penna, V. Mercurio, C. G. Tocchetti, | Pasquale Pagliaro, and C. G. Tocchetti, "Sex-related differences in COVID-19 lethality," *Br J Pharmacol*, vol. 177, no. 19, pp. 4375–4385, 2020, doi: 10.1111/bph.15207.

[23] M. E. A. Araujo, M. T. Silva, T. F. Galvao, and M. G. Pereira, "Prevalence of health services usage and associated factors in the Amazon region of Brazil: A population-based cross-sectional study," *BMJ Open*, vol. 7, no. 11, 2017, doi: 10.1136/bmjopen-2017-017966.

[24] A. Booth *et al.*, "Population risk factors for severe disease and mortality in COVID-19: A global systematic review and meta-analysis," *PLoS One*, vol. 16, no. 3, Mar. 2021, doi: 10.1371/JOURNAL.PONE.0247461.

[25] F. S. H. de Souza, N. S. Hojo-Souza, B. D. de O. Batista, C. M. da Silva, and D. L. Guidoni, "On the analysis of mortality risk factors for hospitalized COVID-19 patients: A

data-driven study using the major Brazilian database," *PLoS One*, vol. 16, no. 3, p. e0248580, Mar. 2021, doi: 10.1371/JOURNAL.PONE.0248580.

[26] M. S. Marcolino *et al.*, "Clinical characteristics and outcomes of patients hospitalized with COVID-19 in Brazil: Results from the Brazilian COVID-19 registry," *Int. J. Infect. Dis.*, vol. 107, pp. 300–310, Jun. 2021, doi: 10.1016/J.IJID.2021.01.019.

[27] L. ZJ *et al.*, "Case Fatality Rates for Patients with COVID-19 Requiring Invasive Mechanical Ventilation. A Meta-analysis," *Am. J. Respir. Crit. Care Med.*, vol. 203, no. 1, pp. 54–66, Jan. 2021, doi: 10.1164/RCCM.202006-2405OC.

[28] Z. Qian, S. Lu, X. Luo, Y. Chen, and L. Liu, "Mortality and Clinical Interventions in Critically ill Patient With Coronavirus Disease 2019: A Systematic Review and Meta-Analysis," *Front. Med.*, vol. 8, p. 635560, Jul. 2021, doi: 10.3389/FMED.2021.635560.

Nutritional profile of patients with cancer of the digestive tract hospitalized to a university hospital in Pará state

Rozinéia de Nazaré Alberto Miranda[1], Thalyta Mayara Andrade Silva[2], Thalita Luana do Nascimento Mendonça[3], Walyson Santos de Souza[4], Cinthia Regina Sales Furtado Vieira[5]*, Fabiana Costa Cardoso[6], Aldair da Silva Guterres[7]

[1]Federal Universityof Pará, Brazil (UFPA), Faculdade de Nutrição. Belém, PA, Brazil.
[2]Federal Universityof Pará, Brazil (UFPA), Faculdade de Nutrição. Belém, PA, Brazil.
[3]Federal Universityof Pará, Brazil (UFPA), Faculdade de Nutrição. Belém, PA, Brazil.
[4]Hospital Universitário João de Barros Barreto (HUJBB/UFPA/EBSERH), Belém, PA, Brazil.
[5]Federal University of Pará, Brazil (UFPA), PPGBAIP. Belém, PA, Brazil.
E-mail: crsfurtado@yahoo.com.br
[6]Federal Universityof Pará, Brazil (UFPA), Faculdade de Nutrição. Belém, PA, Brazil.
[7]Federal Universityof Pará, Brazil (UFPA), Faculdade de Nutrição. Belém, PA, Brazil.

Abstract — *Patients with cancer ot the digestive tract show changes in their nutritional status, leading them to various degrees of malnutrition. The assessment of nutritional status is essential to identify malnutrition and risks to it. Objective: To characterize the clinical, anthropometric and dietary profile of patients with digestive cancer admitted to a University Hospital in Belém, PA. Method: Descriptive, cross-sectional and prospective study, carried out at the João de Barros Barreto University Hospital, from July 2018 to March 2020. Sample composed of 59 cancer patients of both sexes, diagnosed with digestive tract neoplasia. Results: Among the variables studied, there was a prevalence of males in 50.8%. Among the women, 96.6% were classified as former smokers and 76.3%, former alcoholic. The main gastrointestinal symptoms presented were: constipation 36%, vomiting 22.3%, diarrhea and abdominal pain both 18.6%. In swallowing disorders: odynophagia and dysphagia manifested in 28.8% and 27.1%, respectively. The most common neurological symptoms were: headache 20.3% and motor weakness 17%. The most frequent type of cancer was stomach 57.6%, followed by intestine 16.9%. As for IMC, most adults were classified as eutrophic 61.8%, among the elderly 60% were malnourished, of these 56% had loss of muscle mass based on calf circumference. When analyzing eating habits, a high consumption of foods considered carcinogenic was identified. Conclusion: Malnutrition was prevalent, especially in the elderly. The presence of symptoms and food inappetence were associated with anticancer treatment. And high consumption of neoplasm-promoting foods to the detriment of protective foods.*

I. INTRODUCTION

The concept of cancer corresponds to the disordered growth of cells, which affect tissues and organs[1]. The onset process is called oncogenesis or carcinogenesis, of which the initiation, promotion, progression and inhibition of the tumor are responsible for the cumulative effects of different carcinogens or carcinogens[2].

The etiology of cancer is multifactorial and includes genetic and environmental factors. Such factors can be divided into modifiable and non-modifiable, among the modifiable ones we can mention: smoking, inadequate diet, physical inactivity, obesity, etc. While the non-modifiable factors are age, ethnicity or race, heredity and gender[3]. In this context, dietary factors and physical inactivity can contribute to approximately 1/3 of all types of cancer.

According to data from the World Health Organization[4] from 2018, the incidence of the disease rose to 18,1 million cases. In Brazil, according to the National Cancer Institute[5] for the year 2018, the estimate was 634.880,000 new cases of cancer. Regarding digestive tract neoplasms, around 50.360 cases were estimated, of which colon and rectum would have 17.380; stomach, 13.540; oral cavity, 11.200 and esophagus, 8.240 among men. Among females, there were 267.30 cases, of which 18.980 were from the colon and rectum and 7.750 from the stomach [6].

The Mortality Information System (SIM) revealed in 2017 that the cancers that most resulted in death in men were: colon and rectum, stomach, esophagus, liver and biliary tract, pancreas and oral cavity, respectively. In women, colon and rectum, stomach, liver and biliary tract were the most common[7].

Cancer patients present changes in their nutritional status with specific changes in body composition. These can be estimated based on nutritional history as well as on biochemical and clinical examinations, through dietary anamnesis, anthropometric measurements and subjective global nutritional assessment (SGA) [8].

These patients are already at nutritional risk, and malnutrition arises through it a series of clinical consequences described above, including deterioration in quality of life, reduced response to treatment, increased risk of chemotherapy-induced toxicity and decreased cancer survival[9].

Usually, these patients have dysfunction in nutrient intake due to changes in gastrointestinal functions, which, in turn, are consequences of the use of anticancer drugs. The most common symptoms when the GIT is affected are: vomiting, nausea, diarrhea, constipation, dysphagia, odynophagia, dysgeusia, dysosmia and xerostomia[10].

In this sense, this work aims to characterize the nutritional profile of patients with digestive tract cancer admitted to a University Hospital in Belém-PA.

II. METHOD

This is a descriptive, cross-sectional and prospective study with analytical characteristics. Carried out at the João de Barros Barreto University Hospital (HUJBB)/Federal University of Pará (UFPA), in the city of Belém-PA, after approval by the Research Ethics Committee of the Institute of Health Sciences, under protocol nº 950.479.

This study included 59 adult and elderly patients, over 18 years of both sexes, with confirmed diagnosis of digestive tract neoplasm and adnexal glands, admitted to HUJBB clinics from July 2018 to March 2020, oriented, aware , ambulant or not and who agreed to participate in the study by signing the Informed Consent Form (FICF) and excluded patients with cancer in other locations, disoriented in time and space, without a confirmed diagnosis of the object of study.

Sociodemographic profile: A specific form containing questions about sex, age and history of smoking and alcohol consumption was applied.

Clinical semiology: Data were collected in a specific form with questions regarding the location of the neoplasm; gastrointestinal changes (diarrhea, pain, constipation, vomiting) and bowel function; restriction of oral food intake, such as changes in chewing, odynophagia and dysphagia and neurological changes (headache, mental confusion, motor weakness, leg pain, neck stiffness, drowsiness, seizure, motor paralysis).

Nutritional assessment: The anthropometric measurements used were weight and height to characterize the Body Mass Index (BMI), Brachial Circumference (BC), Calf Circumference (CC), percentage of recent weight loss (%WL). For measurements following the criteria proposed by Lohman et al., 1988, an inelastic measuring tape, a G-Tech BALGL 10 digital scale and a Sanny clinical adipometer were used. The BMI was classified according to the parameters of the World Health Organization (WHO, 2000) for adults and for the elderly, the classification of LIPSCHITZ, 1994 was used. The BC was analyzed according to the normality pattern of Frisancho (1981) and the results classified through the values references adapted from Blackburn & Thornton (1979). The CC was analyzed according to the WHO (1995), with a value less

than 31 cm indicative of loss of muscle mass. For weight loss percentage, patients were classified according to reference values established by Blackburn and Thornton (1979).

Food consumption: Eating habits were identified through the adapted food frequency questionnaire (FFQ). The foods were analyzed based on the 2014 Food Guide for the Brazilian Population.

III. STATISTICAL ANALYSIS

The collected data were organized in the Microsoft Excel 2010 program. The tables were built using Microsoft Word software. Qualitative variables were described by frequency and percentage.

IV. RESULTS

The sample consisted of 59 cancer patients, 50.8% males. The predominant age group ranged from 40 to 82 years. It was observed that 96.6% of the patients were former smokers and 76.3% were former alcoholics (Table 1).

Table. 1 – Sociodemographic profile of patients hospitalized with digestive tract cancer at the HUJBB from July 2018 to March 2020, Belém, Pará – Brazil.

SociodemographicVariables	Frequency	%
Sex		
Male	30	50.8
Female	29	49.2
Age		
27 to 39 yearsold	7	11.9
40 to 59 yearsold	27	45.8
60 to 82 yearsold	25	42.4
Smoker		
Non-smoker	2	3.4
Formersmoker	57	96.6
Drinker		
Nondrinker	13	22.0
Drinker	1	1.7
Formerdrinker	45	76.3

Source: data colta.

Stomach cancer predominated (57.6%), followed by intestine (16.9%) and esophagus (10.2%) (Table 2).

Table. 2 – Types of cancer in patients hospitalized with HUJBB digestive tract cancer from July 2018 to March 2020, Belém, Pará – Brazil.

TypeofCancer	Frequency	%
Stomach	34	57.6
Intestine	10	16.9
Esophagus	6	10.2
Liver	4	6.8
Pharynx	2	3.4
Pancreas	2	3.4
Mouth	1	1.7

Source: data colta.

In swallowing alterations, odynophagia and dysphagia were manifested by (28.8%) and (27.1%) respectively. Of the gastrointestinal symptoms, constipation prevailed (35.5%), followed by vomiting (20.3%), diarrhea and abdominal pain both with 18.6%. Among the neurological symptoms, headache (20.3%) and motor weakness (16.9%) as the most prevalent symptoms (Table 3).

Table. 3 - Prevalence of clinical symptoms in patients hospitalized with cancer of the digestive tract at HUJBB from July 2018 to March 2020, Belém, Pará - Brazil.

ChewingandSwallowingChanges	Frequency	%
Difficulty in Chewing	14	23.7
Odynophagy	16	28.8
Dysphagia	14	27.1
No symptoms	28	47.5
Gastrointestinal Symptoms		
Constipation	21	35.6
Vomiting	12	20.3
Diarrhea	11	18.6
Abdominal pain	11	18.6
No symptoms	14	23.7
NeurologicalSymptoms		
Headache	12	20.3
Motor weakness	10	16.09
Somnolence	6	10.2
Others	10	16.9
No symptoms	21	35.6

Source: data colta

With regard to the total number of patients, 62.7% were malnourished based on the Brachial Circumference

(BC), a high percentage compared to obesity, which had an incidence of 1.7%.Of the 25 elderly, 56% had loss of muscle mass in relation to Calf Circumference (CC). Regarding Body Mass Index (BMI), most adults (61.8%) were eutrophic, while most of the elderly (60%) were malnourished (Table 4). Both elderly and adults showed low results for overweight, 20% and 17.6%, respectively.

Table. 4 – Classification of the nutritional status of patients hospitalized with cancer at the HUJBB from July 2018 to March 2020, Belém, Pará – Brazil.

BrachialCircumference - (All)	Frequency	%
Severemalnutrition	15	25.4
Moderatemalnutrition	4	6.8
Mildmalnutrition	18	30.5
Eutrophy	18	30.5
Overweight	3	5.1
Obesity	1	1.7
CalfCircumference – (Elderly)		
Lossofmusclemass	14	56.0
Normal	11	44.0
Body Mass Index – (Adults)		
Malnourished (thinness grades 1 and 2)	4	11.8
Eutrophic	21	61.8
Overweight	6	17.6
Grade 2 obesity	3	8.8
Body Mass Index – (Elderly)		
Malnourished	15	60.0
Eutrophic	5	20.0
Overweight	5	20.0

Source: data colta.

Weight loss, in relation to time, 31.9% of hospitalized patients suffered significant weight loss and 68.2% had severe loss (Table 5).

Table. 5 – Classification of weight loss percentage in relation to time of patients with cancer of the digestive tract admitted to the HUJBB from July 2018 to March 2020, Belém, Pará – Brazil.

Time	Significantloss (n=14)	Seriousloss (n=30)
1 week	5 (11.4)	0
1 month	3 (6.8)	0
3 months	5 (11.4)	0
6 months	1 (2.3)	30 (68.2)

Source: data colta.

As for the frequency of food consumption, the most consumed foods daily were milk (76.3%), rice (72.9%) and cassava flour (55.9%), while the most consumed weekly foods were chicken (81.4 %), beef (72.9%) and fish (69.5%). Compared to these, the least consumed foods were pork and soy (1.7%) (Table 6).

Table. 6 – Frequency of the food survey in relation to food consumption in general by patients with cancer of the digestive tract hospitalized at the HUJBB from July 2018 to March 2020, Belém, Pará – Brazil.

Food in General	Frequency of Consumption (%)					
	D	S	Q	M	N	R
Milk	76.3	8.5	-	-	-	15.3
Cheese	22.0	18.6	8.5	5.1	6.8	39.0
Butter	40.7	6.8	-	-	32.2	20.3
Margarine	40.7	10.2	-	-	30.5	18.6
Beef	8.5	72.9	-	1.7	3.4	13.6
Pork	1.7	11.9	1.7	5.1	35.6	44.1
Chicken	6.8	81.4	1.7	-	6.8	3.4
Fish	11.9	69.5	3.4	8.5	1.7	5.1
Egg	22.0	45.8	3.4	-	8.5	20.3
Legumes	44.1	33.9	-	3.4	3.4	15.3
Soy	1.7	10.2	5.1	-	55.9	27.1
Rice	72.9	15.3	-	-	1.7	10.2
Cassava flour	55.9	23.7	-	-	8.5	11.9
Tapioca	8.5	45.8	8.5	10.2	10.2	16.9

D: Diary; S: Weekly; Q: Biweekly; M: Monthly; A: Rare; N: Never.

Source: data colta.

In relation to foods considered cancer promoters, sugar (64.4%) and cracker (33.9%) were the most consumed daily. In relation to the foods eaten weekly, frying had the highest consumption (49.2%), fast food and soda had a consumption of (23.7%) per week (Table 7).

Table. 7 – Frequency of the dietary survey in relation to the consumption of foods considered to promote the disease among patients with digestive tract cancer hospitalized at the HUJBB from July 2018 to March 2020, Belém, Pará – Brazil.

Food Promoters	Frequency of Consumption (%)					
	D	S	Q	M	N	R
Cracker	33.9	32.2	-	1.7	8.5	23.7
Stuffed cookie	6.8	8.5	1.7	1.7	45.8	35.6
Sugar	64.4	11.9	-	1.7	10.2	11.9
Soda	5.1	23.7	1.7	1.7	37.3	30.5
Fried food	11.9	49.2	5.1	-	16.9	16.9
Embedded food	5.1	18.6	1.7	1.7	47.5	25.4
Canned food	6.8	11.9	1.7	5.1	37.3	37.3
Fast food	-	23.7	-	3.4	28.8	42.4

D: Diary; S: Weekly; Q: Biweekly; M: Monthly; A: Rare; N: Never.

Source: data colta.

Among the foods identified as protective, fruit juice (57.6%), fruits (55.9%) and vegetables (44.1%) were the most consumed on a daily basis. Oats (39%), açaífruit (37.3%) and olive oil (28.8%) were the most consumed foods weekly (Table 8).

Table. 8 – Frequency of the food survey in relation to the consumption of foods considered to be protective among patients with digestive tract cancer hospitalized at the HUJBB from July 2018 to March 2020, Belém, Pará – Brazil.

ProtectiveFoods	Frequency of Consumption (%)					
	D	S	Q	M	N	R
Oat	28.8	39	3.4	1.7	10.2	16.9
Olive oil	28.8	28.8	-	-	22	20.3
Açaí fruit	25.4	37.3	3.4	8.5	11.9	13.6
Fruit	55.9	33.9	-	1.7	1.7	6.8
Fruitjuice	57.6	28.8	-	-	1.7	11.9
Vegetables	44.1	33.9	-	3.4	3.4	15.3

D: Diary; S: Weekly; Q: Biweekly; M: Monthly; A: Rare; N: Never.

Source: data colta.

V. DISCUSSION

In the present study, there was a predominance of digestive tract cancer in adults compared to the elderly, and smoking and alcohol were present in most patients. The association between smoking and alcohol abuse are among the main risk factors for the onset of cancer[11].

In this context, some cancers are directly related to these habits, such as: stomach, pancreas, oral cavity, liver, oropharynx, esophagus, colon, among others, due to inorganic components (potassium, sodium, aluminum, copper), carcinogenic aromatic hydrocarbons or not proven to be carcinogenic, nitrogenous bases and alkaloids, such as nicotine; in the case of cigarettes[12]. Alcohol, in turn, favors the malignancy of tobacco substances, as it dissolves them, leaving them in high concentration. Thus, the association of smoking with alcoholic beverages becomes one of the most common causes of malignant neoplasm[13].

In this study, the types of cancer that most affected the patients were stomach, intestine and esophagus. It was also observed that the most common was stomach with 57.6%, confirming the high prevalence of this in the Brazilian population, which was elucidated by the National Cancer Institute [14] when considering it the third most common among men and fifth among women. Bowel cancer had an occurrence of 16.9% among the interviewed patients and is considered a serious public health problem in the world, being also identified as the third most common type of cancer globally[14]. The third most frequent cancer among the population studied is esophageal cancer. It currently represents the eighth most common neoplasm in the world and the sixth most recurrent cause of death from cancer[15].

The clinical symptoms of the disease were classified into three categories: Changes in the chewing and swallowing process, gastrointestinal symptoms and neurological symptoms. Generally, gastrointestinal clinical alterations are related to chemotherapy treatment,

as it is considered systemic, it affects both healthy cells and neoplastic cells, causing adverse reactions in the patient. Gastrointestinal tract cells with high replication capacity are the most affected during anti-neoplastic therapy, which explains the persistence of symptoms such as: constipation, nausea, vomiting, anorexia, diarrhea and dysphagia and odynophagia in patients[16].

Nutritional status is the most impacted by cancer. The study classified the nutritional status of the investigated patients based on the BMI of adults and the elderly, the BC of all hospitalized patients and the CC of the elderly. With regard to adults, the present study did not show a high prevalence of malnutrition according to BMI. A result similar to the research was found in the study[17], which revealed 45% of adults with normal weight, out of a population of 40 patients.

BMI is the most used anthropometric parameter, however its use in the elderly is questioned, as it does not take into account the change in fat distribution in the physiology of aging. The verification of anthropometric measurements can change in the elderly by bending the back and shortening the vertebrae, decreasing height and, as a result, increasing BMI values. Lipschitz, in 1994, suggested a classification that took into account the bodily changes that result from aging, as well as the susceptibility of geriatric patients to malnutrition; since, in addition to the loss of lean mass, they have a higher percentage of fat when compared to adults[18].

It is important to emphasize that BMI has a restricted value in cancer patients, since they have increased inflammatory parameters, which can cause proteolysis and increased extracellular fluid, leading to water retention and edema. Thus, it camouflages the real nutritional status. Besides that, many chemotherapy treatments make use of hormone therapy and or glucocorticoids, which can also cause adverse effects that disguise the nutritional status and disguise the actual weight. As for the high prevalence of malnourished elderly, this can be explained due to the intrinsic physiological changes that they present to the aging process, such as reduced protein synthesis and sarcopenia, which associated with the adverse effects of treatment increase the risk of malnutrition and foster inappetence[19].

In contrast to the BC findings, it evidenced a high occurrence of malnourished people among adults and the elderly (62.7%). Although the BMI of adults showed mostly eutrophy, around 62%, the adequacy of BC better defines the nutritional profile of these patients, as it represents the sum of bone, muscle and adipose tissues[20]. In their study, they stated that in digestive

system neoplasms, depending on the physical location of the tumor, it can cause gastrointestinal symptoms that result in lower food intake, as well as reduced absorption and, consequently, bioavailability, negatively reflecting on the nutritional status of the patient, which contributes to malnutrition. Furthermore, most cancer patients are in critical condition. In this sense, metabolic alterations (protein hypercatabolism and hypermetabolism) are also capable of triggering malnutrition, due to increased caloric expenditure[21].

In concern to the 25 elderly, 56% had loss of muscle mass in relation to CC. This is considered a sensitive measure to monitor and assess muscle mass loss in older adults of both sexes[18]. Its decrease implies a reduction in muscle strength and is related to the risk of developing the syndrome called sarcopenia. However, it is noteworthy that the calf perimeter cannot be used as an isolated indicator to assess the nutritional status of the elderly[22]. It is noteworthy that sarcopenia is an integral part of cancer cachexia and is recognized as a geriatric syndrome in these patients, which is defined as a combination of loss of lean mass and physical performance[23].

Analyzing the weight loss percentage in relation to time, it was found that 31.9% of hospitalized patients had significant loss, 68.2% had severe weight loss. Possibly, in some of these individuals, the weight loss process was already underway at the time of diagnosis, because according to Santos et al. [24] significant catabolic changes that cause cachexia - a syndrome that contributes to progressive marked weight loss, muscle tissue catabolism , related or not to the adipose tissue – are characteristic of the disease. The weight losspercentage in relation to time was an important variable to be analyzed, as it is a valid factor in determining the risk of malnutrition, and may reflect situations of neoplastic cachexia[25]. Of the 59 patients, 15 did not experience weight loss.

With regard to food consumption, this was assessed by frequency of intake category (daily, weekly, fortnightly, monthly, rare and never). And, also, subdivided as consumption of foods in general, foods that promote and foods that protect the disease. In general, milk, rice and cassava flour were the most consumed daily, while chicken, beef and fish were the most consumed weekly. It is important to highlight that food has a direct influence on carcinogenesis, playing an important role in the stages of initiation, promotion and development of cancer. It is estimated that nutrition and lifestyle factors are determinant in one third of all cancer cases[26]. WHO (2015) draws attention to the

consumption of red meat (beef, pork and sheep) as being carcinogenic to humans. Furthermore, both the cooking of red meat (hydrocarbon release) and the high intake of iron from this food play important roles in the development of cancer[27].

According to the subcategories of foods in this study, those considered to be promoters of the disease have broad importance in the discussion, given their contribution to the development of malignant neoplasms. Thus, according to information from the International Agency for Research on Cancer [28], diet may be related to some types of cancer, especially stomach, liver, rectum and intestine (especially colon cancer). In this study, it was observed that the most consumed promoting foods were: sugar (64.4%), fried foods (49.2%), biscuits (33.9%), and fast food and soda (23.7%). It is thus correlated that industrialized foods have nitrates and nitrites in their composition, which are widely used in the food industry to preserve and enhance flavor, such as sausages and preserves. However, the high consumption of these foods is closely linked to the increased risk of gastrointestinal cancer. Such substances are transformed into nitrosamines in the gastrointestinal tract (TGI), being considered one of the main carcinogens. Thus, foods preserved in salt, such as dried meat, jerky and salted fish, are also associated with the development of cancer, in regions where the consumption of these foods is indiscriminate[26].

As for the consumption of foods known to be protective for the prevention of the disease, the frequency with which they presented themselves daily and weekly was considered interesting, as follows: fruits (55.9%), natural fruit juice (57.6%), vegetables (44.1%), oats (39%), açaífruit (37.3%) and olive oil (28.8%). In this sense, fruits, vegetables and vegetables play a prominent role in cancer prevention, as they have bioactive compounds, vitamins and minerals such as beta-carotene, fiber, anthocyanins, lycopene, flavonoids, selenium, lutein, vitamin C, E and zinc. The prominent position of these foods is due to their antioxidant function and their action in the functioning of the intestine. Therefore, the consumption of these foods must be a priority[29].

Despite the daily consumption of fruits and vegetables being above 50% and being a health benefit to patients, the consumption of foods that may favor the onset of the disease was highly significant (96.6%). This may be associated with the lack of information on healthy eating[26], as well as lifestyle habits that do not comply with the protection of your health (cigarette consumption and alcoholic beverages) which leads to an increase in

oxidative stress, favoring the high production of free radicals[29].

VI.   CONCLUSION

Although adults were eutrophic in terms of BMI, malnutrition was a prevalent clinical condition in cancer patients with malignant neoplasms of the digestive tract, with the elderly being the most affected, associated with gastrointestinal symptoms resulting from antineoplastic treatment, which impair adequate nutrition, due to inappetence, ending up reducing food intake. Therefore, the relevance of more immediate nutritional assessment in this group for preventing the risk of malnutrition is highlighted.

Although in this study the consumption of protective foods was satisfactory, the consumption of carcinogenic foods was more expressive. Ratifying that the unrestrained consumption of these foods is related to the onset of the disease. The assessment of food consumption among cancer patients should be routine, as it will provide subsidies for more targeted nutrition education, which is important for therapy, not only for its nutritional aspects, but also for its symbolic and subjective dimension**.**

VII.   LIMITATION OF THE STUDY

The present study faced some significant limitations regarding its sample size. Due to the Covid-19 pandemic, which started in 2020, access to patients was restricted. As a result, the sample size was reduced, undermining much of the initial research objective.

REFERENCES

[1] National Cancer Institute (2019). Ministry of Health. What is câncer. [Accessed september25, 2019]. Available at: https://www.inca.gov.br/o-que-e-cancer

[2] National Cancer Institute (2019). Ministry of Health .How does cancer arise? [7 nov 2019]. Available at: https://www.inca.gov.br/como-surge-o-cancer

[3] Cuppari, L. (2014).Clinical Nutrition in Adults. Outpatient and Hospital Medicine Guides – Nutrition – Clinical Nutrition in Adults. 3rd Ed.

[4] Stump, S. (2011). Nutrition Related to Diagnosis and Treatment. 6 edition. São Paulo.

[5] International Agency for Research on Cancer (2018). World Health Organization. World cancer report. Available at: https://www.iarc.fr/cards_page/world-cancer-report

[6] National Cancer Institute (2019). Ministry of Health. Cancer numbers. [7 nov 2019]. Available at: https://www.inca.gov.br/numeros-de-cancer/mortalidade.

[7] Brazil-Ministryof Health (2017). José de Alencar Gomes da Silva. NationalCancerInstitute(INCA). 2018 estimate:câncer incidence in Brazil. Rio de Janeiro: INCA.

[8] Brazil- Ministry of Health (2019). Mortality information system. [7 nov 2019].Health Surveillance Department. Available at: https://www.sim.saude.gov.br

[9] Guimarães, R.M., Sousa, A.L.C., Oliveira, C.M., Sptringhini, M.L.F. (2016).Nutritional assessment and quality of life of patients with cancer of the digestive system. Health in Review; 16; for.2-3.

[10] Santos, A.F.S., Lima, F.R.S., Maciel, M.G., Martins, I.C.V.S., Dias, L.P., Barros, C.M., et al (2017). Nutritional Assessment of Patients with Gastric cancer and Other Locations. Health research Journal; 18(1); for.1-2.

[11] Gangadhara, A., et al (2017). Protein calorie malnutrition, nutritional intervention and personalized cancercare. Oncotarget;8 (14);p. 24009-24030.

[12] Leite, R.B., et al (2021). The Influence of the tobacco and alcohol association on oral câncer: Literature Review. Brazilian Journal of Laboratory pathology and medicine.57; for. 1-2.

[13] Bittencourt, C.P., Abreu,M.C.,, Souza, T.F., Hot, A.M., Partata, A.K (2017). Tobacco use and its relationship with the development of cancer. ITPAC Scientific Journal. 10 (1); p. 5.

[14] National Cancer Institute (2021). Ministry of Health. [Feb 11, 2021]. Available at: <https://www.inca.gov.br/tipos-de-cancer/cancer-de-estomago>

[15] Menezes, C.S., Ferreira, C.B.B., Faro, D.B.A., Bomfim, F.S., Trindade, M.D.F., Maria,L.(2016). Colorectal cancer in the brazilian population: mortality rate in the period 2005-2015. Brazilian journal on health promotion, vol. 29, nº 2, april-june; 172-179.

[16] Steenhagen, E., Vulpen, J.K.V., Hillegersberg, R.V., May, A.M., Siersema, P.D. (2017). Nutrition in peri-operative esophageal cancer management, Expert Review of Gastroenterology & Hepatology.11:7, 663-672.

[17] Hackbarth, L., Machado,J.(2015).Nutritional status of patients undergoing treatment for gastrointestinal câncer. Brazilian journal of clinical nutrition. 30 (4); p. 3.

[18] Cardozo, N.R., Duval, P.A., Cascaes, A.M., Silva,A.E.R.(2017).Orlando, SP. Nutritional status of elderly people attended by Family health units in the city of pelotas- RS. 32 (1); p. 2.

[19] Costa, T.F., Miranda, L.M.P., Braga, C.B.M., Alves, L., Luz, S.A.B., Trevisan,M.C.(2021).Gastrointestinal symptoms in câncer patients during chemotherapy treatment: assessment of the impacto n nutritional status. Brazilian journal of health review.4 (5); p. 11.

[20] Fugolar, F., Hacke, A., Brandão, P.C., Kato,M.(2016). Relationships of the nutritional risk index with postoperative complications of digestive system surgeries in an oncology hospital. NutrCli and diet hosp. 36 (4); p. 2.

[21] Fruchtenicht, A.V.G., Poziomyck, A.K., Klabe, G.B., Loss, S.H., Antoniazzi, J.L., Steemburgo, T., Moreira,L.F.(2015).Nutritional risk assessment in critically ill cancer patients: a systematic review. Rev Bra de Ter Int. 27 (3): 274-283.

[22] Brazil. Ministry of health (2018).Health care department. Department of strategic programmatic actions. Manual for the use of the elderly health handbook- Brazilia.

[23] Collins, J.T.,et al.(2015). Association of sarcopenia and observed physical performance with attainment of multidisciplinary team planned treatment in non-small cell lung cancer: na observational study protocol. BMC Cancer. 15: 544.

[24] Santos, A.F.S., Lima, F.R.S., Maciel, M.G., Martins, I.C.V.S., Dias, L.P., Barros, C.M., Chein,M.B.C.(2017).Nutritional assessment of patients with gastric câncer and Other locations. RevPesq Saúde. v. 18; p. 1-2.

[25] Lima, K.D.S., Luz, M.C.L., Araújo AO, Lima KDS, Burgos MGPA, Arruda IKG, Maio R (2017).Cachexia and pre-cachexia in patients with câncer of the gastrointestinal tract. NutrClí Diet Hosp. 37(4):101-107.

[26] Almeida, L., Santos, B.T., Prates, R.P., Leão, L.L., Pereira, E.J., Silva, V.S., Farias, P.K.S.(2017).Diet as a risk fator for bowel câncer in university students. RevBras em Prom da Saúde.30; p. 2.

[27] Barbosa, L.B., Montenegro, R.C., Moraes, M.E.A., Nunes-Moreira,C.A.(2020).Dietary habits and their correlation with the development of gastric carcinogenesis in the Brazilian population: A literature review. Brazilian journal of health review. 3 (3); p. 8-9.

[28] IARC – International Agency for Research on Cancer(2009) - Identification of Research Needs to Resolve the Carcinogenicity of High-Priority IARC Carcinogens. IARC TechnicalPublication No. 42; 2 de julho de 2009. Acesso em: 11 de fevereiro de 2021. Disponível em: https://monographs.iarc.who.int/iarc-technical-publications-related-to-iarc-monographs-evaluations/.

[29] Santos, A.C.F., Aguiar, M.M., Costa, V.V.L., Sá, N.N.B., Ainett, W.S.O., Santos,T.O.C.G.(2019)Consumption of protective foods and risk for developing câncer among health students. DEMETRA. 14; p. 1-21.

Agrobiodiversity and food sovereignty among peasant families in two municipalities in the south of Bahia/Brazil

Alessandra Quirino Bertoso dos Santos Jardim[1], Angelo Giuseppe Chaves Alves[2], Paulo Rogério Lopes[3]

[1]Doctoral student, Postgraduate Program in Agroecology and Territorial Development, Rural Federal University of Pernambuco (UFRPE) Campus Recife - PE, Brazil
Email: allejardim@gmail.com

[2]Teacher, Program in Agroecology and Territorial Development, Rural Federal University of Pernambuco (UFRPE) Campus Recife - PE, Brazil
Email: agcalves.ufrpe@hotmail.com

[3]Teacher and Coordinator of the Agroecology course, Federal University of Paraná (UFPR) – Litoral
Email: agroecologialopes@gmail.com

Abstract— This article presents a research at a regional level, which includes two municipalities in the South of Bahia/Brazil, in an agroforestry system known as "cabruca". A survey of the main Unconventional Food Plants (PANC) used by the peasant community was carried out. Data were obtained using a quali-quantitative approach, taking into account the quantity and variety of unconventional plants that participants indicated they knew and used, and which had potential for food use. The main species indicated by the community, with food potential, were duly identified. Gastronomic workshops were also held, seeking to encourage the use of Non-Conventional Food Plants (PANC-portuguese) and strengthen the sovereignty and food security of peasant families. The main objective was to investigate the factor(s) that lead some people to not use certain plants in their diet, even though they may be suffering from food deprivation and having with the knowledge the feed potential of these plants.

I. INTRODUCTION

Brazil has the greatest plant biodiversity on the planet with a total of 40,989 native species of flora (BFG, 2018), and these numbers tend to increase, since on average, more than 250 new species are cataloged per year (Fioravanti, 2016). It is noteworthy that of the total number of species mentioned above, 33,099 are Angiosperms, that is, plants that have seeds protected by fleshy or dry fruits (BFG, 2018).

The Atlantic Forest has a high level of flora diversity, forming a complex system with a high degree of endemism, being considered a priority environment (hot spot) for the conservation of biodiversity. One of these important points for conservation is the South of Bahia, where there is an Agroforestry System known as "*Cabruca*", which has great relevance for the remnants of Atlantic Forest in that region. According to Sambuichi (2003), this agroforestry system is characterized by the thinning of the forest and the cultivation of cocoa (*Theobroma cacao* L.), under the shade of large trees. Within this SAF there is a great diversity of Unconventional Food plants, which are widely known in the region, including among peasant families. However, there is a need for studies that help to measure the real

dimension of the diversity of these species and the ways in which they are consumed.

The term PANC was proposed by Valdely Kinupp to designate species of native, exotic, wild or cultivated spontaneous plants, present in different regions, influencing the food culture of traditional and regional populations (Kinupp & Lorenzi, 2014). They are distributed in all Brazilian biomes, some of which are known and widely used in cooking, but the vast majority are still unknown by Brazilians.

According to Brack (2016), PANC are not restricted to plants considered native, being a broad concept that encompasses all plants that are not conventional in our menu or produced in conventional systems, considered food plants of agrobiodiversity. More broadly, the concept values the specificities of bioregions and forms of production, and may include creole seeds and other plants associated with different traditional and food cultures, rescuing ethnic wealth and strengthening the self-esteem of rural and traditional communities (Kinupp, 2007; Silva, 2015; Brack, 2016).

In recent years, some works related to PANC have been published in Brazil (Kinupp, 2007; Rufino, 2008; Brasil, 2010; Kinupp & Lorenzi, 2014; Filho, 2015; Brack, 2016; Polesi, 2016). However, the number of publications is still low when compared to the species richness and cultural diversity recorded in the country. Many of the species with potential for use in food are not used or only parts are used, due to the lack of knowledge of how they can be consumed and their nutritional content, with a part of the plant not conventionally consumed being discarded.

The concern with quality food has contributed to increasing the population's interest in agro-food systems and the preservation of biological and cultural diversity (Rufino, 2008; Chaves, 2016; Polesi, 2016). In addition to the concern with the production of quality food, agroecology announces proposals for rural development, maintaining a high level of biodiversity and strengthening new mechanisms for food distribution, a condition that favors producers and consumers to reassume their decision-making power over your food (Brasil, 2006, 2010; Burity, 2010; Filho, 2015).

The cultivation and use of PANC associated with agroforestry systems, by peasant and/or traditional populations, can be a way to affirm the autonomy of knowledge accumulated by the communities about these species and to rescue the regional food culture, in addition to enabling the creating new healthy recipes (Brasil, 2010; Kinupp & Lorenzi, 2014; Altieri, 2016; Brack, 2016; Jardim et al.., 2019, 2020).

We know that, associated with the richness of plant species, is the cultural diversity of the peasant population that lives with these plants and that has knowledge associated with their use as a source of food, medicines, fibers, dyes, condiments and so many other features. They are farming families, traditional communities, autonomous collectives that seek to use biodiversity resources in a sustainable way, through ecological production systems, guaranteeing environmental conservation, income generation and the production of food sovereignty (Kinupp, 2007; Köhler & Brack, 2016).

Therefore, food monotony (always eating the same foods) is not due to a lack of options, but a lack of knowledge (or the existence of prejudices) about the existence of species, their characteristics and their potential for use, whether in the form of harvest , planting, handling, processing or simply whether a plant can be consumed, in addition to these barriers, the lack of PANC varieties in open markets and markets, makes consumption difficult (Kinupp, 2007).

The existing studies always approach the quantitative aspects of the species existing in the places, however, due importance is not given to the cultural factors that lead people not to use certain vegetables, even knowing that they could be consumed. As a result, we see a large number of zone rural people experiencing food deprivation, despite the large number of plants that could help meet their food shortages.

Therefore, an approach was used that also contemplates the ethnobotanical aspects that are of fundamental importance to create and support public policies that promote the dissemination of unconventional food plants, as well as practical ways for their recognition, availability of recipes, which can be prepared with these plants, so that they strengthen the agrofood systems and the food sovereignty and security of the population. With the objective of encouraging peasant families to include certain PANC in their food, in order to subsidize actions to strengthen the sovereignty and food security of the peasantry.

II.   METHODOLOGY

2.1 Characterization of the study area

The "*Cabruca*" Agroforestry System is of great relevance to the Atlantic Forest remnants of southern Bahia, since endemic, rare and threatened species are still distributed in the existing "*cabrucas*". Many of these species have already been eliminated in remaining areas of forest, remaining only in areas of fertile soils where the "*cabruca*" system was established. These Agroforestry

Systems also function as ecological corridors, linking one forest fragment to another.

The study area is located in the municipalities of Itacaré and Ubaitaba, a region that still has coverage in a good state of conservation of remnants of the Atlantic Forest. The area where the research was developed is inside and around the in the Serra do Vinhático Ecological Complex and its surroundings. This set was created by the Master Plan of the municipality of Itacaré LEI 271/2014, which established Special Zones of Social Interest. Serra do Vinhático still has areas with intact Atlantic Forest coverage. Due to its proximity to Parque do Conduru, which is considered the point with the greatest diversity of woody plants on the planet, it is a potential area of great interest for research involving biodiversity. According to the municipal zoning map of Itacaré (Fig. 01), this region comprises Macrozone F4- Northern Range, located in the northern part of the municipality and separated from the others by the Contas river divider, containing: the villages of Baetés, Cuiúdos, Mata Grande, Matinha, Piracanga, Pontal, Socó, Tijuípe, Vinhático and Volta do Poço.

This Complex is considered an agroforestry conservation zone, composed of the *Cabruca* agrosystem and remnants of the Atlantic Forest. From the point of view of biodiversity conservation, there is a positive relationship between the *cabrucas* and the remaining forest fragments. This reinforces the need to maintain these systems through the dissemination of their importance and the political-financial incentive of governmental entities to favor the maintenance of combined areas of *cabruca* and forest. With this, significant opportunities for food security can be created with the offer of multiple products and services, also favoring the inflow of additional income for peasant families.

2.2 Species collection and identification

The collection of botanical materials was carried out with the social actors, at the time of the workshops. The species that needed to be collected for better identification were herborized according to the techniques described by Mori et al. (1989) and incorporated into the Herbarium. All were photographed for the preparation of identification materials. The identifications were carried out with the help of specific bibliographies, comparison with previously identified specimens, with the support of specialists and botanical knowledge of the author of the research.

For the selection of species, the ethno-directed approach was used, which consists of an indication based on the knowledge expressed by local social actors. To contribute to the enrichment of the number of species, the chemotaxonomic or phylogenetic approach was also used,

consisting in the selection of species from a family or genus (Albuquerque & Hanazaki, 2006), for which there is some knowledge of use in food.

2.3 Gastronomic workshops

The workshops were held at partner farms that showed interest. After conversations with the peasant community to identify possible species already used in food, a walk was carried out in the area to harvest the plants previously indicated, as well as edible species that are known to the researcher.

The preparation of the dishes was carried out with the participation of all local members, seeking at times to use ingredients and condiments that the community usually uses in the daily preparation of their food. On other occasions, plants that were already known, but little used in food, gained new forms of preparation that positively surprised the expectations of the participants.

III. RESULTS AND DISCUSSION

The concern with quality food and the price of food has contributed to increasing the population's interest in the search for alternatives linked to more sustainable production, and consequently linked to the preservation of biological and cultural diversity (Rufino, 2008; Chaves, 2016; Polesi, 2016; Jardim et al., 2019). One of the allies in the contribution of this more sustainable alternative is agroecology, which has a proposal for rural development, maintaining a high level of biodiversity and strengthening mechanisms for food distribution, a condition that favors producers and consumers to reassume their decision-making power and control over food (Brasil, 2006, 2010; Burity, 2010; Filho, 2015). In this search for development, be it local, regional or territorial, considering the term sustainable, food assumes a leading role in achieving social, environmental, territorial, cultural and political sustainability.

For Morgan and Soninno (2010) the agri-food sector acquires a unique status in sustainable development for the simple fact that food is essential for everyone and food raises a series of questions, which constitute the center of debates related to sustainability, such as , public health, social inclusion, consumption pattern and environmental implications. In other words, food in the most different ways is a determining factor in the individual and collective commitment to achieving sustainable development.
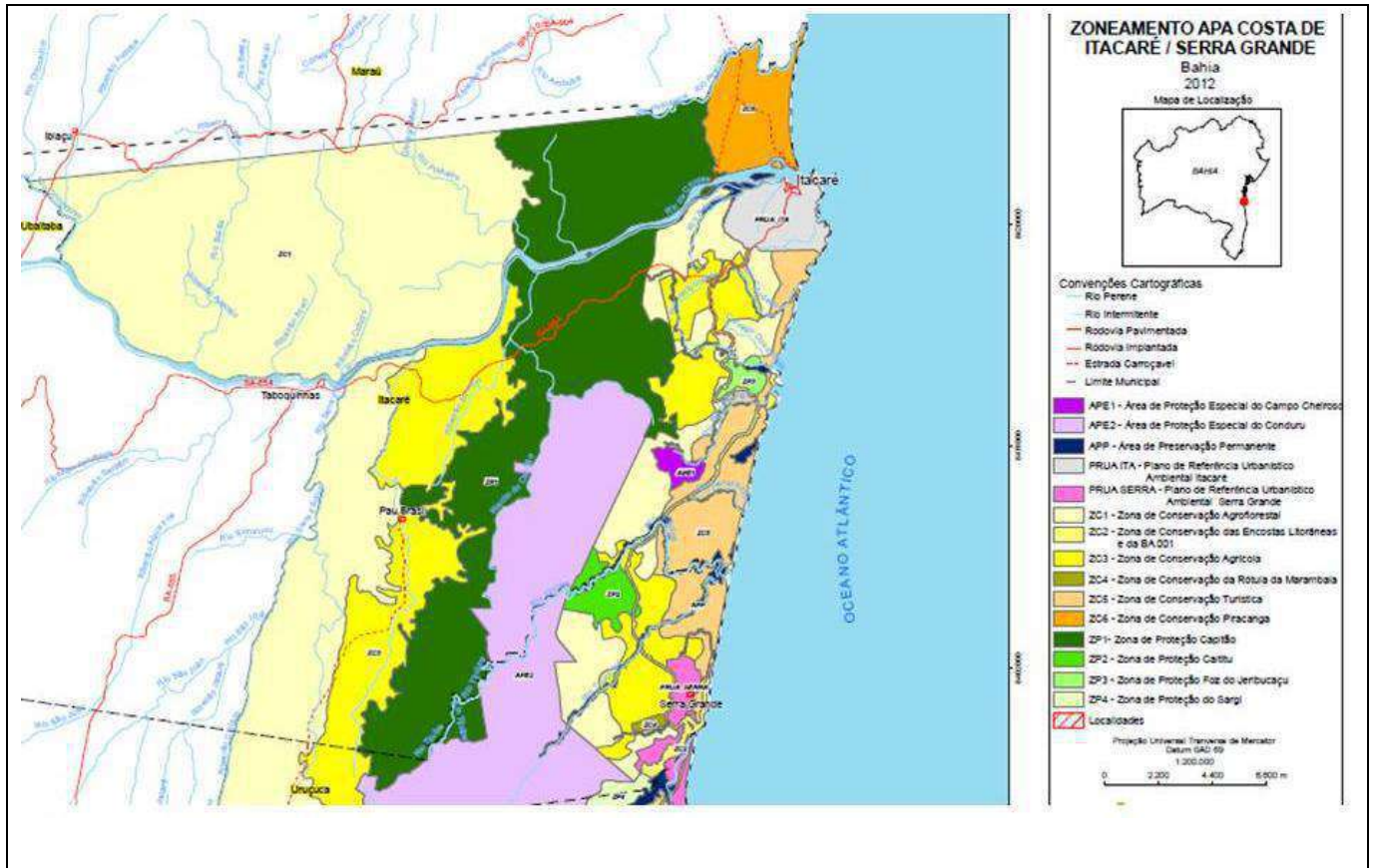
Fig. 01: Map of the ZONEING APA COSTA DE ITACARÉ / SERRA GRANDE Bahia-BR (Master Plan of the municipality of Itacaré LEI 271/2014), where the Serra do Vinhático Ecological Complex is located.

Source: CEPRAM Resolution No. 3503 of September 30, 2005 Municipal Limits

In this perspective, Bezerra and Schneider (2012) emphasize that the dynamics of the hegemonic agri-food system has an impact on the production and consumption model, bringing with it significant risks and losses. Both with regard to the health and quality of food, considering the aspects of reducing nutrients and contamination by pesticides, as well as in the social and cultural dimension of food, causing a profound reduction in the consumption of food, culturally used and produced locally or regionally, thus decharacterizing the traditional consumption of a people (Bezerra; Schneider, 2012). In addition, these processes affect food diversity and the right of each person or group to exercise free choice about what to consume and also to produce (Braga, 2004).

It is necessary to observe the agri-food chain in which we are inserted and the practice of (un)sustainable development. Although we have laws that define what would be ideal when we talk about food as a basis for human dignity and equity, observing the concept of Food and Nutrition Security (FNS), according to Law No. 11.346, of September 15, 2006, it considers that:

> *"Art. 3° ... consiste na realização do direito de todos ao acesso regular e permanente a alimentos de qualidade, em quantidade suficiente, sem comprometer o acesso a outras necessidades essenciais, tendo como base práticas alimentares promotoras de saúde que respeitem a diversidade cultural e que sejam ambiental, cultural, econômica e socialmente sustentáveis"* (Brasil, 2006).

Fig. 02: A-B: A - Some species found in Cabruca (*Carica papaya* L.; *Manihot esculenta* Crantz; *Artocarpus heterophyllus* Lam.; *Elaeis guineensis* Jacq.; *Musa paradisiaco* L.), B - Dishes prepared in a workshop with the plant species in the fig. (A). Photos: A: Jardim, J.; B: Jardim, A.

Fig. 03: A-B: *Taraxacum officinale* F.H. Wigg. (Dandelion); B: Dandelion with guandu bean (*Cajanus cajan* (L.) Huth) and dried meat. C-D: *Piper umbellatum L.* (Capeba); D: Capeba cigar. E-F: (vegetable sponge); F: sponge with cheese sauce. G-H: *Urera baccifera* (L.) Gaudich. ex Wedd. (urtiga); H: Rice cake. I-J: *Eugenia stipitata* McVaugh (Araçá-boi); J: Araçá-boi mousse pie. K-L: *Talinum triangulare* (Jacq.) Willd. (Beldroega); K: Shrimp moqueca with beldroega. M-N *Carica papaya* L. (Papaya); N: Noodles with *Macrocybe titans* mushroom and papaya pith. O-P: *Xanthosoma taioba* E.G.Gonç. (taioba); O: Taioba risotto. Photos: Jardim, A.

Following this FNS approach, we can say that the agri-food chain will still have to undergo major changes to guarantee the Human Right to Adequate Food (HRAF), which will be directly linked to quantity, quality and regularity. As well as changes to meet what we call Food Sovereignty, which seeks to rescue and preserve the food culture of the people and the sustainability of the agri-food system; intersectoriality; equity and social participation (Triches; Gerhart and Schneider, 2014). Faced with the challenges to build the Food Sovereignty of the people, or even the FNS, as HRAF, many realities, even in Brazil, which has food biodiversity and in many other parts of the world, are of Nutritional Food Insecurity. In the search for viable and inexpensive alternatives, related to improving the situation of Food and Nutrition Insecurity (ISAN) of peasant families, the increase in the consumption of local plant diversity in food, such as the PANC, can be an affordable option that would value the inheritances food (Jardim et al., 2020).

The PANC are standing out as a strong ally to ensure Food and Nutrition Security and Sovereignty, as it is an alternative that has low cost, is often linked to food heritage and traditional knowledge, in addition to many having a high nutritional level that can replace plant species. (Fig. 02), we present several plants and dishes that were prepared in workshops in communities that are part of the *cabruca* system (Fig. 03).

In the complex and diverse Agroforestry System that *Cabruca* takes over, different plant species, in addition to cocoa, share the space and fulfill their functions in the system. Among ornamental, arboreal, medicinal, condiment, and various plants that can be used in food, which have their potential little used (Jardim et al., 2019).

In addition to analyzing which plants already had knowledge of their potential for use in food, we observed which were the main foods that served as a basis for this population's diet. One of the results is that in most peasant families in this region the food base is composed of rice, beans, manioc flour and jerked meat (salted and dried beef), with or without vegetables. A fact that had also been observed by Castro (1965), in one of his books called *Geografia da fome* (geography of hunger), where he reports the situation of hunger in Brazil and mentions that there is a similarity in the nutritional deficiency of the population of the semi-arid region of northeastern Brazil and that of the Southern Bahia (humid region), both are based on the same foods.

One of the possible links between the report by Josué de Castro in 1965 and the situation still observed by the authors of this article, may be linked to the origin of the eating habits of the formation of this population, who work on cocoa farms in that region. As the south of Bahia received many people from the semi-arid region of northeastern Brazil, who migrated in search of improvements in the quality of life, as this region was considered very rich due to the status that cocoa plantation gave it, and consequently they brought their eating habits, which is predominantly observed to this day.

IV.   CONCLUDING REMARKS

In this sense, it should be noted that the food plant species found in *Cabruca* is a cultural heritage and is configured as a strategy to guarantee the situation of food and nutritional security, having the potential to help families improve their food and nutrition conditions of family income. One of the functions of this Agroforestry System is to be reservoirs of biodiversity in communities. Another relevant aspect that can be incorporated into this production system are agroecological practices, which seek a more sustainable model for the generation of safe food, enriching the food of producing families, in addition to subsidizing actions by the local Government and Public Policies.

In this way, the diversity of food plant species, as well as the preservation of food culture and natural resources, can supply and supplement, even if in part, the daily subsistence needs in most households of the peasant population, collaborating to improve the quality of food for these families. Therefore the search for more alternatives contributing to the guarantee of Food and Nutrition Security through independence in relation to the production and consumption of food, preservation of food and productive culture and maintenance of agrobiodiversity in these spaces.

REFERENCES

[1] Albuquerque, U. P.; Hanazak, N. (2006). As pesquisas etnodirigidas na descoberta de novos fármacos de interesse médico e farmacêutico: fragilidade e perspectivas. *Revista Brasileira de Farmacognosia*. 16(Supl.), p. 678-689.

[2] Altieri, M. A. (2016). Os quelites: Usos, manejo e Efeitos ecológicos na agricultura camponesa. *Agriculturas*. v.13, n.2, p. 30-33.

[3] Bezerra, I. ; Schneider, S. (2012). Produção e consumo de alimentos: o papel das políticas públicas na relação entre o plantar e o comer. *Revista Faz Ciência*, v.14, n.20, pp.35-61.

[4] BFG - The Brazil Flora Group. Brazilian Flora (2020): Innovation and collaboration to meet Target 1 of the Global Strategy for Plant Conservation (GSPC). *Rodriguésia.* 69, n.4, p. 1513–1527, 2018. DOI: 10.1590/2175-7860201869402

[5] Braga, V. (2004). Cultura Alimentar: contribuições da antropologia da alimentação**.** *Saúde em Revista*, Piracicaba, v.6, n.13.

[6] Brasil. Ministério da Agricultura, Pecuária e Abastecimento. (2010). *Hortaliças não convencionais (tradicionais)* MAPA. Secretaria de Desenvolvimento Agropecuário e Cooperativismo. Brasília: MAPA/ACS, p. 52.

[7] Brasil. Lei 11.346/2006 de 15 de setembro (2006). Cria o Sistema Nacional de Segurança Alimentar e Nutricional - SISAN. *Diário Oficial da União*, Seção 1, Brasília, DF, 18 set 2006. Disponível em: <http://www.planalto.gov.br/ccivil_03/_ato2004-2006/2006/lei/l11346.htm>. Acesso em 20/06/2019.

[8] Brack, P. (2016). Plantas alimentícias não convencionais. *Agriculturas.* v. 13, n.2, p. 4-6.

[9] Burity, Váleria *et al*. (2010). .Direito humano à alimentação adequada no contexto da segurança alimentar e nutricional. Brasília. *ABRANDH*, p. 204.

[10] Castro. Josué de. (1965). *Geopolítica da fome*: ensaio sobre os problemas de alimentação e de população. São Paulo: Brasiliense.

[11] Chaves, Mariane Sousa. (2016). *Plantas Alimentícias Não Convencionais em comunidades ribeirinhas na AMAZÔNIA.* Dissertação (Mestrado em Agroecologia) - Universidade Federal de Viçosa, Viçosa.

[12] Filho, G. X. P. (2015) Agroecologia e recursos alimentares não convencionais: contribuições ao fortalecimento da soberania alimentar e nutricional. *Campo-Território*: revista de geografia agrária, v. 10, n. 20 p. 227-245.

[13] Fioravanti, C. (2016). A maior diversidade de plantas do mundo. *Pesquisa FAPESP*. n. 241, p. 42-47.

[14] Jardim, A. Q. B. dos S., Jardim, J. G., Paixão, J. L. da, & Costa, L. C. do B. (2019). Plantas Alimentícias Não Convencionais (PANC) associadas ao agrossistema cacau-cabruca no sul da Bahia. In E. Gross & T. G. Viana (Orgs.), *Guia de Manejo do Agroecossistema Cacau Cabruca* (2ª edição, p. 118–132).

[15] Jardim, A. Q. B. S.; SILVA, J. N. & ALVES, A. G. C. A. (2020). Quintais produtivos e o cultivo de PANC como fonte de alimentação para as famílias da região semiárida em Pernambuco, Brasil. *In:* – *Agroecologia e Territórios: imersões, sujeitos, experiências e caminhos para o desenvolvimento territorial* / Ana Maria Dubeux Gervais... [et al.], organizadores – Recife: EDUFRPE.2020. 383p. (Série Diálogos interdisciplinares agroecologia e territórios: V.1) 339-356. Disponível: https://ppgadt.univasf.edu.br/wp-content/uploads/2021/05/Dialogo-Interdiciplinar-v1-compactado-1.pdf

[16] Kinupp, V. F. (2007). *Plantas Alimentícias não convencionais da região metropolitana de Porto Alegre, RS.* 2007. Tese (Doutorado em Fitotecnia) - Universidade Federal de Rio Grande do Sul, Porto Alegre, RS.

[17] Kinupp, V. F.; Lorenzi, H. (2014). *Plantas Alimentícias Não Convencionais (PANC) no Brasil:* guia de identificação, aspectos nutricionais e receitas ilustradas. São Paulo. Instituto Plantarum de Estudos da Flora, p. 768.

[18] Köhler, M. & Brack, P. **(**2016**).** Frutas nativas no Rio Grande do Sul: cultivando e valorizando a diversidade. *Agriculturas*. vol. 13, n.2, p. 7-15.

[19] Morgan, K; Soninno, R. (2010). Repensando a Alimentação Escolar: O Poder do Prato Público. In: The Worldwatch Iinstiitute. *Estado do Mundo*: Transformando culturas do consumismo a sustentabilidade. Washington: WWI/UMA, p. 298.

[20] Mori, S. A. *et al*. (1989). *Manual de Manejo do Herbário fanerogâmico.* 2ª ed. Itabuna. Centro de Pesquisas do Cacau. CEPLAC.

[21] Polesi, R. G. (2016). *Agrobiodiversidade e Segurança Alimentar no Vale do Taquari: plantas alimentícias não convencionais e frutas nativas.* Monografia (Especialização em Gestão da Qualidade no Processamento de Alimentos) - Unidade de Encantado, Universidade Estadual do Rio Grande do Sul, Encantado.

[22] Rufino, M. S. M. (2008). *Propriedades funcionais de frutas tropicais brasileiras não tradicionais..* Tese (Doutorado em Agronomia) - Universidade Federal do Semiárido. Mossoró,

[23] Sambuichi, R. H. R. (2003). *Ecologia da vegetação arbórea de cabruca - Mata Atlântica raleada utilizada para cultivo de cacau - na região sul da Bahia*. Tese de Doutorado - Universidade de Brasília.

[24] Silva, A. T. R. (2015). A conservação da biodiversidade entre os saberes da tradição e a ciência. *Estudos avançados,* v.29, n.83, p. 233-259.

[25] Triches, R. M.; Gerhardt, T. E.; Schneider, S. (2014).. Políticas alimentares: interações entre saúde, consumo e produção de alimentos. *Interações,* Campo Grande, v. 15, n. 1, jan./jun. p. 109- 120.

Animals as subjects of dignity in the Brazilian Law

Renata Marafon[1], Roberto Miyashiro Junior[2], Priscila E. A. Vasconcelos[3]

[1]Master's student in Law and Sustainable Development at Unifacvest, public servant at the Federal Institute of Santa Catarina; email renatamarafon27@gmail.com

[2] Master's student in Law and Sustainable Development at Unifacvest, public servant at public servant at the Federal Technological University of Paraná; email robertojunior86@gmail.com

[3] Adjunct Professor at Federal University of Roraima – CCJ UFRR; Post-Doctorate in Cities Law (UERJ); Doctor in Law (UVA); Master in Agribusiness (UFGD); Specialist in Environment (COPPE UFRJ) and Public and Private Law (EMERJ ESA); Researcher at GGINNS - Global Comparative Law: Governance, Innovation and Sustainability; Teacher and Lawyer.

Abstract— It is easy to see how animals have been treated over the years by humans, like property, without rationality, objects. Most recently studies have showed that is not true, on contrary, the simpler way, they are able to have some sensibility, or, sensitive animals, and the last years, the law are bringing these concepts to their rules, including giving decisions in animals favor. Other countries' Constitutions, Brazilian own rules and decisions, are going along this news, and this will be the main purpose of this study, using the deductive method and bibliographical research, how the history of dignity has been changing over the years, considering animals as subjects; and about specific objectives, a few studies of dignity; how animals are saw by the law and finally, how come justice are changing its way to see them

I. INTRODUCTION

For so many years, as long the human evolution, animals have been saw as way of production, food, property devoid feelings, pain and dignity. Corroborating this rule, it is possible to see how they are been used for all these years, always saw like objects by the law, philosophy and others subjects.

In philosophy studies, at the beginning, animals just are useful to comply with humans needs and at time of Schopenhauer lectures, for example, they achieved a status higher, as compassion objects.

Most recently, in the law, this scene has also been changing, with animals achieving another status, sentient being. United Nations Educational, Scientific and Cultural Organization (UNESCO), at 1978 approved the Universal Declaration of Animal Rights (DUDA); and in the national rights, Brazilian Constitution prescribed the article 225 which preserves the environment, 9.605/98 Law where mistreatment is punished, as the other decisions made by

the Justice that give rights to animals and also include them as part of family.

Using the deductive method and bibliographical research, this will be the main goal of the study, how the history of dignity has been changing over the years, considering animals as subjects; and about specific objectives, a few studies of dignity; how animals are saw by the law and finally, how come justice are changing its way to see them.

II. A LITTLE OF DIGNITY

For beginning, it's inevitable don't write of Brazilian Constitution which in its first article ever mention dignity: "Art. 1 The Federative Republic of Brazil, formed by the indissoluble union of States and Municipalities and the Federal District, constitutes a Democratic State of Law and has as its foundations: […] III - the dignity of the human person […] (our translation)

Belchior (2021) mentions that human dignity promotion is a law provided at first article of Universal Declaration of Human Rights and at 5° article of American Convention of Human Rights, where it's watched human dignity ought to be assured because it's essential to anyone, including all the degrading treatment, hate discrimination referred to nationality, political option, ethical origin, sexual option and creed, for example.

In the history concept, dignity at ancient times was known at Rome, where just was considered worthy who had a prominent place in society. Pires and Pozzoli (2020) mention "the subject of absolute value it was not the community or class, but the personal human being, although existential and socially in community and the class" (p. 2)

The main characters of dignity at historical and philosophical scene are Zenon, Aristotle and Cicero.

Zenon has lived in ancient Greece at final of IV B.C century and his contribution to dignity was the development of human being moral unity to all. For him, as Zeus sons, the dignity means for having laws innate and equals, putting the human being above everything in the universe. He was the father of stoicism. (PIRES and POZZOLI, 2020)

Aristotle, in turn, says the human being is a social being and rational for nature, which means he was a defender of laws and nature in a superior way. The mental ideas appear in Creon and Antigone, where emerge as a doctrinarian elaboration of natural law. (PIRES AND POZZOLI 2020)

Cicero, the last one, it is told he is a character of stoic thought to comprehend and understand dignity in a large way of the equitable sense of dignity in all human beings. It's also told that was about his thoughts, Saint Thomas Aquinas, in the Middle age wrote of *dignitas humanas* the first time. (SARLET, 1998). The dignity is rational, as a result of a personal investment for letting lead by reason or faith. The recognition of well turns into action, on this account a life of failure is the lack of knowledge and discernment. (FREDES, 2014)

Hegel in a most recently history, in his studies about Philosophy of Law, tells the human being social capability of development, shared to a system which defines itself as Abstract Law, Morality and Ethic and in these structures are inserted the dignity and human autonomy that needs to be showed with reason and freedom to being understanding. (FREDES, 2014)

Manzone (2010) teaches the notion of social justice, as a main principle to the social institution is placed on concept the dignity is a social question, more than a private one, driving to a genuine moral solicitation about organized models over which the public life is structured. For him, social justice notices the human laws has a social base and individual, expressing the protection of these rights just be assured by a development social process what means, the political ordering has a moral function to exercise in this process.

Although the dignity principle could be noted it's ancient, as a positive right is recently. Just right after the Second World War and Universal Declaration of Human Rights at 1948, the human dignity started being recognized in the Constitution of so many countries. (SARLET, 2011 – BOOK)

It's important to know before the Declaration, just two documents contained mention to human rights, what are United States Independence Declaration of 1776 and Declaration of Human and Citizen's Rights, France, 1789, but the focus as the human rights, not the dignity specially.

Explaining how dignity has been viewed today:

> The dignity is an intangible value and an essential right of human person. In Saint Thomas Aquina saying (2004, p. 51) it is impossible meeting a definition to the concept of human person dignity, standing out the term dignity is something absolutely and belongs to essence. (ALVES, 2009, p. 31) (our translation)

In general, creeds had been given support along history to ideas of nature appropriation and unbalance between human being and non-human being. Christianism, for example, always had a real division between humans and all other creatures which lasts today, especially after Industry Revolution, when nature lost it sacre appearance toward man.(CHALFUN; GOMES, W.Y)

In Brazil, you could notice it when the country was a Colony from Portugal, where its territory had been explored: animals, forests, gold, ground, everything that could be explored, was explored. (CHALFUN; GOMES, W.Y).

III. ANIMALS IN THE LAW

In a legal aspect, the United Nations Educational, Scientific and Cultural Organization (UNESCO) prescribed in 1978 the recognizing to all living being the value of life, dignity respect and integrity:

The Universal Declaration of Animal Rights (DUDA), approved by UNESCO (1978) enshrines a bundle of rights for animals: the right to life and existence (Article 1); the right to be respected, not to be exterminated or exploited

(Article 2) and the right to physical integrity (Article 3), the right of pet animals to a life span according to their natural longevity and not to be abandoned (Article 6), being the death of an animal without need (of course not the slaughter of animals) biocide, not as a reflection of the human being's duties towards animals, but listing them as subjects of rights.(COSTA; FERREIRA, 2018, p. 28)(our translation)

In Brazilian Constitution of 1988, the article 225 forbids cruelty acts against animals, and also Law n. 9.605/98 defines environmental crimes. In the civil law, animals are been saw as property. Let's see what tells each rule, beginning for Brazilian Constitution:

> Art. 225. Everyone has the right to an ecologically balanced environment, a good for common use by the people and essential to a healthy quality of life, imposing on the Public Power and the community the duty to defend and preserve it for those present and future generations.
>
> § 1 In order to ensure the effectiveness of this right, it is incumbent upon the Government:
>
> I - preserve and restore essential ecological processes and provide ecological management of species and ecosystems; (Regulation)
>
> […]
>
> IV - require, in accordance with the law, for the installation of a work or activity potentially causing significant degradation of the environment, a prior environmental impact study, which will be publicized; (Regulation)
>
> [..]
>
> VI - to promote environmental education at all levels of education and public awareness for the preservation of the environment;
>
> VII - protect the fauna and flora, prohibiting, in accordance with the law, practices that endanger their ecological function, cause the extinction of species or submit animals to cruelty. (Regulation)
>
> § 2º Anyone who explores mineral resources is obliged to recover the degraded environment, in accordance with a technical solution required by the competent public agency, in accordance with the law.
>
> § 3 The conduct and activities considered harmful to the environment will subject the offenders, natural or legal persons, to criminal and administrative sanctions, regardless of the obligation to repair the damage caused.
>
> [..]

> § 5º The vacant lands or lands collected by the States, for discriminatory actions, necessary for the protection of natural ecosystems, are unavailable.
>
> […]
>
> § 7 For the purposes of the final part of item VII of § 1 of this article, sports practices that use animals are not considered cruel, provided they are cultural manifestations, pursuant to § 1 of art. 215 of this Federal Constitution, registered as an immaterial asset that is part of the Brazilian cultural heritage, and must be regulated by a specific law that ensures the welfare of the animals involved. (our translation)

The following rules could been saw in 9.605/98 Law:

> Crimes against Fauna
>
> Art. 29. Killing, chasing, hunting, capturing, using specimens of wild fauna, native or on a migratory route, without the proper permission, license or authorization of the competent authority, or in disagreement with the obtained:
>
> Penalty - imprisonment from six months to one year, and fine.
>
> § 1 Incurs the same penalties:
>
> I - who prevents the procreation of fauna, without a license, authorization or in disagreement with the one obtained;
>
> II - whoever modifies, damages or destroys a nest, shelter or natural breeding;
>
> III - whoever sells, exposes for sale, exports or acquires, keeps, keeps in captivity or deposits, uses or transports eggs, larvae or specimens of wild fauna, native or on a migratory route, as well as products and objects originating therefrom, from breeding sites unauthorized or without proper permission, license or authorization from the competent authority.
>
> § 2 In the case of domestic guards of a wild species not considered threatened with extinction, the judge may, considering the circumstances, fail to apply the penalty.
>
> § 3° Specimens of wild fauna are all those belonging to native, migratory and any other species, aquatic or terrestrial, which have all or part of their life cycle occurring within the limits of Brazilian territory, or Brazilian jurisdictional waters.

§ 4 The penalty is increased by half, if the crime is committed:

I - against a rare or endangered species, even if only in the place of infringement;

II - during a period prohibited to hunting;

III - during the night;

IV - with abuse of license;

V - in a conservation unit;

VI - using methods or instruments capable of causing mass destruction.

§ 5 The penalty is increased up to three times, if the crime results from the exercise of professional hunting.

§ 6 The provisions of this article do not apply to fishing acts.

Art. 30. Exporting raw skins and hides of amphibians and reptiles abroad, without the authorization of the competent environmental authority:

Penalty - imprisonment, from one to three years, and fine.

Art. 31. To introduce an animal specimen into the country, without a favorable official technical opinion and a license issued by a competent authority:

Penalty - imprisonment, from three months to one year, and fine.

Art. 32. Practicing an act of abuse, ill-treatment, injuring or mutilating wild, domestic or domesticated animals, native or exotic:

Penalty - imprisonment, from three months to one year, and fine.

§ 1 The same penalties apply to those who carry out a painful or cruel experience on a live animal, even for didactic or scientific purposes, when there are alternative resources.

§ 1-A In the case of a dog or cat, the penalty for the conduct described in the caput of this article will be imprisonment, from 2 (two) to 5 (five) years, fine and prohibition of custody.

§ 2 The penalty is increased from one sixth to one third, if the animal is killed.

Art. 33. Cause, through the emission of effluents or the carrying of materials, the perishing of specimens of aquatic fauna existing in rivers, lakes, dams, lagoons, bays or Brazilian jurisdictional waters:

Penalty - imprisonment, from one to three years, or fine, or both cumulatively.

Single paragraph. Incurs the same penalties:

I - who causes degradation in public domain aquaculture nurseries, dams or stations;

II - anyone who explores natural fields of aquatic invertebrates and algae, without a license, permission or authorization from the competent authority;

III - whoever anchors vessels or throws debris of any nature on mollusc or coral banks, duly demarcated on a nautical chart.

Art. 34. Fishing during a period in which fishing is prohibited or in places prohibited by a competent body:

Penalty - imprisonment from one year to three years or a fine, or both cumulatively.

Single paragraph. Those who:

I - fish species that must be preserved or specimens with sizes smaller than those allowed;

II - fishes in quantities greater than those allowed, or through the use of devices, gear, techniques and methods that are not allowed;

III - transports, sells, benefits or industrializes specimens from prohibited collection, harvesting and fishing.

Art. 35. Fishing through the use of:

I - explosives or substances that, in contact with water, produce a similar effect;

II - toxic substances, or other means prohibited by the competent authority:

Penalty - imprisonment from one year to five years.

Art. 36. For the purposes of this Law, fishing is considered to be any act that tends to withdraw, extract, collect, catch, seize or capture specimens from groups of fish, crustaceans, molluscs and hydrobic vegetables, susceptible or not of economic use, except the endangered species, included in the official fauna and flora lists.

Art. 37. It is not a crime to slaughter an animal, when performed:

I - in a state of need, to satisfy the agent's or his family's hunger;

II - to protect crops, orchards and herds from the predatory or destructive action of animals,

provided that it is legally and expressly authorized by the competent authority;

III - (VETOED)

IV - because the animal is harmful, as long as it is characterized as such by the competent body.(our translation)

Oki and Pandeff (2016) discourse of the incongruity between article 29 § 1º, III, animals trade, penalty from six months to a year; and article 30, exporting skins and leathers of amphibians and reptiles abroad, penalty of three years confinement. The legislator put most several penalty to exporting of leather and skin than trade of own animal, giving animals less importance than an object made from it, demonstrating the missing of ethical and value analysis.

In Civil Law are still saw as objects, property:

Art. 936. The owner, or holder, of the animal will reimburse the damage caused by it, if it does not prove the victim's guilt or force majeure.

Art. 1,397. The offspring of the animals belong to the usufructuary, deducted how many are enough to fill the existing heads of cattle when the usufruct begins.

Article 1,445. The debtor may not dispose of the pledged animals without the creditor's prior written consent

Article 1,447. Machines, appliances, materials, instruments, installed and in operation, with or without accessories, may be pledged; animals, used in industry; salt and goods intended for the exploitation of salt pans;swine products, animals for the industrialization of meat and meat products;r aw materials and industrialized products.

Single paragraph. It is regulated by the provisions relating to general warehouses the pledge of goods deposited in them.(our translation)

Then, it's clear that Brazilian rules needs to get better as measure other countries are already doing the same, for example, considering animals a higher status than things: France, has changed their Civil Law 2015-177 at article 515, including the animal as sensible; Germany Law prescribes only corporeal objects are stuff, not animals which are protected by special rules. Portugal, in turn, claims specific behaviors against company animals are crimes. (COSTA; FERREIRA, 2018).

IV. ANIMALS AS SUBJECTS OF RIGHTS

Philosophers around the world have already criticized the relationship between humans and animals, giving just

to human beings the concept of being capability, despising non-humans which are considered instruments to human welfare. Pythagoras, Plutarch, Porphyry, Jeremy Bentham, Nietzsche, Tom Regan and Peter Singer and even Heidegger are some names who disagree with that in a different degree. (STRECK, 2013)

A really important philosopher who got started the studies about animals, Arthur Schopenhauer, in his book The World as Will and Representation in which had considered the Christian morality limited and obtuse by look on just human being. Nevertheless, the morality that is just convenient for the man it is not morality, because the real and pure genuineness morality doesn't look just at itself and its own specie. (ARIOCH, 2018)

Thinking In Based on Morality, Schopenhauer tends to emphasize a non-anthropocentric ethical approach, the beginning of an animal ethic. An investigation of good deed sense to conclude it is the deed of a disinterested person who doesn't look for own desires, not even aim to rewards for each deed, free from selfishness and vain pretensions. (BARBOSA, 2012)

In an International Vegetarian Congress occurred at 1957, it is told that Schopenhauer assigned that:

the unpardonable oblivion of non-human animals are relegated by European moralists were well known. They pretend animals doesn't have any rights. They believe and make the others believe the human behavior to animals has nothing to do with moral, the human being has nothing duties to animals. (ARIOCH, 2018, p. 4-5)(our translation)

Rousseau, in that time, also has already told in his book, Discourse of Inequality:

It appears, in fact, that if I am bound to do no injury to my fellow−creatures, this is less because they are rational than because they are sentient beings: and this quality, being common both to men and beasts, ought to entitle the latter at least to the privilege of not being wantonly ill−treated by the former (ROUSSEAU, 1754, n.p). (our translation)

The sentient is considered a prerequisite to be a subject of interests. In this way, if the interest is put in a sense of subjective right, the protection would be made for all the beings' sentient, including animals. (ANDRADE, ZANBAM, 2016)

In the XVIII century, Jeremy Bentham, known as an of utilitarianism modern creator urges how an animal is a creature that also feels the pain so deeply as a human being, despite their rationality and, this is the measure:

The day may come when the non-human part of the animal creation will acquire the rights that never

could have been withheld from them except by the hand of tyranny.

The French have already discovered that the blackness of the skin is no reason why a human being should be abandoned without redress to the whims of a tormentor. Perhaps it will someday be recognized that the number of legs, the hairiness of the skin, or the possession of a tail, are equally insufficient reasons for abandoning to the same fate a creature that can feel? What else could be used to draw the line? Is it the faculty of reason or the possession of language? But a full-grown horse or dog is incomparably more rational and conversable than an infant of a day, or a week, or even a month old. Even if that were not so, what difference would that make? The question is not can they reason? Or can they talk? But can they suffer? (BENTHAM, 1823, p. 143-144) (our translation)

According to Chalfun and Gomes (w.y), nowadays, everything tends to sense to consider them subjects of rights, as their rights are being insured by the *parquet* in so many civil public processes, and also, a lot of rules protecting them, not just a little part of environment. This insurance by the Brazilian law is increasing last years and are involving non-human lives, being a new root to be studied.

Most recently at philosophical scene, Gary L. Francione applies the Abolitionist Approach, presenting the schizophrenia moral theory that assumes forwards back to slavery human abolition since humanitarian treatment. To Francione, in spite of the recognizing by the humans that those non-humans have some moral value, these interests could be totally ignored: this is the idea of schizophrenia, when ethical treatment to those non-humans presents itself connected to speciesism notion. (CARDOSO; NUNES; TRINDADE, 2015)

In turn, Robert Garner mention that property condition of animals is not an obstacle to gradual banishment of exploratory, because animals does not have interest in not being treated like mobile stuff. Nevertheless, the non-humans are unable of having an individual autonomy individual what justify the prohibition for being used by humans, or, animals do not care about being used for human goals provided that don't suffer. To conclude, what he intends, is to implement a political about creating and institutionalized management of non-humans (CARDOSO; NUNES; TRINDADE, 2015).

In words from Conceição, Tonella and Tonella (2016), visible or not, animals, despite the fact they are not able to litigate in justice, the prosecutor represents them, so, they are subjects of rights and not private goods or diffuse at

men's hand. Having a worth life is not just a human right, but all being lives as carrier of a minimum existential conscious.

Streck (2013) mentions, for example, the Ecuador Constitution of 2008 evokes, in a brand-new preview, Nature Rights, beyond human species rules, the nature as subject, despite the fact Nature rights are not the same thing than animals' rights. Also, Bolivia Constitution walks on this way, changing paradigms.

Nowadays the rules are moving on to better, ensuring each more the animal right, including them, for example, at the discussions of keeping by the owners when is talked of separation, shared behavior and increasing the penalty for mistreatment. Most recently, a pet rabbit was assured to flight with his owner in a domestic flight where just allowed cats and dogs (O GLOBO, 2021) and even a horse is been represented by a lawyer against mistreatment to ancient owners (GAZETA DO POVO, 2021).

About the decision of the rabbit, the judge mentioned that demands to live animals were accomplished. Despite the fact the animal was not a dog or even a cat, this does not take off the domestic pet condition of it.

V.   CONCLUSION

Right after all presented, it's possible to conclude animals, instead ancient thoughts, are more than objects, are subjects, which science day by day tends to show they've feelings and pain.

Saint Thomas Aquinas wrote of *dignitas humanas* the first time in the Middle Age, but human dignity is a recent right guaranteed by the law, mainly after Second Word War, with Universal Declaration of Human Rights.

The dignity is rational, as a result of a personal investment for letting lead by reason or faith in words of Sarlet. But it's needed change way it's tought about dignity. It transposes human being and set other elements like nature and animals.

The UNESCO prescribed in 1978 the recognizing to all living being the value of life, dignity respect and integrity; Brazilian Constitution of 1988 asserts the article 225 forbids cruelty acts against animals, and also Law n. 9.605/98 defines environmental crimes. In civil rights, animals are been saw as property.

Philosophers around the world over time say animals have the right to be respected, they are sensitive and needed to be assured of their rights.

As mentioned before, despite the fact they are not able to litigate in justice, the prosecutor might represent them, so, they are subjects of rights and Brazilian Law is

improving itself in a way that now, it's already argued, for example, about shared guard and increasing the penalty for mistreatment, standing out they need to be protected from human hands.

A conclusion section must be included and should indicate clearly the advantages, limitations, and possible applications of the paper. Although a conclusion may review the main points of the paper, do not replicate the abstract as the conclusion. A conclusion might elaborate on the importance of the work or suggest applications and extensions.

REFERENCES

[1] ALVES, Rosa Maria Guimarães. O princípio da dignidade da pessoa humana. Colloquium Humanarum. ISSN: 1809-8207, 6(2), 28–37. Available in: https://journal.unoeste.br/index.php/ch/article/view/456 Accessed: Oct. 31 2021.

[2] ANDRADE, Fernanda; ZAMBAM, Neuro José. The condition of subject of law of human and non---human animals and the criteria of sentience. RBDA, Salvador, V. 11, N. 23, p. 143---171, Set-Dez 2016. Available in: https://periodicos.ufba.br/index.php/RBDA/article/view/203 73/12957 Accessed: Nov, 17, 2021.

[3] ARIOCH, David. Schopenhauer: animais não são artigos para o nosso uso. 2018. Available in : https://vegazeta.com.br/schopenhauer-sobre-os-animais/ Accessed: Oct. 31 2021

[4] BARBOSA, Jair. O acerto de Schopenhauer e a compaixão com os animais. Available in: https://emais.estadao.com.br/blogs/jair-barboza/o-acerto-de-schopenhauer-e-a-compaixao-canina/ Accessed: Oct. 31 2021

[5] BELCHIOR, Ygor Klain. Por uma história antiga que promova a Dignidade humana: um ensaio/provocação. v. 1 n. 21 (2021): Ensino de História: Antiga e Medieval Available in: https://ppg.revistas.uema.br/index.php/brathair/article/view/2500/1902 Accessed: Oct. 31 2021.

[6] BENTHAM, Jeremy. An Introduction to the Principles of Morals and Legislation. 1823. Available in: https://www.earlymoderntexts.com/assets/pdfs/bentham178 0.pdf Accessed: Nov. 31 2021

[7] CARDOSO, Waleska Mendes; NUNES, Lauren de Lacerda; TRINDADE, Gabriel Garmendia da. Rejeição do instrumentalismo animal: uma discussão a partir da abordagem abolicionista de Gary L. Francione e do protecionismo animal de Robert Garner. IV International Congress of Moral and Political Philosophy.UFPEL. 2015. Available in: http://cifmp.ufpel.edu.br/anais/2/cdrom/mesas/mesa10/04.pd f Accessed: Nov. 05 2021.

[8] CHALFUN, Mery; GOMES, Rosangela Mª. A. Direito dos animais: um novo e fundamental direito. Publica direito. Available in: http://www.publicadireito.com.br/conpedi/manaus/arquivos/ anais/salvador/mery_chalfun.pdf Accessed: Nov. 05. 2021

[9] CONCEIÇÃO, Eliezer de Oliveira da, TONELLA, Celene; TONELLA, Lívia Helena. Filosofia do direito ambiental: os animais enquanto sujeitos de direito. ACTIO REVISTA DE ESTUDOS JURÍDICOS (Faculdade Maringá) ISSN: 2447-0384 – VOL. I1, n. 26, (jul./dez.), 2016 Available in: http://www.actiorevista.com.br/index.php/actiorevista/articl e/view/31/57 Accessed: Nov. 08 2021

[10] COSTA, Deborah Regina Lambach Ferreira da; FERREIRA, Fabiano Montiani.O direito dos animais de companhia. Revista Brasileira de Direito Animal, e-issn: 2317-4552, Salvador, volume 13, número 02, p. 24-39, Mai-Ago 2018. Available in: https://periodicos.ufba.br/index.php/RBDA/article/download /27939/16590 Accessed: Nov. 08 2021.

[11] FREDES, Mariana Secani Lucas. A dignidade e a autonomia garantidas pelo Estado hegeliano. Available in: https://revistaseletronicas.pucrs.br/index.php/intuitio/article/ view/18765/12379 Accessed: oct. 31 2021

[12] GAZETA DO POVO. Égua "aciona" Justiça para poder viver em liberdade. 2021 Available in: https://www.gazetadopovo.com.br/vida-e-cidadania/breves/egua-aciona-justica-rj-viver-liberdade/ Accessed: Nov. 18, 2021.

[13] O GLOBO. Coelho de estimação é autorizado pela Justiça a viajar na cabine do avião. 2021 Available in: https://oglobo.globo.com/brasil/coelho-de-estimacao-autorizado-pela-justica-viajar-na-cabine-do-aviao-25213036 Accessed: Nov. 18, 2021.

[14] MANZONE, Gianni. A dignidade da pessoa humana na doutrina social da igreja. Translated by Geraldo Luiz Borges Hackmann. Teocomunicação, Porto Alegre, v. 40, n. 3, p. 289-306, set./dez. 2010. Available in: https://revistaseletronicas.pucrs.br/index.php/teo/article/vie w/8153/5840 Accessed: Oct. 31 2021.

[15] OKI, Vanessa Gonçalves; PANDEFF, Pando Angeloff. Análise da efetividade da lei de crimes ambientais e o tráfico de animais no Brasil. Ampliando, scientific magazine of Facerb, v. 3. n. 1. Jan./Jun.2016 Available in: https://web.archive.org/web/20180411174453id_/http://ww w.cnecrj.com.br/ojs/index.php/ampliando/article/viewFile/2 45/159 Accessed: Nov. 05 2021

[16] PIRES, Adão de Souza; POZZOLI, Lafayette. A dignidade da pessoa humana na história e no direito: aspectos de tempo e espaço. RJLB, Ano 6 (2020), nº 6 Available in: https://www.cidp.pt/revistas/rjlb/2020/6/2020_06_0001_003 4.pdf Accessed: Oct. 31 2021.

[17] ROSSEAU, Jean Jacques. Discourse on Inequality. 1754. e-book. Available in: https://aub.edu.lb/fas/cvsp/Documents/DiscourseonInequalit y.pdf879500092.pdf Accessed: Nov. 05, 2021.

[18] SARLET, Ingo Wolfgang. Dignidade da pessoa humana e direitos fundamentais na Constituição Federal de 1988**.** 9. ed. rev. atual. Porto Alegre: Livraria do Advogado, 2011.

[19] SARLET, Ingo Wolfgang. A dignidade da pessoa humana. Revista de Direito Administrativo, 1998 - maxwell.vrac.puc-

rio.br Available in: https://www.maxwell.vrac.puc-rio.br/13488/13488_3.PDF Accessed: Oct. 31 2021.

[20] STRECK, Lenio Luiz.Quem são esses cães e gatos que nos olham nus? Consultor Jurídico, 2013. Available in: https://www.conjur.com.br/2013-jun-06/senso-incomum-quem-sao-caes-gatos-olham-nus#_ftn5_2834 Accessed: Nov, 17, 2021.

Human Rights, Native Lands and Environmental Issues: The Demise of Mother Nature and of the Indigenous Peoples of Brazil

Marlei Angela Ribeiro dos Santos[1], Thais Janaina Wenczenovicz[2], Émelyn Linhares[3]

[1]Doctoral student in Law at the University of the West of Santa Catarina/UNOESC; Prosuc/Capes Scholarship in the Doctoral course; Master in Fundamental Rights. Member of the Citizenship and Human Rights Research Line/UNOESC. Graduated in Law-Faculties of Applied Social Sciences, /FACISA. Technologist in Environmental Management-Universidade Norte do Paraná, UNOPAR. Specialist in Public and Private Law: Material and Procedural-Universidade do Oeste de Santa Catarina/UNOESC.
Email: marlei.ange.adv@hotmail.com

[2]Adjunct professor/senior researcher at the State University of Rio Grande do Sul/UERGS. Full Professor at the Stricto Sensu Postgraduate Program in Law/UNOESC. Collaborating Professor at the Stricto Sensu Postgraduate Program in Education at the State University of Paraná - UNIOESTE. INEP Evaluator - BNI ENADE/MEC. Member of the International Committee Global Alliance on Media and Gender (GAMAG) - UNESCO. Leader of the Citizenship and Human Rights Research Line: decolonial perspectives/PPGD UNOESC.
Email: t.wencze@terra.com.br

[3]Student of the Interdisciplinary Master's in Human Sciences at UFFS, Erechim/RS campus. Scholarship holder of the Capes Social Demand Program, for the Interdisciplinary Postgraduate Program in Human Sciences – UFFS. Specialist in Public Law (Fundação Universidade Regional de Blumenau – FURB), in Criminal Law and Criminal Procedure (Faculdade Santa Rita). Bachelor of Laws (Facisa/Funoesc).
Email: emy_dr@outlook.com.br

Abstract— The aim of this paper is to analyze the historical trajectory of demarcations of Brazil's traditional lands, as well as the rights and emergent violence concerning this issue. The choice of this topic is justified by the constant violation of the demarcation rights of indigenous lands, the lag in administrative processes, or judicial decisions and bills that do not acknowledge or hamper these rights, as well as the effects of this oversight on the life and demise of indigenous peoples and on nature. The method used was bibliographical-investigative through the use of data from the Social-environmental Institute, the Indigenous Missionary Council, national and international court of laws and current legislation. First, a reflection on the identitary and personal construction of Amerindians is carried out; followed by an analysis of the development of colonialism in Brazil through its effect on traditional territories and peoples; and, finally, numbers and consequences regarding the life and demise of indigenous peoples and the environment are discussed. State negligence concerning the demarcation of these lands is confirmed, as well as the occurrence of violations and violence towards native peoples, along with scarce environmental protection. There is a need for the evolution and reconstruction of concepts and of the legal framework within a decolonial perspective, in order for the full-fledged recognition of indigenous peoples' rights to take place.

I.   INTRODUCTION

Taking the colonial and capitalist trajectory into consideration, and the emerging environmental and climate crisis seen in Brazil and around the world, it is important to recall the definition of the environment as the complex of domains, influences and physical, chemical and biological factors that allow, shelter and determine life in all its forms (art. 3, item I, Law no. 6938/81 – Brazil, 1981). Within this mindset, it is essential to understand the causes and origins for the demise of indigenous peoples in Brazil as a result of the destruction of the environment.

Brazilian society is known for its diversity and the contrast of its cultures and experiences. The concepts accepted by a part of the population regarding lifestyles, property, nature, death and borders are hegemonic. The composition of individuality and humanity is a result of several factors related to identity, culture, race and subjectivities. Within this context, there are factors that dictate the legitimacy to appoint the truth, rationality, knowledge, power and domination over communities. As clearly expressed in the Brazilian Constitution, life, property and an ecologically balanced environment are rights seen as the backbone of numerous international legal orders. Nevertheless, one can clearly see a contention in the fact that members of the Union are the exclusive interpreters of these rights, seeing individual rights according to the idea of equality, hence, not allowing differentiations according to race, color or gender. In other words, the possibility of difference is invalidated. Thus, the Brazilian Constitution, as well as most Brazilian juridical orders, is based on a classical liberal perspective, with the establishment of the State in a mono-juridical system.

The actions of Brazilian legal orders, as well as state practices, are part of a heritage of colonialism that has endured with coloniality, and these have repercussions in the mechanisms of subalternation of indigenous peoples, who have routinely experienced the violation of their rights and freedoms since colonial times, resulting in violent and discriminating narratives and episodes.

Hence, the aim here is to analyze the historical and legislative narrative of indigenous peoples and their right to land demarcation, as well as the connection between non-demarcation and the demise of numerous indigenous individuals (ethnocide) and the destruction of nature (ecocide). This article is divided into three parts: 1) Breaking away from Eurocentric ideology: building the Amerindian identity and being; 2) Colonialism and the "discovery" of Brazil: territories and indigenous peoples; 3) Death to the natives and death to nature: numbers and consequences.

The present text turns to Brazilian juridical orders, as well as national and international court interpretations. It is also based on decolonial theories taken from the Modernity/Coloniality group established in the 1990s under the direction of Anibal Quijano, Maldonado-Torres and Mignolo. The method used is bibliographical and investigative through statistics found in the Social-environmental Institute (Instituto Socioambiental – ISA), the Indigenous Missionary Council (Conselho Indigenista Missionario – CIMI), among others.

The question of non-demarcation of Indigenous land (Terras Indigenas – TI) and the effects of this negligence on the life and demise of indigenous peoples and on the environment are evident. Conflicts over land lead to violent actions against native peoples and the failure to respect their fundamental and human rights. These conflicts are instigated by a hegemonic culture based on European beliefs that have categorized race and class with the undeniable support of capitalism and patriarchy that continue to influence traditional communities, keeping them bound to inhospitable situations and invalidating their rights.

II.   BREAKING AWAY FROM EUROCENTRIC IDEOLOGY: BUILDING THE AMERINDIAN IDENTITY AND BEING

Although Brazil recognizes indigenous peoples and their right to live according to their "practices, customs and traditions" (Art. 231, §1º, CF/88 – BRAZIL/1988), which are different from those adopted by society in the rest of the nation, the very same policy allows for the dissolution of these communities and their rights. Indeed, the reality is that equality is associated to totality, the idea of "one and only nation", and does not include the notion of community, which is essential in understanding Amerindian logic, knowledge, memory and being, especially in terms of life, death, property and the environment/nature. In regard to building an individual's being and to the social body, Le Breton states that

The sociology of the body is a chapter within sociology particularly dedicated to understanding human corporality as a social and cultural phenomena, symbolic motive, the object of representations and the imaginary. It reminds us that the actions that weave the fabric of daily life, from the most trivial, or the least concrete, to those that take place in a public scenario, involve the mediation of corporality; if nothing else, it is through perceptive activity that man can develop at every instance and is able to see, hear, taste, feel and thus supply the world around him with precise meanings.

By reason of ideas regarding the development of meanings in the world that surrounds individuals, and based on the view of indigenous communities, it is imperative that we back away from modern representations and put an end to processes that aim at suppressing ambivalence, difference and multiplicity.[NT2] The construction of the indigenous being and identity goes beyond hegemonic and Europeanized perceptions because it is connected to external elements, the majority of which are not linked to human possessions but to a relation between people and other beings (nature, animals), including entities, the deceased, kin, friends, enemies and white people.

From the time one is born, living in community/society/with people calls for the acceptance of impositions and sanctions to cosmological impossibilities and practical decisions. The starting point is an idea of body, person, death and social dynamics. The relations found in structural systems are constituted by bodily references that generate identities. In these we find an abundance of exchanges, whether through blood or affects, in a continuous chain of knowledge and local teaching/learning[1].

The being is elaborated through the construction and development of learning what it means to be human. In this sense, the knowledge obtained regarding social life (being and acting necessarily according to rules) determines the nature of the consubstantiality of the defined being and, hence, kinship. Through ancestralism and the cosmology of the indigenous peoples, unions and entities are confirmed (through the earth or forest/nature), and this constitutes indigenous universes. In other words, it is the protagonism of the body that gives structure to the Amerindian. The foundation of the social worlds diversifies all beings, and this alterity shapes relations among kin, ethnicities, the earth and death.

By the same token, there is a constant relation among the living, the dead and the gods, which is the result of how the body is conceived as central to the world and the difference among beings and the relations they establish. With death, the fracture between the social world of the living is created, in other words, it is a transformation, a continuation of the processes in which the body flows. This is expressed with clarity by Viveiros de Castro:

One dies repeatedly during our lifetime – and we shall die numerous times in death. Dying is defined by all states in which there is a loss of "consciousness", with the inebriation from cauim […], states of shock produced by frights, illness or severe wounds and, finally, the temporary situation of homicide – in which, between death and decay, and until the dead enemy spirit revives it […] any victim of a violent bodily "transition" that extirpates a person from him/herself is "dead". […] this does not mean that there is a rush to bury those who are "dead" in this manner. Indeed, one of the most important human traits is that "we do not actually die" – even when we do. Actual death is merely one more violent situation, from a certain stance, among the many deaths and resurrections a person will be submitted to.

According to Amerindian ontologies, the notion and condition of being a person is not exclusive to humans. There are certain differentiations among relationships, i.e., an individual belongs to a community constituted by material and immaterial elements in which bodies have successive formations. Undoubtedly, Amerindian ideas on body and being are not the same as those held by western society, which are hegemonical. The civilizing and "evolutionary" stages that take us from primitiveness to modernity, also known as "progress", are different and removed from indigenous humanity and the advancement of the body, which are connected to kinship.

What are the boundaries between the human and the forest/environment/earth according to indigenous understanding? There are clear differences interpretations, concepts and perceptions between indigenous and non-indigenous peoples. Hence, what happens to indigenous people after death by homicide and suicide, and what their causes are (personal/intimate, social/collective) is detached from the hegemonic and biomedical idea which sees death as simply the end of biological life.

III.   COLONIALISM AND THE "DISCOVERY" OF BRAZIL: TERRITORIES AND INDIGENOUS PEOPLES

It is imperative that we address the historical and legislative narrative of the traditional peoples of Brazil by revisiting the year 1500, the period in which colonization and the process of personification of the State took place, brought about by colonialism, capitalism and patriarchy, and bolstered by coloniality. Before the "uncurtaining" of the country, the territory was inhabited by indigenous peoples. However, with European occupation, a hegemonic European ideology established the domains of an exploitative society, one in which indigenous identities and rights were eradicated. As a consequence, colonialism,

---

[NT2] Tradução livre de "ambivalências, das diferenças e aos múltiplos" (BAUMAN, 1999).

[1] "Ensinagem" in Portuguese. Term coined by Léa das Graças Camargos Anastasiou in 1994 to refer to a complex and critical social practice in education between teacher and student, "comprising both teaching and learning (ANASTASIOU; ALVES, 2004, p. 15) whether in the classroom or not.

through its power and the establishment of patterns of racial classification, bastardized certain types of knowledge and practices, specifying and differentiating oppressors and the oppressed (QUIJANO, 2005).

The colonial context was founded on violence and the exploitation of slave/indigenous land and labor, resulting in ethnocide and memoricide. These exploitations strengthened the concepts of social class, racial phenotype and brute power relations, all in association with colonial/modern capitalism. The ballast of capitalism was the worldwide standard consolidated by coloniality, which warrants and certifies social, racial, regional and gender classifications. These, in their turn, take shape in the scope of human existence by means of the family, culture, school/academia, work and the economy, which are carried out according to the social hierarchy imposed.

Thus, colonialism founded the territorial and social-political structure (bodies, identities and land as property) widely reproduced by means of coloniality today. As a reflex and a result, we witness violence and the violation of individual and collective rights, leading to cases of epistemicide, genocide and ethnocide. Likewise, capitalism has used Eurocentric knowledge (considered superior and the only rational possibility) to naturalize the violence against subaltern groups according to the powers that be.

As a result of the process of colonialism and capitalism, European laws were imposed upon Brazilian territories. Thus, Portuguese juridical law was established, as well as its ordinances and systems, all in alignment with its traditions, religion and language. This led to ethnic and territorial adversities and subsequent violence and the exclusion of several peoples from their lands. As for the legislation brought over to this country, its is relevant to refer to the 1824 Constitution, which, in article 179, guaranteed the inviolability of the civil and political rights of its citizens, based on liberty, individual safety and, especially, property (Brazil, 1824).

Another important Constitution was the 1934 version which, in article 129, recognized the land ownership of indigenous peoples, with special emphasis to the lands "where they are found", and making the divestiture of these territories by these peoples void (Brazil, 1934). Later, in 1973, the Statute of the Indian (Bill no. 6001/December 19) was issued, and native areas were divided among occupied lands, reservations (indigenous reserves, indigenous parks and indigenous agricultural colonies), indigenous federal territories, as well as lands under indigenous domain (Brazil, 1973). These laws and measures demonstrate in a perfunctory manner the lack of recognition of territorial property by native peoples, in

alignment with the indigenous policies of cleansing in colonization.

It was only with the proclamation of the 1988 Federal Constitution (CF/88) – known as the "Citizen's Constitution" - that the precepts of integration were discontinued (at least officially) and the lands traditionally occupied by native peoples were recognized, along with their practices, customs and traditions (Brazil, 1988). I would like to highlight that, in spite of this recognition, the constitutional text is clear when it states that indigenous territory is the property of the Union and hence native peoples can benefit from the land (article 231§ 2º, CF/88). Furthermore, CF/88 determines that the Union is responsible for marking off land (article 231), and gives indigenous peoples the assurance that they can take legal action to defend their rights and interests (article 232, Brazil, 1988).

Indigenous land in Brazil comprises 724 areas and occupies an extension of 290,046,250 acres (1,173,776 km^2), a total of 13.8% of the total of the country's area. Most of these are located in Legal Amazon (around 98.25%), while the rest (1.75%) are found in the northeastern, southeastern and southern regions, as well as in the states of Mato Grosso do Sul and Goiás (ISA, 2021a). Currently, indigenous lands can be classified as being a) in the process of identification/with restrictions upon non-native use (120 TIs); b) identified (44 TIs); c) designated (73 TIs); and d) reserve approved (487 TIs) (ISA, 2021b).

Undoubtedly, depending on the situation the abovementioned land is going through as to its ordinance and the (de)territorialization of indigenous communities, there are several effects for both indigenous and non-indigenous groups in national, international and worldwide terms, especially when the issue is environmental, not to mention the social, economic, cultural and health impacts concerned.

As important areas for the protection of a large share of global forest resources and, consequently, of the capacity to store over 293 gigatons of carbon, 1/3 of the TIs in 64 countries are under threat due to the absence of proper demarcation (Clara, 2018). Until 2016, changes caused by human action on the Earth's surface reached 95%. In face of this scenario, TIs are areas in which climatic balance is preserved, and respect for nature is upheld (LEPAN, 2020). Currently, Brazil has only 13.8% of the territory reserved for native peoples, the highest it has ever been in the last 35 years, in a total of less than 1% of deforestation in the country during this period (APIB,2021a). More data can be seen in the following:

In the last 36 years, the area for soy and sugar cane crops reached the same extension of the entire cropland formation in Brazil. Just as an example, soy crops represent an area equal to that of the state of Maranhão, while sugar cane occupies double the country's urbanized area. The main form of land occupation in Brazil is still forests: 59.7%. However, this percentage is mostly found in the Amazon region. In other words, with the exception of the Amazon region, what we see in the rest of the country is very different. In the Pampa, only 12.5% of the territory is forestland. Almost half is taken up by agriculture and cattle raising. In the Atlantic Forest, the area used for farming and cattle raising is even larger, amounting to 2/3 (66.7%) of the biome. The Cerrado (45%) and Caatinga (37.4%) comprise third and fourth places in aforementioned activities. In a more detailed analysis of land occupation and use in Brazil, the study shows that the 66.3% of native vegetation does not necessarily correspond to preserved areas. "A part of this native vegetation is already degraded or has been cleared or is in the process of regeneration […] On the other hand, the indigenous territories that have been marked off, or that are awaiting this process, are those that have most kept their original characteristics. Less than 1% of deforestation in Brazil between 1985 and 2020 took place on indigenous land.

In the last few years, severe climatic tragedies have taken place in Brazil due to deforestation, mining, fires, among others. For example, from 1985 to 2020, the average area burned annually comprised 370.66 acres (1.8% of the country's total area); among these, 83% occurred between July and October. In addition, 59% of river basins had a reduction in their water surface; the loss of water surface in the country was 7.6%. Furthermore, the following increases were observed: 600% in mining areas; 300% in mining inside conservation areas, in which 50% of the mining area is found inside preservation units and indigenous land (MAPBIOMAS, 2021).

Though many indigenous territories have been marked off, they are in a state of conflict/lawsuit, or legislative risk (in which a solution is still pending), while unconstitutional forms of disavowing the presence of traditional peoples in the country and, above all, in their own lands, where they have been before the very "discovery" of Brazil, are upheld. As examples of the obstacles to indigenous rights, we can refer to proposals for bills (projeto de lei – PL) that hinder and restrict specific indigenous rights, such as PL 490/07, which submits the demarcations of TIs to Congress (Congresso Nacional – CN), and addresses a time frame and reforms in how indigenous peoples may benefit from the land, with the installation of military bases, the expansion of highways and the possibility of tapping into energy sources. According to aforementioned bill, national defense and sovereignty take precedence over any indigenous benefits (CÂMARA DOS DEPUTADOS, 2021a).

In addition, PL 2633/2021, known as the "grilagem" (land grabbing) PL, has harmful consequences for indigenous peoples (CÂMARA DOS DEPUTADOS, 2021b). According to the interpretation of a lawyer form the Social Environmental Institute (ISA), this project manifests the "disposition of a parliamentary majority to legislate in favor of land grabbers and organized crime in the Amazon region", adding that the text "hands over property deeds to deforesters and invaders, without verifying if environmental damages caused were ever recovered. It is a blank check and an inducement to crime" (ISA, 2021c).

In order to analyze the legal aspects regarding these territories and their adequate demarcations, it is essential to verify the interpretations of national and international tribunals and courts concerning the demarcations of TIs and what their repercussions are. In the legal area, we should bring up the international disapproval of Brazil in 2018 by the Inter-American Court of Human Rights (IACHR) due to the disproportionate delay in marking off the Xucuru/PE indigenous land, which had begun in 1989. The Court ordered compensation be paid due to collective moral damages, and sentenced the country to comply to other measures as well (IACHR, 2018). As to national case laws, the situation that occurred in the north of the state of Santa Catarina is relevant. Natives of the Guarani tribe were kept in limbo due to governmental indecision regarding the demarcation of lands in Mbiguaçu, Corveta I and II, Rio do Meio, Garuva, Rio Bonito, Reta, Pindoty, Piraí and Tarumã. Studies of these occupations had begun in 1996 and, due to the delay, the Federal Public Ministry (federal prosecutors) decided to file a civil lawsuit demanding the expediency of the case. The preliminary injunction put forward was granted in 2002 and the lawsuit was judged to be undeniably justified in 2007 when it was established that the identification and demarcation of all Guarani land in the abovementioned towns should necessarily be carried out within 24 months, subject to daily fines. This decision was confirmed by the Federal Regional Court of the 4th Region, the Superior Court of Justice and the Supreme Court (MPF, 2019).[2]

---

[2] For more information, RESP 1114012/SC, Ministra Relatora Denise Arruda, 1° Turma do STJ, 11/10/2009. The decision in its entirety can be accessed at https://processo.stj.jus.br/processo/revista/documento/mediado/?c

As we can see from the examples mentioned, the demarcation and ownership of indigenous lands is one of the most important rights demanded by these peoples, and that have been breached by a part of the State. Indigenous land demarcation must be seen not only as a right of these communities, but also as an assurance, insofar as it implements the recognition of their identities, culture and knowledge. Moreover, it protects Brazilian society as a whole in that indigenous peoples care for the land, flora and fauna, hence abating climatic crises in the country and the world. It is tantamount that Federative Agencies carry out demarcations swiftly according to the law, assuring that these peoples be protected.

IV.   DEATH TO THE NATIVES AND DEATH TO NATURE: NUMBERS AND CONSEQUENCES

The impact that deforestation, mining and the non-demarcation of indigenous lands has had can be seen in the long trajectory of these peoples since colonization. Nevertheless, they remain unrecognized, their rights disregarded, and their identities despised, subjected to state negligence and to social decline, which daily affect their livelihood and experiences. Sonia Guajajara's words clearly express what the land means to native peoples: "We do not negotiate land rights because the earth, to us, is our life: Mother Earth. And you do not sell your mother, you do not negotiate. You have to take care of your mother, defend her and protect her" (MPF, 2019, p.69).

Indigenous movements have been seen on the news in the struggle different ethnicities and nationalities go through, protesting against deforestation, climate change and the illegal exploitation of natural resources and the violation of rights. An example of this type of struggle could be seen in the United Nations Climate Change Conference in Glasgow, Scotland (COP26) between October 31 and November 12, 2021 (ONUNEWS, 2021a). It must be noted that the indigenous movement represented the largest delegation of Brazilian indigenous leadership in the history of the climate conference, emphasizing the importance of indigenous land demarcation as one of the solutions given. Over 40 representatives of traditional peoples were represented in Glasgow, stressing the urgent need of territorial demarcation and the protection of peoples for the benefit of the planet's future (APIB, 2021b).

During the COP26, the Brazilian indigenous delegation denounced the indigenous genocide and ecocide taking place in Brazil, exacerbated by the Covid-19 pandemic and the indigenous policies adopted by the federal government (APIB, 2021b). The delegation also stated that

We shape and protect our biomes with the blood of millions of our kin. The genocide of native peoples, the oppression against those who defend our land, and its illegal confiscation are the largest and most widespread crimes that humanity has produced throughout history. It is a constant and ongoing crime which we denounce at every forum we can […] We are in Glasgow to, once again, warn the world, and, at this moment, with even greater significance: humanity is leading the fate of us all to chaos and death! Our Mother Earth is exhausted. The future of the planet and the species that inhabit it depend on our global capacity to cooperate in the defense and strengthening of indigenous peoples and local communities, to ensure the safety of traditional territories in face of predatory economic interests, and to create and promote effective climatic solutions with nature and the communities that protect it in mind.

Indigenous voices call out for climatic justice, stating that the management of these territories and fundamental regard to these peoples is the solution. It is important to remember that during the COP26, the Coordinating Body of Indigenous Organizations of the Amazon Basin (Coordenadoria das Organizações Indígenas da Bacia Amazônica - COICA) launched a campaign called "No consultation, no consent" with the aim of reviving and strengthening the right of native people to deliberate and approve in advance and with information in hand (COICA, 2019), in other words, with the purpose of creating a pluri-national constitutionalism.[3]

An issue that must be brought to the front is that the COP26 emphasized how women have taken the brunt of climate change, in other words, that it is not neutral in terms of gender since the burden of this emergency widens the inequalities faced by women. Of the people who are displaced due to climate change, 80% are women and girls. It is crucial to recognize that a real or potential female contribution will help the planet survive and develop in a sustainable form. In regard to this, the indigenous activist of the Wapixana people from Guyana stated that her activity is aimed at giving the women in her community more power to "break" with patriarchy. Casimero also pointed out that women are better leaders than men and that "all of humanity exists" because of them. (ONUNEWS, 2021b).

---

omponente=ITA&sequencial=927736&num_registro=20090082
5478&data=20091201&formato=PDF

---

[3] "Native people are a part of the construction of the State (in terms of the origin of power) and indigenous law is considered (with no juridical monism). There are also important mechanisms for direct democracy" (NUNES JÚNIOR, 2018, p. 96).

Indigenous peoples have long been observing climate change and how their rights are being violated. Nevertheless, they go on fighting for the preservation of forests. The Indigenous Amazon Agenda presents some solutions for a sustainable life, some of which are guided by the autonomy of native peoples; gender and generational equity; indigenous territories and their natural resources; legal systems pertaining to the peoples themselves; collective and individual rights; maintaining regional and worldwide significance; strengthening ancestral knowledge, as well as academic and scientific education, intercultural bilingual education, and virtual interactive education; an ancestral economy in production and commercialization; regional, national and international systems, technology and communication, among others (COICA, 2017).

When considering the evidence found in climate change caused by accumulation, the incorrect disposal of substances, land exploitation, and air and water pollution, it is unrealistic to expect any solutions from practices in a consumer, liquid society. Environmental and energy solutions can be found in the knowledge/experience of indigenous peoples, without prejudice or stigmas on the part of white society, as we have witnessed for centuries.

Technological debate and million-dollar solutions ignore and underestimate the indigenous agenda with its multiple factors and focus on human relations and the land. The enhancement of indigenous procedures and resources can ensure land protection, as seen in the Plans for Territorial and Environmental Management of Indigenous Lands (Planos de Gestão Territorial e Ambiental das Terras Indígenas - PGTA), an instrument that was collectively created by these communities in an attempt to follow through on pledges related to the land and the well-being of current and future generations (APIB, 2021a).

It is widely known that indigenous land has been the scope of a great number of disputes that began with the colonization of the country, and that there is structural and symbolic violence consolidated by the ideology of colonialism and coloniality. Added to this is the current problem of omission and delay in land regulation due to the conflicts concerning territorial rights, the invasions for ownership, the illegal exploitation of natural resources and a myriad of damages done to the land.

It is crucial the world, and especially the Brazilian population, understand that there is no solution for the planet unless it is grounded in reality. The Earth is undergoing a cycle of unbalance that causes not only environmental damage, but also harms humans, whether individually/personally or collectively, resulting in ecocides, ethnocides, homicides, suicides and

epistemicide. When nature is harmed, so are the keepers of the forests, and this is seen in the number of homicides and suicides among indigenous people. According to data from the Special Department for Indigenous Health (Secretaria Especial de Saúde Indígena – SESAI) 182 murders of indigenous people took place in 2020, an increase of around 61.06% from 2019. In addition, there were 110 indigenous suicides in 2020 (21 females and 89 males) (CIMI, 2021). Below are the Reports of Violence against Indigenous Peoples in Brazil (2020 data) listing the percentages:

Table 1 – Number of indigenous homicides per state from January to December 2020.

State	Number of homicides
Amazonas	41
Bahia	5
Ceará	15
Maranhão	1
Mato Grosso	1
Mato Grosso do Sul	34
Minas Gerais	1
Pará	4
Paraíba	2
Pernambuco	6
Paraná	1
Rondônia	2
Roraima	66
Santa Catarina	3
Total	**182**

Source: CIMI, 2021, p. 156.

Table 2 – Number of indigenous suicides per state from January to December 2020.

State	Deaths by self-inflicted wounds
Acre	1
Amazonas	42
Bahia	1
Ceará	2
Espírito Santo	1
Maranhão	2
Minas Gerais	2

Mato Grosso do Sul	28
Mato Grosso	1
Pará	1
Paraíba	2
Pernambuco	2
Paraná	3
Rio de Janeiro	1
Roraima	15
Santa Catarina	2
Tocantins	4
Total	**110**

Source: CIMI, 2021, p. 217.

The understanding of how murder and suicide are represented and what their personal and social causes are in the indigenous context is a qualitative dimension that is rarely researched despite its extreme relevance. Which of these deaths are masked as suicides? Which of them are actual suicides? Who is the perpetrator of indigenous suicide? These are some of the questions that need answers, especially in regard to the actions and reasons that cause these fatalities. Can an act that caused the death of a native individual by his own hand have been some other person's fault? In other words, the focus has leaned towards aspects of the biomedical classification system that differentiates homicide and suicide (the latter evidently referring to death by one's own hand), however, they are also associated to constitutive relations of indigenous being and the violence it undergoes.

Is death by homicide and suicide, according to an indigenous standpoint, the result of acts practiced by others? What is brought up here is an investigation of suicide as caused by a third party and not exclusively pertaining to the person who has died. This demands ethnographic studies on the social-cosmic systems of the native peoples. By understanding the processes of construction of indigenous being and kinship, as well as their context, relationship with the land, nature and natural resources, the reconstruction of suicide episodes can be carried out, associating these to conflicts (social and territorial) that permeate these communities within historical, social-cultural and intergenerational issues.

V.   CONCLUSION

As a final comment, it is fundamental that we recognize the processes of Brazil's occupation and settlement founded on colonialism and coloniality and thus analyze

the triad of this reflection: indigenous peoples, the environment and death. It is indispensable that we commit to laying down a decolonial path with the aim of accepting the approaches presented by native peoples who, historically, have been petitioning that their demands be heard. Therefore, one of the solutions is the reconstruction of concepts, arguments and formulas that unravel the categories established by colonialism, coloniality, capitalism and the patriarchy, breaking free from the obsoleteness of specific uses, wordings and actions that have so far been understood as scientific and accepted by the judicial world.

The fight against the worldwide and national crises concerning these peoples must be dealt with considering the broad diversity that comprises Brazilian society, governed by social, cultural, environmental, economic and ethnic-racial experiences. Maintaining coloniality, capitalism and other social marks of domination and power, and the non-recognition of traditional peoples and their rights, only leads to more ecocide, ethnocide, epistemicide and memoricide in relation to society and science.

It is key that the epistemological movement for the critical renewal of Juridical and Social Sciences in Latin America is encouraged, based on the postcolonial argument associated to the idea of a decolonial turn. The critique carried out in Latin American studies offers historical re-readings, bringing up ponderous old and new issues for the continent, defending the "decolonial option" in understanding a world characterized by coloniality at different levels in personal and collective life.

ACKNOWLEDGEMENTS

REFERENCES

[1] ANASTASIOU, L. G. C.; ALVES, L. P. (Org.). *Teaching processes at the university: assumptions for classroom work strategies*. 5. ed. Joinville, SC: UNIVILLE, 2005.

[2] APIB – Articulation of the Indigenous Peoples of Brazil. *Demarcation as a solution to the global climate crisis*. 2021a. Available in: https://apiboficial.org/cop26/. Access on: 10 Nov. 2021.

[3] APIB – Articulation of the Indigenous Peoples of Brazil. *Indigenous peoples attend COP26: "There is no solution to the climate crisis without us"*. 2021b. Available in: https://apiboficial.org/2021/10/29/povos-indigenas-vao-a-cop26-nao-ha-solucao-para-crise-climatica-sem-nos/. Access on: 11 Nov. 2021.

[4] BAUMAN, Zygmund. *Modernity and Ambivalence*. Rio de Janeiro: Jorge Zagar, 1999.

[5] BRAZIL. *Political Constitution of the Empire of Brazil*. Political Constitution of the Empire of Brazil, prepared by a Council of State and granted by Emperor D. Pedro I, on 03.25.1824. Rio de Janeiro: March, 1824. Available in: http://www.planalto.gov.br/ccivil_03/constituicao/constituicao24.htm. Access on: 10 Agu. 2021.

[6] BRAZIL. *Constitution of the Republic of the United States of Brazil*. Rio de Janeiro: July, 1934. Available in: http://www.planalto.gov.br/ccivil_03/constituicao/constituicao34.htm . Access on: 11 Agu. 2021.

[7] BRAZIL. *Law no. 6001, of December 19, 1973*. Provides for the Indigenous Statute. Brasília: Official Diary of the Union, 1973. Available in: http://www.planalto.gov.br/ccivil_03/leis/l6001.htm. Access on:11 Agu. 2021.

[8] BRAZIL. *Law no. 6,938, of August 31, 1981*. Provides for the National Environmental Policy, its purposes and mechanisms of formulation and application, and other provisions. Brasília: Official Diary of the Union, 31 Agu. 1981. Available in: http://www.planalto.gov.br/ccivil_03/leis/l6938.htm. Access on: 11 nov. 2021.

[9] BRAZIL. *Constitution of the Federative Republic of Brazil of 1988*. Brasília: Official Diary of the Union, 5 October, 1988. Available in:: http://www.planalto.gov.br/ccivil_03/leis/l6938.htm. Access on: 11 Agu. 2021.

[10] CÂMARA DOS DEPUTADOS. *Bill 490 of March 20, 2007. Amends Law n. 6001, of December 19, 1973, which provide for the Indigenous Statute*. Processing Information. Brasília, 2021a. Available in:: https://www.camara.leg.br/proposicoesWeb/fichadetramitacao?idProposicao=345311. Access on: 15 Agu. 2021.

[11] CÂMARA DOS DEPUTADOS. *Bill 2633/2020*. Processing Information, Brasília, 2021b. Available in:: https://www.camara.leg.br/proposicoesWeb/fichadetramitacao?idProposicao=2252589. Access on: 15 Agu. 2021.

[12] CIMI. Report Violence Against Indigenous Peoples in Brazil: 2020 data. RANGEL, Lucia Helena (Coord.) 2021. Available in: https://cimi.org.br/wp-content/uploads/2021/11/relatorio-violencia-povos-indigenas-2020-cimi.pdf. Access on: 11 Nov. 2021.

[13] CLARA. *Missing Pathways to 1.5ºC: the role of the land sector in ambitious climate action*. October, 2018. Available in: https://static1.squarespace.com/static/610ffde0dd5c39015edc6873/t/614941978e904e3e3f260db3/1632190875859/MissingPathwaysCLARAexecsumm_2018.pdf. Access on:10 Nov. 2021.

[14] COICA – Coordination of Indigenous Organizations of the Amazon Basin. *Amazon indigenous agenda*. COICA: 2017. Available in: http://coica.org.ec/wp-content/uploads/2017/10/Agenda-Indi%CC%81gena-Amazo%CC%81nica.pdf. Access on: 11 Nov. 2021.

[15] COICA – Coordination of Indigenous Organizations of the Amazon Basin. At COP25, COICA launched the campaign "No consultation without Consent". COICA Communications: 13 Dec. 2019. Available in: https://coica.org.ec/en-la-cop25-la-coica-lanzo-la-campana-no-hay-consulta-sin-consentimiento/. Access on: 11 Nov. 2021.

[16] IACHR - Inter-American Court of Human Rights. Case of the Xucuru Indigenous People and their members v. Brazil. Sentence of February 5, 2018. Available in: https://www.corteidh.or.cr/docs/casos/articulos/seriec_346_por.pdf. Access on: 12 Agu. 2021.

[17] ISA – Socio-environmental Institute. *Location and extent of ITs*. Page last modified on January 25, 2021. 2021a. Available in: https://pib.socioambiental.org/pt/Localiza%C3%A7%C3%A3o_e_extens%C3%A3o_das_TIs#:~:text=A%20maior%20parte%20das%20TIs,Grosso%20do%20Sul%20e%20Goi%C3%A1s. Access on: 12 Agu. 2021.

[18] ISA – Socio-environmental Institute. *Legal status of ITs in Brazil today*. Page updated on August 12, 2021. 2021b. Available in: https://pib.socioambiental.org/pt/Situa%C3%A7%C3%A3o_jur%C3%ADdica_das_TIs_no_Brasil_hoje#Situa.C3.A7.C3.A3o_das_TIs_no_Brasil. Access on: 12 Agu. 2021.

[19] ISA Socioenvironmental Institute. '*Blank check' for land grabbing, PL 2633 goes to the Senate*. Posted on 04 Aug 2021c. Available in: https://www.socioambiental.org/pt-br/noticias-socioambientais/cheque-em-branco-para-a-grilagem-pl-2633-segue-ao-senado. Access on: 15 Agu. 2021.

[20] LE BRETON, David. *The sociology of the body*. 2nd ed. Petrópolis, RJ: Vozes, 2007.

[21] LEPAN, Nicholas. *This maps shows the extent of human impact on the Earth`s surface*. Visual Capitalist; World Economic Forum. December, 2020. Available in: https://www.weforum.org/agenda/2020/12/visualizing-the-human-impact-on-the-earth-s-surface/. Access on: 10 Nov. 2021.

[22] MAPBIOMES. *Native vegetation loses space for agriculture in the last three decades*. Mapbiomes: August, 2021. Available in: https://mapbiomas.org/vegetacao-nativa-perde-espaco-para-a-agropecuaria-nas-ultimas-tres-decadas. Access on: 10 Nov. 2021.

[23] MPF – Federal Public Ministry. *Handbook of jurisprudence on indigenous rights*. 6th Coordination and Review Chamber, Indigenous Populations and Traditional Communities. – Brasília p: MPF, 2019. 920 p. Available in: http://www.mpf.mp.br/atuacao-tematica/ccr6/documentos-e-publicacoes/manual-de-atuacao/manual-de-jurisprudencia-dos-direitos-indigenas.pdf. Access on: 12 Agu. 2021.

[24] NUNES JUNIOR, Flávio Martins Alves. *Constitutional law course*. 2nd ed. rev., current. and amp. – São Paulo: Thomson Reuters Brazil, 2018.

[25] ONUNEWS. *COP26: UN News Special Coverage*. 2021a. Available in: https://news.un.org/pt/events/cop26. Access on: 11 Nov. 2021.

[26] ONUNEWS. *COP26 highlights that women bear the brunt of the climate crisis*. 2021b. Available in:

https://news.un.org/pt/story/2021/11/1769822. Access on: 11 Nov. 2021.

[27] QUIJANO, Aníbal. *Coloniality of power, Eurocentrism and Latin America. In: The coloniality of knowledge: Eurocentrism and social sciences*. Latin American perspectives. Latin American Council of Social Sciences – CLACSO, 2005. Available in: http://biblioteca.clacso.edu.ar/clacso/sur-sur/20100624103322/12_Quijano.pdf. Access on: 01 Jul. 2021.

[28] VIVEIROS DE CASTRO, Eduardo. *Araweté: the cannibal gods*. Rio de Janeiro: Jorge Zahar, 1986.

Hydrocephalus and its implications for the central nervous system: A contemporary literature review

Bárbara Maciel Grama Santiago Peixoto, Camilla Fernandes Camana, Hildete Souza De Araújo Santos, Thalyta Karller Dias Correira, Eduardo Fernanddes Marques

Institute of Tocantinense President Antônio Carlos Porto Nacional - To – Brazil

Abstract— Hydrocephalus is a pathology characterized by the accumulation of cerebrospinal fluid (CSF) in the cerebral ventricles (intercommunicating cavities located in areas of the brain) and in the subarachnoid space between the arachnoid and pia mater membranes of the meninges. The aim of this study was to present a review of the literature, with a contemporary character, on Hydrocephalus and its implications on the central nervous system. The present research was carried out during the years 2018 to 2022 through a search of the keywords in the descriptors in Health Science (DECS) and were added in the databases: VHL (Virtual Health Library), Google Scholar, LILACS, PubMed, Scielo. In total, 08 (nine) articles were used as primary search and 33 (thirty-three) articles as secondary search. The titles of the articles included in the present study were those that presented a direct correlation with the keywords, articles up to 05 (five) years old or classic authors of the theme even with a later date. Bibliographic data, such as electronic journals and websites that clearly explain hydrocephalus. Through the analysis of the bibliographic data that were studied, it was noticed that the head of the patient with hydrocephalus suffers more visibility when talking about anatomical structure, and sequelae regarding the Central Nervous System.

I. INTRODUCTION

The word "hydrocephalus" comes from Greek origin, giving the designs to hidro=water and cephalo=head, it is considered a disease caused in the brain, when there is excess of cerebrospinal fluid in the cerebral ventricles or also in the subarachnoid areas, being this called by the acronym CSF or even called CSF, thus causing the increase in the head due to the dilation of the ventricles.

According to Alcântara (2009) there are three types of hydrocephalus, which are: obstructive or non-communicating, non-obstructive or communicating and normal pressure. The causes of hydrocephalus can be the most diverse, more specifically the congenital and acquired, it is evident more occurrences in children and the elderly, although it can develop in other stages of life (JUCA; NETO; OLIVEIRA; MACHADO, 2002).
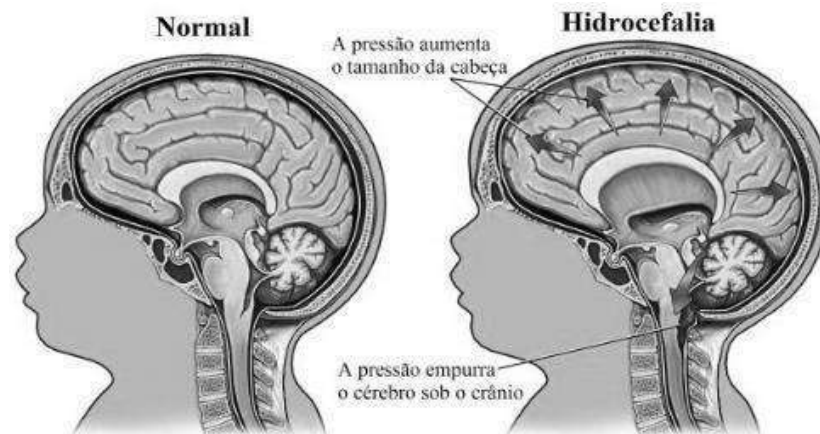
Fonte Imagem: Reprodução/Internet

Fig.1: Comparison of a child with hydrocephalus, the image on the left shows a child who does not have the disease, and on the right, with the disease and the places where there is accumulation of fluid, in which the anatomical structure of the head is the most visible, due to pressure cerebral ventricular.

The evaluation of symptoms for this disease is according to age, but the most visible are: the different size of the head, vomiting, drowsiness, irritability, convulsions and in more serious cases: mental and psychomotor retardation. The diagnosis is made through a clinical history of the person, computed tomography or magnetic resonance imaging. The form of treatment can be done with medication and, in most cases, surgery is performed, in which the obstruction occurs by drainage for the removal of the liquid.

The search to research on this topic arose after the curiosity to know and deepen more about the implications that occur in the Central Nervous System (CNS) when a patient is diagnosed with hydrocephalus, and for that important information about the disease was addressed, from of a bibliographic survey.

The following study is of great relevance to the medical field, as it is a research in which studies were concentrated on the Central Nervous System, since this is the part most affected by hydrocephalus. It can serve as a basis for future works that have the same tenuous line of medical research.

The study on hydrocephalus and its implications on the central nervous system had as main objectives to understand the disease in general, from the etymological meaning of the word to its treatment, with the support of bibliographic materials and careful analysis. And also the description of the main implications of hydrocephalus in the Nervous System.

II. THEORETICAL REFERENCE

From the anatomical point of view, hydrocephalus has as main deformities that are according to the type of disease and whether the patient is a child or elderly, and the Central Nervous System is the most affected. Enlargement of the head is the most visible, and per hour present more in children's cases, although this is not restricted to occur in young people, adults or elderly people.

Hydrocephalus has no cure, but advances in health have made the treatment increasingly effective, and there are cases in which the person after surgery is even able to lead a normal life.

Because hydrocephalus occurs in two ways: congenital and acquired, the cause of both is given by different situations. While in congenital the main origin is when the child is still in the mother's uterus. And other appearances are diagnosed after birth, preferably in the first few months of the baby. In addition to diagnosis at birth, it is common to appear due to infections, such as meningitis and toxoplasmosis. If the child's mother used drugs during pregnancy, this cause is also common. And other causes are: spina bifida, known by the scientific name-myelomeningocele, and non-formation of the spinal cord. (ALCANTÂRA, 2009)

Unlike congenital, acquired has no specific age for onset. And the causes are diverse: head trauma (due to a car accident or fall in which the head impacted the ground or similar object was too strong), brain tumors, infections and hemorrhages, including a stroke/ AVE (PEREIRA; MAZETI; LOPES; PINTO, 2012).

Excess CSF in the skull compromises the anatomical structure of the head, especially the oversized head, which results in cerebrospinal fluid when it is produced beyond the brain and spinal cord need, the cerebral ventricles, which are four in total, suffer pressure,

causing the head shape to increase, and cause problems in the Nervous System (ALCANTÂRA, 2009).

These problems often occur according to age: in children we can identify: slow psychomotor development, irritability and a large head, as described above. In adolescents and adults: frequent headaches, lack of attention and concentration, convulsions, lack of balance in the body. In the elderly: difficulty walking, state of dementia and memory loss (JUCA; NETO; OLIVEIRA; MACHADO, 2002).

III.   MATERIAL AND METHODS

The research was carried out during the years 2018 to 2022 through a search for keywords in the descriptors in Health Science (DECS), using the words: Hydrocephalus; Nervous system; Clinical Assessment.

They were used in the VHL, Google Scholar, LILACS, PubMed and Scielo databases with a filter for publications from the last 05 (five) years and research in humans. However, classic articles that supported the key subject were kept despite the year of publication.

In the VHL (Virtual Health Library) database, 04 (four) were found and 01 (one) was used. In Google Scholar, the first 200 (two hundred) of a total of 6,680 (six thousand six hundred and eighty) were observed, taking advantage of 03 (three). In LILACS, 07 (seven) were observed but none were used. In PubMed, 128 (one hundred and twenty-eight) were found, in which 04 (four) were used. In the Scielo database, only 01 (one) article was found and the same article was used. In total, 08 (nine) articles were used as primary search and 33 (thirty-three) articles as secondary search.

The titles of the articles were analyzed and those that presented a direct correlation with the keywords, articles up to 05 (five) years old and with research in humans, were included in the present study. The others were automatically excluded.

IV.   RESULTS AND DISCUSSION

It was observed that Hydrocephalus, due to the CSF fluid that is present in our brain, and when it exceeds, there is a lack of control of the necessary total produced, causing at a time the encephalic enlargement and other consequences, which mainly affects the Nervous System. Central.

It can be verified through the information studied about the disease that there is no cure, but treatment, with the use of obstruction of the liquid through drainage. It is notorious that when hydrocephalus affects the Nervous

System, the patient has psychomotor difficulties, a large head (in which there is dilation of the cerebral ventricles), memory loss, drowsiness, headaches, irritability, lack of concentration, etc.

The most common cases are in children, preferably newborns, and when the disease is detected as soon as possible, the more chance there is to take care and take appropriate measures. Although there are records in the elderly, adults and adolescents. Based on the studies pointed out by Alcantâra (2009), when it is noticed that the baby has a head of a different size than normal, it should measure to see if the growth will not continue, and if it continues to apply medicine to reduce the continuous production of the baby. cerebrospinal fluid.

V.   FINAL CONSIDERATIONS

The analytical study on Hydrocephalus and the main implications on the Central Nervous System, addressed what the disease is, how to treat it, what are the most common cases, diagnosis, types, emphasizing the most impaired anatomical structure.

Cerebrospinal fluid, when produced in proportionate quantity, is very important to avoid the impact of our nervous system with the bones, but when it produces more than necessary, it causes the disease which is called Hydrocephalus. This fluid causes the ventricles to dilate and the head to become larger than normal.

It has treatment, both with drugs and surgery. The detection of hydrocephalus is taken with the help of computed tomography, magnetic resonance imaging and others. And the sooner it is diagnosed, the better the chances of treating it. There are three types of hydrocephalus: obstructive or non-communicative, non-obstructive or communicative, and normal pressure. And as much as hydrocephalus has no cure, medicinal treatments have been increasingly effective.

Thus, it can be noted that hydrocephalus, despite being a little better known, there are still few studies describing with more precision and clarity about the problems caused in the Central Nervous System, and that better address the CSF disorder that causes hydrocephalus.

REFERENCES

[1] ALCÂNTARA, Maria Cláudia Moreira de. Clinical care for children with hydrocephalus: construction and validation of an instrument for the Systematization of Nursing Care. Fortaleza- Ceará: 2009. Available at: www.revistas.usp.br. Accessed on: November 23, 2018, at 4:36 pm.

[2] HYDROCEPHALY.   Available   at: https://drauziovarella.uol.com.br/doenças-e-

sintomas/hidrocefalia. Access on: November 23, 2018, at 3:12 pm.

[3] HYDROCEPHALY.   Available   at: https://pt.m.wikipedia.org.wiki/hidrografia.   Accessed   on: November 23, 2018, at 2:42 pm.

[4] HYDROCEPHALY.   Available   at: https://www.minhavida.com.br/amp/saude/temas/hidrocefali a. Accessed on: November 23, 2018, at 2:53 pm.

[5] HYDROCEPHALY.   Available   at: www.anatomiaresumida.com/hidrocephalia.   Access   on: November 23, 2018, at 3:30 pm.

[6] JUCÁ, Carlos Eduardo Barros; NETO, Antônio Lins; OLIVEIRA, Ricardo Santos de; MACHADO, Helio Rubens. Treatment of hydrocephalus with ventriculoperitoneal shunt: Analysis of 150 consecutive cases at the Hospital das Clínicas in Ribeirão Preto. Brazilian Surgical Record. Vol. 17 (Supplement 3.São Paulo: 2002. pp 59-63. Available at: www.scielo.br. Accessed on: November 23, 2018, at 4:02 pm.

[7] PEREIRA, Renan Muralho; MAZETI, Laura; LOPES, Deborah Cristina Pereira; PINTO, Fernando Campos Gomes. Normal pressure hydrocephalus: current view on pathophysiology, diagnosis and treatment. Rev. Med (São Paulo). São Paulo: 2012. pp. 96-109. Available at: www.uece.br. Accessed on: November 23, 2018, at 4:17 pm.

Nonlinear analysis of reinforced concrete slabs through the finite element method

Carlos Henrique Hernandorena Viegas[1], Mauro de Vasconcelos Real[2], Eduardo Pagnussat Titello[3]

[1]Engineering School, Federal University of Rio Grande, Brazil
Email: chviegas@furg.br
[2]Engineering School, Federal University of Rio Grande, Brazil
Email: mauroreal@furg.br
[3]Department of Civil Engineering, Engineering School, Federal University of Rio Grande do Sul, Brazil
Email: du.titello@gmail.com

Abstract— One of the significant difficulties in representing the behavior of reinforced concrete structures in mathematical models is the post-cracking non-linearity. And so, reinforced concrete slabs are no exception to the rule. Still, the usual analysis models for this structural element are verified in the elastic regime when the concrete tensile strength is considered. This model is acceptable for the service limit states but not the ultimate limit state. These aspects associated with the great difference in the behavior of concrete when subjected to tension or compression make it necessary to study a nonlinear mathematical model that can represent a reinforced concrete slab subjected to bending, from the beginning of loading until its failure, as accurately as possible. With this, the ANSYS software, from its version 18, made available in its library the Drucker-Prager-Rankine model arranged with two distinct rupture surfaces. A Drucker-Prager criterion for the concrete subjected to compression and a Rankine criterion for concrete in tension. In addition, the software is based on the finite element method, giving the possibility of precise and nonlinear analysis through load and deformation increments, taking into account both elastic and plastic deformations after concrete cracking. Thus, this work aims to present the modeling of reinforced concrete slabs through the Drucker-Prager-Rankine surface, validating the model by comparing it with several experimental tests. The model results were coherent and acceptable, presenting a good approximation of the results of the tests.

I. INTRODUCTION

From the beginning of their loading to failure, the reinforced concrete structures' behavior is considered complex due to their physical and geometric non-linearity. This non-linearity leads to uncertainties regarding structural design [1].

These phenomena are due to relationships such as nonlinear stress-strain curves, the difference between tension and compression behavior, cracking and crushing of concrete, interactions between aggregates and adhesion of steel bars and concrete, and, still, the phenomena of creep and shrinkage of concrete [2, 3].

Despite this, the usual methods for design focus their theories on uncracked concrete, that is, on the elastic regime when the concrete material still resists the tensile stresses. When in a service situation, these analysis theories are seen as efficient. However, when the objective is to evaluate the failure behavior of reinforced concrete elements subjected to bending, examining the after-cracking and plastic behavior is necessary. So fracture, and plastic theories should be included in the analysis [4].

Thus, one of the objectives of this work was to develop a computational model that would simulate the correct behavior of reinforced concrete slabs subjected to bending from the beginning of loading until its failure. As an instrument, the ANSYS software was used, which is based on the Finite Element Method (FEM) and gives the possibility of using volumetric elements with incorporated reinforcement elements, which simulates the steel rebars inside the slab. Furthermore, the program can use the Drucker-Prager-Rankine failure model, which has the characteristic of using two different failure surfaces when the concrete is subjected to tensile or compression stresses.

II. COMPUTATIONAL MODELING

The ANSYS software was used through its APDL platform, which brings the possibility of developing a text script containing the data entry base and the running of existing models within the libraries of the program itself. It was possible to model the Drucker Prager-Rankine (DP-Rankine) elastoplastic rupture model extended to the HSD (Hardening, Softening, and Dilatation) subroutine. The concrete material is represented by the volumetric finite element SOLID186, which is compatible with plastic behavior materials. The reinforcement finite element REINF265 reproduces the steel. This element can integrate with SOLID186 with perfect adhesion, simulating a reinforced concrete slab in the best possible way.

Finite Elements used

According to the ANSYS Manual [5], the SOLID186 element presents hexahedral, pyramidal, prismatic, or tetrahedral shapes. So the mesh can be adjusted in the best possible way to the model's geometry. Furthermore, it is formed by 20 nodes and three degrees of freedom (translation in the X, Y, and Z axes) in each node, with quadratic interpolation functions. The element is present in Fig. 1.
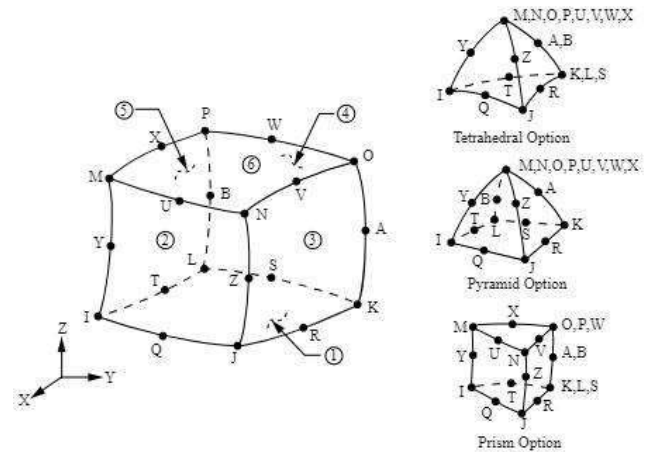

Fig.1: SOLID186 element. Adapted from [5]

The REINF265 element, presented in Fig. 2, shares the same nodes and connectivity as the base element (SOLID186). The element uses the smeared approach. So it is possible to represent equally spaced reinforcing rebars as a surface, generating a significant computational gain in relation to the discrete reinforcement. The main parameters of the element are the reinforcement material, the relative position, the reinforcement cross-section, and the desired spacing for the rebars [5].
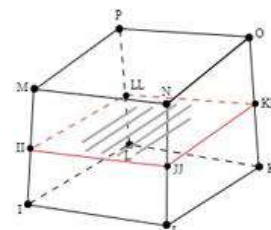
Fig.2: REINF265 element. Adapted from [5]

III. CONSTITUTIVE MODEL OF MATERIALS

The theories used to simulate two-dimensional surface structures, such as shells and plates, aim to adjust empirical equations to the behavior of the stress-strain law of the element.

Still, it is complicated to establish an accurate description of the performance of the three-dimensional structure until its rupture through the most used elastic models through the concepts of Hook's law alone. Thus, the best possibility to have a result close to reality is to develop an analysis through incremental load and deformation modules using the combined principles of elasticity and plasticity.

In this regard, Chen [6] describes that elastic models should be used in conjunction with failure criteria of the concrete material, where the failure surfaces in the space of principal stresses are used to build an initial and later yield surface based on the theory of plasticity.

Furthermore, Chen [6] proposes that concrete under triaxial compression may present ductile behavior on the yield or rupture surface before reaching the condition of crushing. In this way, a complete plastic model can be adopted, as shown in Fig 3.

Fig.3: Schematic failure surface of the concrete in three-dimensional stress space. Adapted from [6]
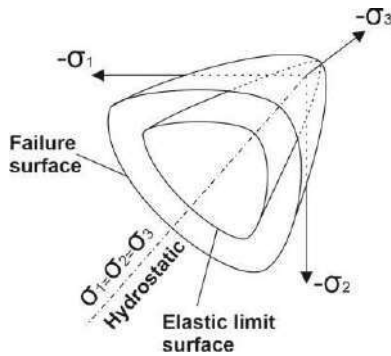
The relationships that must be considered for a perfectly plastic failure model are separated into three parts: before flow (elastic), during plastic flow, and after the fracture (cracking). Thus, the stress invariants' failure criteria are represented through perfectly plastic flow surfaces. For this, a series of numerical models are used.

As a result, plastic failure models use yield models that incorporate a dependence of the yield point stress on the average normal stress (hydrostatic pressure) and the dependence of the invariant on the average maximum shear stress. These models of concrete failure are developed through the strain-hardening plasticity theory. Thus, an increasing loading surface that combines perfect plasticity and strain-hardening after yielding is necessary. This approach is a generalization of the previously mentioned models satisfying the basic principles of continuum mechanics. Thus, a boundary surface for the elastic behavior must be adopted, where the initial flow begins and resembles the rupture surface.

Therefore, the concrete presents failure behavior with plastic deformation in compression and tension. The Young modulus of the elastic region is the same in both cases. In the graph of Fig. 4, it is possible to observe the transition stresses between the elastic medium and the plastic medium where f_c and f_t are given for compression and tension, respectively. At the point of f'_c, the concrete reaches the condition of failure by crushing in compression

for an ultimate strain ε_u; after that, the strength drops to zero. For tensile, the strength and tensile limit are represented by f'_t and ε_t. At the moment of cracking, it is assumed that it occurs in a plane normal to the first principal stress direction. The concrete behavior presents a brittle rupture in the tensioned region. In the plastic regime, unloading behavior in the compressed region is represented by the straight-line BH. The BH line is characterized by following the elastic modulus in parallel to the origin of the diagram.
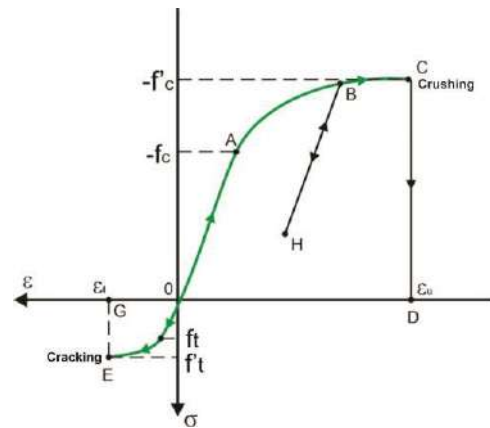
Fig.4: Idealized uniaxial stress-strain curve for concrete. Adapted from [6]

The criteria that define the stress states are characterized by three zones, namely: compression-compression, tensile-compression, and tensile-tensile, as in Fig. 5.
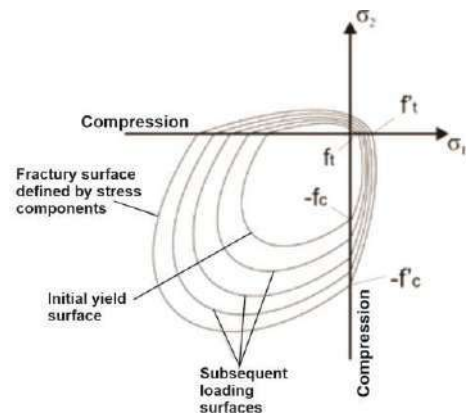
Fig.5: Concrete loading surfaces in the biaxial stress plane for a work hardening plasticity. Adapted from [6]

Drucker-Prager-Rankine

The great challenge in developing a model for simulating reinforced concrete structures is the difference in resistance and deformation behavior in tension and compression. The Drucker-Prager (DP) model is traditionally created to describe the behavior of brittle

failure materials and has been included in the ANSYS library for a considerable time. However, until 2018, the DP offered only one rupture surface. It was not possible to describe the difference in the behavior of concrete when subjected to tensile and compressive stresses, compromising post-cracking results. However, in version 19.2, the software updated the DP to a new Drucker-Prager-Rankine model, containing two distinct rupture surfaces. One for when the element is subjected to compression, implementing the DP, and the other for the element in tension, using the Rankine failure surface. These two failure criteria, together with the possibility of incorporating the reinforcement and using a perfect elastoplastic or bilinear model for steel, made it possible to obtain accurate results compared to experimental tests.

In Fig. 6, the model's input parameters are shown for both tensile and compression stress states. They must be set in the script developed in ADPL language to build the numerical model. The parameters required to use DP-Rankine are:
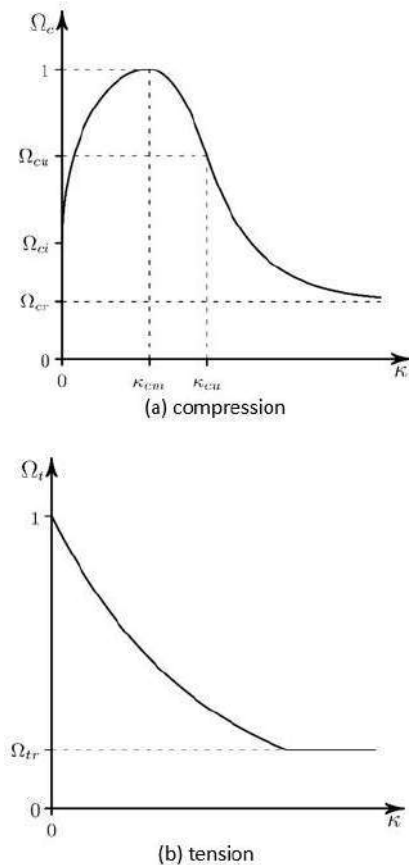

Fig.6: Exponential HSD (hardening, softening, and dilatation) model ANSYS Drucker-Prager Rankine. (a) compression; (b) tension. Adapted from [5]

Dilation factor (δt and δc): the model requests the specification of a dilation factor referring to the surface of

the plastic potential. In the present work, the value suggested in the software manual was used, being 0.25 for tension and 1.0 for compression.

Stress factor relative to the beginning of hardening (Ωci), relative stress level (Ωu), residual relative stress level (Ωcr), plastic stress at uniaxial compressive strength (kcm), plastic stress that defines the beginning of exponential softening (kcu) level of residual relative stress in tension (Ωtr), the parameter of plastic deformation when it reaches the level of residual relative stress (ktr).

The ANSYS manual [6] presents the formulations for the behavior of the DP-Rankine rupture surfaces, Fig. 7, represented by the compression-compression, tension-compression, and tension-tension zones as will be demonstrated.

When the value of f_R is below zero, the behavior in tension and tension-compression is admitted in the elastic-linear regime with the tensile strength values remaining constant. However, when f_R reaches zero, the plastic regime begins with the simulation of a crack opening through increments of plastic deformation through an extended model called HSD, responsible for simulating the hardening and softening of concrete during the plastification. ANSYS has four models that can be chosen with different parameters and behaviors. The models are Linear, Exponential, Steel Reinforcement, and Fracture Energy (Fig. 8). The Exponential HSD was used in this work because the behavior characteristics resemble the proposed concrete behavior [5; 7].
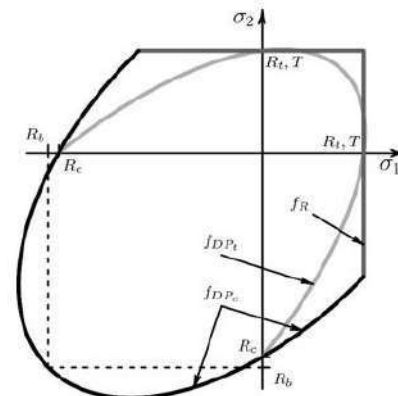

Fig.7: Failure surfaces showing Drucker-Prager and Rankine surfaces. Adapted from [5]
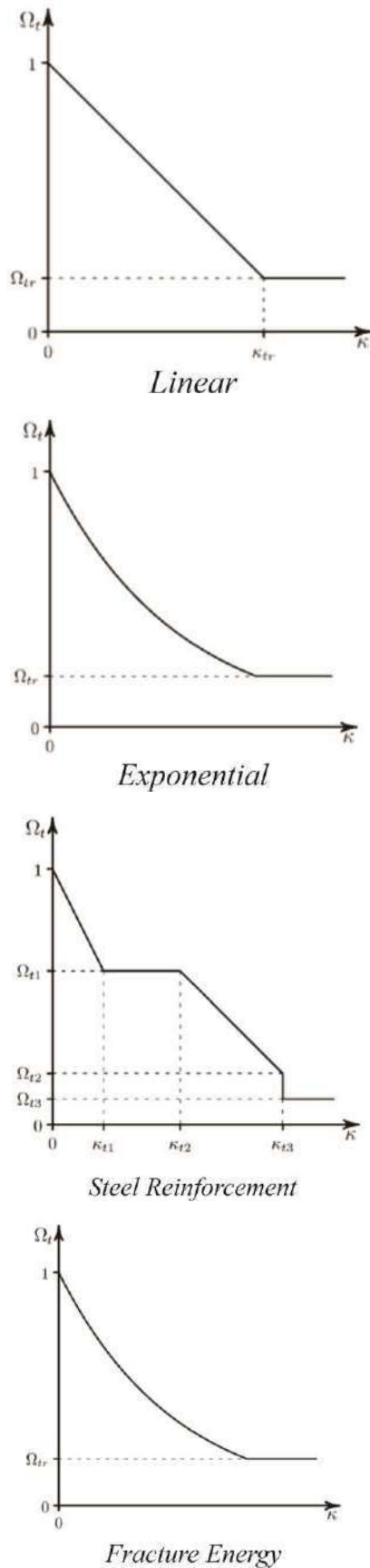
Fig.8: Hardening, Softening, and Dilatation (HSD) Behavior. Adapted from [5]

Drucker Prager compression surface

ANSYS presents the Drucker-Prager compressive loading yield surface formulation given by:

$$f_{DP_c} = \frac{\sigma_e}{\sqrt{3}} + \beta_c \sigma_m - \sigma_{Yc} \Omega_c \qquad (1)$$

$$\sigma_m = \frac{I_1}{3} \qquad (2)$$

$$\sigma_e = \sqrt{3J_2} \qquad (3)$$

where σ_e is given as the von Mises equivalent stress, I_1 is the first stress invariant, J_2 is the second stress invariant, σ_m is the stress average or hydrostatic pressure, and the constants β_c and σ_{Yc} are defined by biaxial compressive strength (R_b) and uniaxial compressive strengths (R_c) strengths

$$\beta_c = \frac{\sqrt{3}(R_b - R_c)}{2(R_b - R_c)} \qquad (4)$$

$$\sigma_{Yc} = \frac{R_b R_c}{\sqrt{3}(2R_b - R_c)} \qquad (5)$$

The variables Ωc and Ωt are hardening and softening functions, both in tension and compression, where they depend on the stress variables σ and hardening "k." From these variables, it is possible to calibrate the model. The flow potential for the Drucker-Praguer tension and tension-compression flow surfaces are given by:

$$Q_{DPc} = \frac{\sigma_e}{\sqrt{3}} + \delta_c \beta_c \sigma_m \qquad (6)$$

where δc is a compression dilation parameter.

Tension and Tension-Compression

William John Macquorn Rankine published, in the year 1876, the Rankine failure criterion, which is known as the maximum tensile stress criterion. The failure occurs when the maximum principal stress reaches the ultimate tensile strength. This strength is obtained through a simple tension test, regardless of the other normal or shear stresses in other planes [6].

The Rankine tensile failure surface becomes fundamental when modeling concrete due to the inefficiency of the Drucker-Prager method in representing the behavior of concrete subjected to tension. Thus, the surface that defines the flow when the principal stress exceeds the tensile strength is given by the equation:

$$f_R = \sigma_m + \frac{2}{3}\sigma_e\, sen\left(\theta + \frac{2}{3}\pi\right) - T\Omega_t \tag{7}$$

where T is the uniaxial tensile strength.

$$\sigma_m = \frac{\sigma_{11} + \sigma_{22} + \sigma_{33}}{3} \tag{8}$$

$$\sigma_e = \sqrt{3J_e} \tag{9}$$

$$sen(3\theta) = -\frac{\frac{3\sqrt{3}}{2}J_3}{\sqrt{J_2^3}} \tag{10}$$

and, where the stress invariants are given by:

$$J_2 = \frac{1}{6}((\sigma_{11} - \sigma_{22})^2 + (\sigma_{22} - \sigma_{33})^2 + (\sigma_{33} - \sigma_{11})^2) + \sigma_{12}^2 + \sigma_{23}^2 + \sigma_{13}^2 \tag{11}$$

$$J_3 = \det(\sigma - I\sigma_m) \tag{12}$$

Steel Behavior

As a hypothesis, the behavior of the steel in tension and compression is not distinct. The same bilinear model is adopted for both. Since a reinforcement line element represents the steel, only the axial stiffness of the rebar is necessary to be modeled. Two different models can be used for reinforcement steel. The first one, presented in Fig. 9, considers a bilinear behavior for the material. Until the yield stress (f_y), the material is elastic linear with an elastic modulus (E_s). After the yield, the material became plastic with a tangent modulus E_i. The second model, the perfect elastoplastic, presented in Fig. 10, has no hardening after yielding, so $E_i = 0$. Regardless of the models used, the loss of convergence and consequent rupture occurs when the steel strain exceeds the value of 10 ‰.
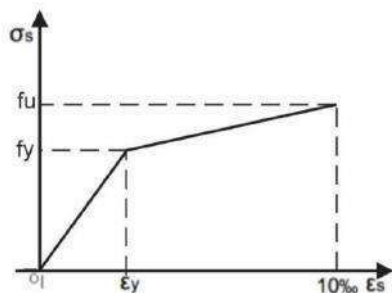
Fig.9: Model stress-strain graph for steel reinforcement with bilinear behavior. Adapted from [5]
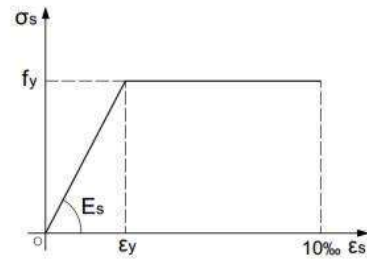
Fig.10: Model stress-strain graph for perfect elastoplastic steel reinforcement. Adapted from [5]

IV. MODEL VALIDATION

Comparing the results obtained from existing models and with actual data becomes essential to demonstrate the validity of the created model. Thus, the model must be calibrated to lead to parameter adjustments within acceptable ranges. And even the differences between the numerical model results of the experimental test must be minimized for good accuracy. One of the ways to develop this validation is to use data collected from other studies already developed in the laboratory or create new data with the necessary actual conditions.

Data referring to the failure test of sixteen rectangular reinforced concrete slabs, presented in three scientific works, were used for comparison. Seven were supported on four sides among these slabs and nine on two sides.

Model configuration

Two different boundary conditions were used in the modeling of these slabs. Supported on the four sides with vertical constraint, Fig. 11, and supported vertically only on two edges, with the other two free, Fig. 12. The model was developed with a quarter of its original size due to its structural symmetry to obtain an efficiency gain in the computational processing time. Thus, to simulate the complete slab, longitudinal constraints were placed on the internal edges of the slab to ensure no rotation at these points. The mesh used in the study comprises 3x3x3 elements in the three Cartesian dimensions, thus having 27 finite elements for a quarter slab.
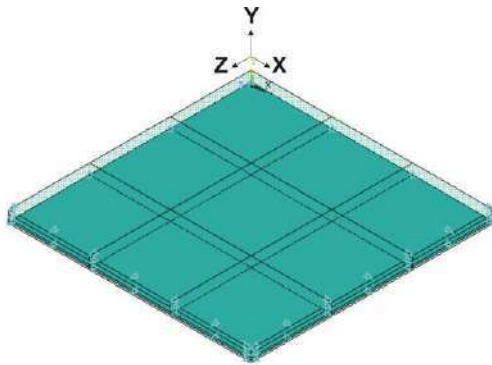
Fig. 11: Slab modeling supported on the 4 borders used in this work.

Fig. 12: Slab model supported on the two borders used in this work.

Taylor, Maher, and Hayes slabs

In 1966, Taylor, Maher, and Hayes [8], verifying the effectiveness of different configurations of reinforcement distribution in a slab supported on four sides, carried out experimental tests of ten square slabs of reinforced concrete. For this study, it was possible to use three of them called S1, S7, and S9. The characteristic of these slabs is the uniformly spaced distribution of their reinforcements and an orthogonal arrangement of bars.

Pires slabs

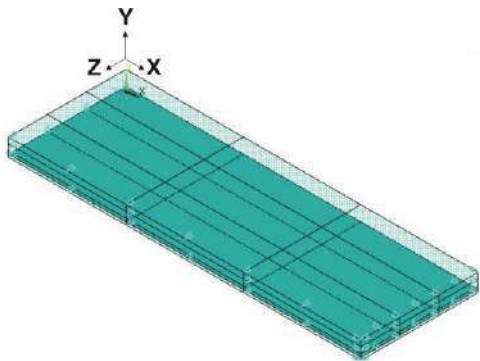Pires [9], in his master's thesis from the Universidade Federal de Minas Gerais, uses the failure data of six single-direction reinforced concrete slabs. This work aimed to study the behavior and failure of monolithic slabs of 10cm (Series 1 A and B) and 15cm (Series 3 A and B) in thickness compared to 10cm slabs with a 5cm reinforced concrete cover. (Series 2 A and B). Slabs named Series 1A, 2A, and 3 (A and B) were chosen to be used in the validation of this model.

Bliuc slabs

In the search for a possible reduction in the thickness of the slabs, Bliuc [10] presented data on failures of reinforced concrete slabs subjected to bending using high-strength concrete. The slabs were supported on four sides (BL3, BL4, BH1, and BH4) and two sides (AH1, AH3, AH4, AL1, and AL4). The concretes had compressive strengths of 65.5 MPa, 77.0 MPa, and 91.5 MPa, with steel yield strength varying between 482.2 MPa and 518.0 MPa.

Analysis of results and discussions regarding model validation

Tab. 1 presents the types of supports used, the identification of the slab, the author, the year of publication, and geometric parameters. Tab. 2 shows the materials' parameters, such as the yield strength of steel (fy), average compressive strength of concrete (fc), and positive reinforcement ratio used in each direction. The parameters for each slab are shown in Tab. 3, where the results of the experimental and ANSYS model failure load values are presented.

Table 1: Geometric parameters of experimental models used for validation

		x	z	y
Slab	**Author**	**L(cm)**	**b(cm)**	**h(cm)**
AH1	Bliuc	240.00	100.00	10.00
AH3	Bliuc	240.00	100.00	10.00
AH4	Bliuc	240.00	100.00	10.00
AL1	Bliuc	240.00	100.00	10.00
AL4	Bliuc	240.00	100.00	10.00
BL3	Bliuc	240.00	240.00	10.00
BL4	Bliuc	240.00	240.00	10.00
BH1	Bliuc	240.00	240.00	10.00
BH4	Bliuc	240.00	240.00	10.00
S1	Taylor. Maher e Hayes	183.00	183.00	5.10
S7	Taylor. Maher e Hayes	183.00	183.00	4.40
S9	Taylor. Maher e Hayes	183.00	183.00	7.60
S1A	Pires	170.00	60.00	10.00
S3A	Pires	170.00	60.00	15.00
S2A	Pires	170.00	60.00	15.00
S3B	Pires	170.00	60.00	15.00

Also, Tab. 3 presents a statistical analysis of the rupture results, with the mean, standard deviation, and coefficient of variation of the failure loads. It was possible to reach the dimensionless average of the ratios of the rupture loads equal to 1.0, demonstrating the convergence of results from the numerical model to the experimental ones. A standard deviation of 0.06 and a coefficient of variation of 6.06% was found. In Fig. 13, the results from

experimental tests and numerical models are compared, where the linear relation has R² = 0.995. The proximity of the experimental results with the numerical model is associated with its good calibration and functioning.

Table 2: Material parameters of the experimental models used for validation.

Slab	fy(kN/cm^2)	x ρ(%)	z ρ(%)	fc (kN/cm^2)
AH1	48.22	1.13	0.36	6.55
AH3	48.22	1.13	0.36	7.70
AH4	51.80	1.13	0.36	9.15
AL1	48.20	0.57	0.36	6.55
AL4	51.80	0.57	0.36	9.15
BL3	48.20	0.57	0.53	7.70
BL4	51.80	0.57	0.53	9.15
BH1	48.20	1.00	0.97	6.55
BH4	51.80	1.00	0.97	9.15
S1	37.60	0.51	0.55	3.50
S7	37.60	0.55	0.80	3.80
S9	37.60	0.21	0.23	3.30
S1A	68.26	0.79	0.10	3.75
S3A	68.26	0.79	0.10	3.75
S2A	68.26	0.79	0.10	3.75
S3B	68.26	0.79	0.10	3.75

Since the model studied here is based on nonlinear analysis, the structural failure does not occur by strain limits, but by the lack of equilibrium between internal forces and external loads, through the finite element method. Usually, the model becomes unstable when the tensile steel reaches the yield stress, or the compressed concrete reaches its ultimate strain. The convergence tolerance adopted in the analysis was 5% of the Euclidean norm for forces and displacements.

Finally, since it is an element subjected to bending, designed to have a ductile behavior, it was checked that the incorporated reinforcement always reaches its yield stress. The reinforcement yielding was verified for each situation, as demonstrated by the example of slab S7 of [8] in Fig. 14.
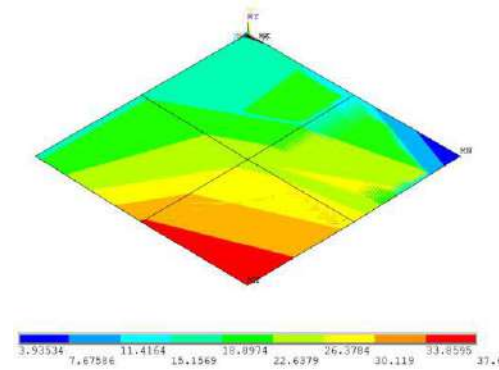
Fig. 14: Tensile stresses (kN/cm^2) in steel after the failure of one of the slabs modeled in ANSYS.

Table 3: Results referring to the validation study of the reinforced concrete slab model.

	Breaking load (kN)	
Slab	Experimental (E)	Drucker-Prager-Rankine (DPR)
AH1	108.70	108.80
AH3	115.90	114.60
AH4	119.00	118.95
AL1	63.32	66.45
AL4	64.45	72.00
BL3	445.00	442.20
BL4	467.00	433.95
BH1	611.00	589.68
BH4	671.00	588.00
S1	90.00	88.88
S7	90.00	88.80
S9	95.86	93.99
S1A	66.40	66.00
S3A	119.00	127.50
S2A	116.57	127.50
S3B	116.36	127.50

Table 4: Material parameters of the experimental models used for validation.

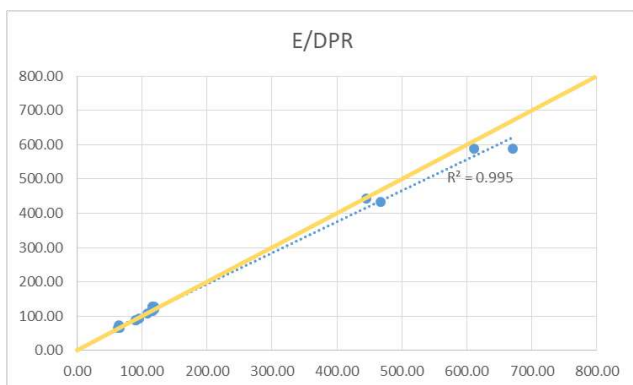| Slab	E/DPR	Average	Standard Deviation	Coefficiente of variation(%)
AH1	1.00	1.00	0.06	6.37
AH3	1.01			
AH4	1.00			
AL1	0.95			
AL4	0.90			
BL3	1.01			
BL4	1.08			
BH1	1.04			
BH4	1.14			
S1	1.01			
S7	1.01			
S9	1.02			
S1A	1.01			
S3A	0.93			
S2A	0.91			
S3B	0.91			

Fig. 13: Graph with the ratio between the experimental loads and the numerical model DPR and the linear correlation between the rupture loads

V. CONCLUSION

It is possible to conclude from this analysis that reinforced concrete is a heterogeneous material with elastoplastic and nonlinear behavior. This complex behavior generates randomness of results for two elements with the same parameters; as presented in the tests by Pires [9] for slabs S2A and S3A, the result for the rupture will not be the same but similar. In other words, a numerical model that always demonstrates the exact experimental behavior of the test must be questioned, as the properties of concrete vary from one model to another, generating natural randomness. Even so, what was sought with the validation was to demonstrate that the numerical model can obtain good results. In this case, to arrive at the failure load, this work showed that the Drucker-Prager-Rankine model provided by the ANSYS software after calibration could present significant accuracy. It can be considered efficient for analyzing reinforced concrete slabs with failure by bending.

REFERENCES

[1] NASSIM, K.; KHALIL, B.r; BEKADDOUR, B. A.. Nonlinear finite element analysis of reinforced concrete members and punching shear strength of HSC slabs. Matec Web Of Conferences, [s.l.], v. 149, p.02056-02062, 2018. EDP Sciences. http://dx.doi.org/10.1051/matecconf/201814902056

[2] H. G. Kwak and F. C. Filippou, Finite Elements Analysis of Reinforced Concrete Structures Under Monotonic Loads (Report UCB/SEMM-90/14). Berkeley, CA: University of California, 1990

[3] FANNING, P. Nonlinear Models of Reinforced and Post-tensioned Concrete Beams. Electronic Journal of Structural Engineering, Dublin, Ireland, 2001.

[4] CARVALHO, M. L.; SILVA, C. R.; STUCCHI, F. R.. Study on reliability of punching shear of flat slabs without shear reinforcement according to NBR6118. Revista Ibracon de Estruturas e Materiais, [s.l.], v. 10, n. 2, p.276-297, abr. 2017. FapUNIFESP (SciELO). http://dx.doi.org/10.1590/s1983-41952017000200002

[5] ANSYS. Help. 2020. Available in: https://ansyshelp.ansys.com/account/secured?returnurl=/Views/Secured/main_page.html. Acessed in: jun. 2020.

[6] CHEN, Wai-Fah. Plasticity in Reinforced Concrete. New York: McGraw-Hill, 2007

[7] BENINCÁ, M. E. Simulação Numérica de Vigas Alveolares Mistas de Aço e Concreto: Modelo Parametrizado de Elementos Finitos. 2019. 205 f. Master thesis, Porto Alegre, RS, Brazil: Universidade Federal do Rio Grande do Sul

[8] TAYLOR, R.; MAHER, D. R. H.; HAYES, B. Effect of the arrangement of reinforcement on the behavior of reinforced concrete slabs. Magazine of Concrete Research, v. 18, n. 55, p.85-94, 1966.

[9] PIRES, E. F. Comportamento e Desempenho do Reforço à Flexão de Lajes de Concreto Armado através do Aumento da Seção na Região Comprimida. 2003. 100 f. Master thesis, Minas Gerais, MG, Brasil: Universidade Federal de Minas Gerais, Minas Gerais, 2003.

[10] BLIUC, Radu. Particularities of the Structural Behaviour of Reinforced High Strength Concrete Slabs. 2004. 255 f. Doctoral dissertation - Curse of School Of Aerospace, Civil And Mechanical Engineering, Australian Defence Force Academy University Of New South Wales, New South Wales, 2004

Analysis of Project Acceleration with Crashing Method on the Rehability and Renovation Project Work of Iain Ambon Library

Ismit Nukuhaly[1], Rudi Serang[2]

Ambon State Polytechnic, Indonesia

E-mail: [1]ismitnukuhaly798@gmail.com

[2]rudiserang65@gmail.com

Abstract— *The construction of a construction project often happens something that is not desirable such as the occurrence of delays in work on the project. Many factors cause delays, one way to anticipate it is by accelerating. In accelerating, the cost and quality factors must be considered, so that the optimum cost and quality are obtained according to the desired standard. The construction of the Iain Ambon Library Rehabilitation and Renovation Project was chosen for a research study due to delays in its implementation. The Critical Path Method can be used to schedule project execution time with the consideration that this method is more effective and efficient. The optimization of time and cost is obtained from the Crash Program with the Network Planning system with the Crashing method by adding accelerated working hours for each job. The acceleration is carried out on the work on the critical path with the lowest cost slope. The results of the analysis show that the total project budget under normal conditions is IDR 1,456,082,119 with a duration of 70 days, in the post-crashing condition with the alternative of adding two hours of working hours, it is IDR 2,246,877,528 or more expensive than the total project cost budget under normal conditions. and the duration of the project implementation is 51 working days or faster than the normal duration*

I. INTODUCTION

Construction management is one of the important aspects that greatly affects the cost and time, in the implementation of a project. One aspect that is reviewed from the construction management study in terms of accelerating the implementation of work is the overtime system (increasing working hours), as well as the system for adding workers. Efficiency steps in a project are capital in work according to a predetermined schedule by determining the right equipment and using skilled and efficient costs and time in carrying out the lwork of a project.

Acceleration of project completion must be done with good planning. Given the limited manpower, the alternative commonly used to support the acceleration of activities is to increase working hours so that it affects the total project cost. To know this it is necessary to learn about the existing network, and the relationship between time and cost, it is called Acceleration Analysis.

PaIn this thesis, the author conducts a case study on the IAIN Ambon Library Rehabilitation and Renovation Project Work.Which is a central government program through the Ministry of Public Works and Public Housing (Kementerian PUPR) through the allocation of DAK

APBN funds.IAIN Ambon Library Rehabilitation and Renovation Project WorkThis was established as a government solution in providing a suitable place to be used for students.DevelopmentIAIN Ambon Library Rehabilitation and Renovation Project WorkThis is expected to improve the quality of students in the field of knowledge.IAIN Ambon Library Rehabilitation and Renovation Project WorkThis address is at the IAIN Ambon Campus Area.

Project work delays often occur due to land disputes, material delays, weather influences.KeteProject work delays can be anticipated by accelerating attention to quality standards. Acceleration can be done by providing additional working hours, more productive tools, using materials that are faster to install, and faster construction methods.

The problem in this development project was chosen because it experienced delays in its implementation, the author will analyze the acceleration of project completion with additional working hours. The analytical method that will be used is the Crashing Method. The purpose of this method is to speed up project implementation time and analyze the extent to which time can be shortened by adding costs to activities that can be accelerated during the implementation period so that the maximum acceleration and minimum costs can be known.

II. LITERATURE REVIEW

2.1 ProjectMeaning

Construction project is a series of activities that are carried out only once and generally have a short period of time. A series of activities in a construction project can be divided into 2 types, namely routine activities and project activities. Routine activities are a series of continuous activities that are repeated and last a long time, while project activities are a series of activities that are carried out only once and generally in a short period of time (Ervianto, 2002).

Of a number of organizations involved in the implementation of construction projects, the role of the owner as the initiator of the project is very decisive in making decisions, formulating implementation strategies, and monitoring the progress of work implementation. Meanwhile, consultants provide services in the form of expertise, when the project owner considers that expertise is not sufficiently available in his organization. Meanwhile, the implementation of the work is usually left to the construction service provider. For this purpose, several procedures are known, one of which is a public auction.

2.2 Project Goals and Three Constraints

Dalam achieving the goals and objectives of the project that has been determined there are limitations in a project, namely Triple Constraints or three constraints consisting of:

- feea
- Watime / Schedule
- Mutu

From a technical point of view, the measure of project success is related to the extent to which these three objectives can be met. For this reason, a good arrangement is needed, so that the combination of the three is as desired, namely with project management (Soeharto, 1997).

2.3 Cost

Satu important thing in planning a project is cost. In working on a project, various types of material resources, labor, equipment and so on are needed. This will eventually involve financial problems, namely the problem of project costs and revenues as well as problems of financial receipts and expenditures.

2.3.1 Direct Cost

Direct costs are costs that arise and are directly related to ongoing project activities. Direct costs include:

a. Materials Cost
   The quantity of material or material to be used must be calculated carefully by taking into account the missing material. Material costs from one place to another may differ, this is influenced by material scarcity, transportation costs and material stock.

b. Wage Cost
   feea labor wages vary and depend on the skills and salary standards in which the project is located. This worker's wages include health care costs and occupational accident insurance. Project locations where the cost of living is high, the standard of salary is also high. For areas where it is quite difficult to find workers who have the required skills, it is possible to bring in workers from other areas which will increase the cost of worker mobility and the cost of lodging for workers is quite large.

c. Tool Cost
   For commonly used equipment, it is necessary to consider renting or buying the equipment. Because with a proper analysis and consideration can reduce equipment costs.

d. Sub-Contractor Cost
   This Fee is required if any part of the work is submitted/done by a sub-contractor. These sub-

contractors are responsible and paid for by the main contractor

2.3.2 Indirect Cost

Indirectcost is the cost required for each project activity, but is not directly related to the activity in question and is calculated from the beginning of the project to the end of the project. If the final implementation of the project is delayed from the planned time, these indirect costs will be large, while the number of jobs and the contract value remains, so that the contractor's profit will be reduced even under certain conditions will suffer losses. These indirect costs include:

1. feea Overhead

   feea Overhead are operational costs that support the implementation of work during the project, which includes:
   - Facilitiess while
   - Osecurity guard operational
   - feea for K3 (KesehatandanKeselamatanKerja)

2. Employee salary

   TeIncluded in this cost element are salaries and honoraria for permanent and non-permanent employees/employees involved or not involved in the project that are charged with financing the project.

3. Unforeseen expenses

   feean unexpected is the cost for events that may or may not occur.

4. Profit

   ToThe contractor's profit recommended in the work contract is generally 10% but it also depends on the magnitude of the risk of the work, the greater the risk, the greater the profit set. For contractors, profit is greatly influenced by how much efficiency the contractor concerned can do by reducing the quality, specifications and time of project implementation (YurryWidyatmoko, 2008).

2.4 Scheduling Method

Scheduling can be defined as the time available for the implementation of each part in the context of completing a project in such a way as to achieve optimal results, taking into account the existing limitations.

the factors in the preparation of the schedule are:

1. Sasaproject run
2. Sasacompany run
3. Ketelink in another project
4. Dawhat is needed
5. Daavailablena
6. Watime needed
7. Waavailable time
8. Hari-holiday

9. Towork overtime
10. Srequired resources
11. Savailable resources
12. Keawork force
13. Swagtask completion
14. Uwork house

2.4.1 Techniques in Scheduling

The outline of the techniques in scheduling can be grouped into:

1) **Metoda Bar Chart (Gant Chart)**

   Bar Charts were introduced by Hendry I. Gantt and Frederick W. Taylor in the early 1900s. A bar chart is a list of activities arranged in vertical columns. The horizontal direction column shows the time scale. The start and end of an activity can be seen clearly, while the duration of the activity is described by the length of the bar chart.

   The process of compiling a bar chart is carried out with the following steps:
   - list of activity items, which contains all types of work activities in the development implementation plan.
   - order of work, from the list of activity items, a sequence of work implementation is arranged based on the priority of the activity items to be carried out first and the activity items to be carried out later, without ruling out the possibility of concurrent execution of the work.
   - Work execution time is the implementation period of all activities calculated from the beginning of the activity until the end of all activities. Work execution time is obtained from the sum of the time required to complete each activity item.

   ToThe advantages and benefits of bar charts include:

   1. Befor its graphics and easy to understand by all levels of management, so it can be accepted and used in the implementation widely.
   2. It is a good planning and scheduling tool, requiring only a few refinements (revisions) and updates than sophisticated systems.

   While the limitations and weaknesses of bar charts include:

   1. the relationship between each activity can not be seen clearly.
   2. Diagram rods are not adequate for use in surveillance work, because the activities that determine the speed of time are not clearly visible.

3. Alternatives to improve the schedule for the implementation of other activities cannot be read in the bar chart.

4. if there are one or several activities experiencing delays, then the overall picture is difficult to know exactly to what extent this will affect the overall project schedule

No.	Job Order	Week												
		1	2	3	4	5	6	7	8	9	10	11	12	13
1	Foundation work													
2	Concrete works													
3	Kap's job													
4	Attic Work													
5	Plastering Work													
6	Floor job													
7	Door work													
8	Painting Work													
9	Equipment Work													

Fig.1: Example of a Bar Chart (Gantt Chart) (Yurry, 2008).

2) CPM Method (Critical Path Method)

PaIn this method the work (activity) is represented by two arrows, while the node as a marker of the start and end of a job. The relationship between activities is possible only in the form of a finish to start relationship. In this method, there is a "dummy" which is a facility that can be considered as an activity that has no duration.

CPM is a planning technique based on a network developed from a research effort initiated in 1956 by the engineering services department of the company E.1 du pont de memoirs. According to CPM, most of the work can be reduced in execution time, if human resources, machines, money and so on are added to its implementation.

if this condition is more favorable then the time of completion of the work must be advanced. On the other hand, if there is no reason to shorten a job, the work has a slack of execution time (float), then the work must be carried out normally or normally.
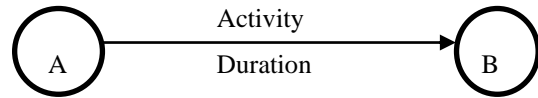
BeHere are 3 terminology on the arrow diagram:

1. Real activity

Activity

Start ⟶ End

Duration

2. Fake activity

Fake activity

Critical
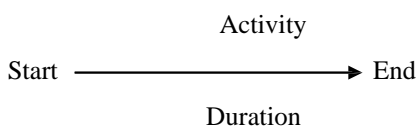
3. Incident
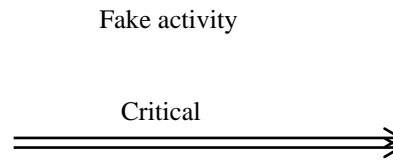
A   Activity   B
     Duration

how much terminology is in the arrow diagram, including:

- **Real activity**
  AReal activity is the implementation of real activities from a job, so it requires human resources, materials, equipment, and other facilities. Real activity is described bygrafis as arrows on the network and the duration of the process is included. Examples are concrete reinforcement work, concrete mold making work, and concrete casting work.

- **Fake Activity**
  AFalse activity is also known as dummy activity and is represented as a dotted arrow. Dummy activities are no different from real activities insofar as they are involved in the logic of the network and should always be required as activities without the dimensions of time and resources.

- **Events**
  Kejadian is the starting point andpointend of an activity. An event does not require time or resources. Graphically, the event is depicted as a circle with a number coded in it and symbolized by an arrow drawn in a straight line and may be broken.

3) Critical Path

To determine activities that are critical, and then determine the critical path, forward calculations and backward calculations can be carried out. Forward calculations are carried out to get the Earliest Start (ES) and Earliest Finish (EF) which are called predecessors. The backward calculation is carried out to get the latest start (LS) and latest finish (LF) which are called successors.

JalCriticalur is characterized by the following conditions:

1. *Earliest Start*(ES) = Latest Start (LS)
2. *Earliest Finish*(EF) = Latest Finish (LF)
3. *Ltest Finish*(LF) – Earliest Start (ES) = Activity duration
4. *Early Start*- the time when all previous tasks were completed

5. *Early finish*- closest start time and time required to complete the task
6. *late finish*- all activities completed without delaying the deadline
7. *Late start*- The last ending time minus the time it took to complete the task.

4) float

*Floats*is the amount of time available in an activity that allows the activity to be delayed or delayed intentionally or unintentionally, but the delay does not cause the project to be delayed in its completion. There are two types of floats, namely total floats and free floats. (Ervianto, 2002).

*Total float*is the amount of time available for delays or delays in the implementation of activities without affecting the completion of the project as a whole.

*Free float*is the amount of time available for delaying or delaying the implementation of activities without affecting the start of activities that immediately follow them. (Ervianto, 2002)

*Independent Float*is the number of delays that can be assigned to each activity without delaying the next activity or limiting the scheduling of the previous activity. Independent Float, (Ifij) for activities (i, j).
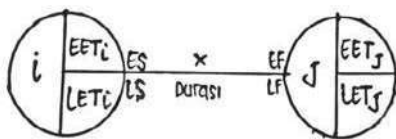
2.5 Accelerate Project Completion Time

Accelerate project completion time is an attempt to complete the project earlier than the completion time under normal circumstances. With the acceleration of this project, there will be a reduction in the duration of the activities that will be held for the crash program. The maximum crash duration of an activity is the shortest duration to complete an activity that is technically still possible assuming the resource is not a bottleneck. The duration of the maximum acceleration is limited by the project area or work location, but there are four factors that can be optimized to accelerate an activity, which include increasing the number of workers, scheduling overtime work, using heavy equipment and changing construction methods in the field. (Ariany, 2010).
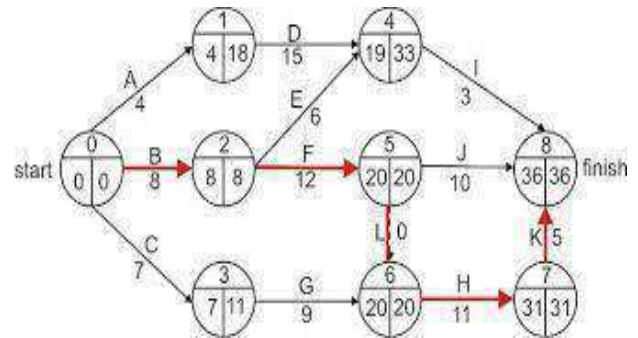

Fig.2: Example of critical path

2.5.1 Additional Working Hours (Overtime)

Speeding up the implementation time of an activity by adding working hours or working overtime is one of the efforts to increase work productivity so that it can speed up the implementation time of an activity. The overtime work plan is:

- Normal working time is 8 hours (08.00 – 17.00), while overtime work is done after normal working time.
- pricea. wages of workers for overtime work according to the Decree of the Minister of Manpower Number KEP.102/MEN/VI/2004 article 11 concerning Overtime Work and Overtime Wages:
  - for the first 1 hour of overtime work is 1.5 (one and a half) times the hourly wage.
  - For each subsequent hour of overtime work must be paid 2 (two) times the hourly wage.

DaFrom the description above can be formulated as follows

Overtimefee per day = (first hour of overtime x 1.5 x normal hourly wage) + (next hour of overtime work x 2 normal hourly pay).

Table.1: Coefficient of Productivity During Overtime

overtime hours (hours)	Productivity Index Decrease	Performance (per hour)	Percentage of Work Performance (%)	Productivity Reduction Coefficien
a	b	c=b*a	d	e=100%-D
a				
1	0,1	0,1	10	0,9
2	0,1	0,2	20	0,8
3	0,1	0,3	30	0,7
4	0,1	0,4	40	0,6

(Source: Fredrika, Ariany. 2010)

2.6 Understanding Crashing

*Crashing*is a deliberate, systematic and analytic process by testing all activities in a project centered on activities that are on the critical path. The crashing process is done by estimating the variable costs in determining the maximum and most economical reduction in the duration of an activity that is still possible

to be reduced. This process seems simple, but is in fact very complex. There are various ways to reduce the duration of a project and many combinations of activity duration and cost must be considered in a detailed analysis.

2.6.1 Process Crash

Speeding up the implementation of a project must be designed in advance. This can result in a good duration acceleration. It is necessary to pay attention to balance in the design, even though it may be with the consequence of increasing human resources. But as long as adding human resources is still cheaper than extra payments due to project delays, then the addition of human resources can be taken into account.

Generally, when the execution time of a job is shortened (crashing), the direct costs will increase. Planning based on the lowest direct cost is not necessarily the best, because it is synonymous with a long time, even though the total cost of the project, including indirect costs, also affects the implementation time.

Accelerating the duration of an activity will increase costs, but will not necessarily shorten the overall project time, unless the activity is a critical activity. That is why we need the best combination of activities that accelerate the duration of their implementation in producing the most economical project time, where our goal is to complete a technical and economical project requires a careful calculation to where we can shorten the time by adding the smallest possible cost. .

Activities in a project can be accelerated in various ways, namely:

* By holding work shifts, it means additional costs in the form of costs for lighting, meals and so on.
* By extending working time (overtime).
* By using more productive tools.
* Increase the number of workers.
* By using materials that can be installed faster
* Using another construction method which is faster.
* Subcontracting an activity.

To implement the use of multiple shifts in the work is more suitable if the duration set by the project owner is very short. However, so that the set duration is quite reasonable, this should be avoided. Because if you do a shift, you have to consider various things, such as lighting, support services, safety and productivity. Usually with the use of shifts, the costs incurred will exceed the budget plan set for the use of facilities for work services and decrease worker productivity. So, it can be said that the use of shifts in a job will increase the costs that must be incurred. However, it can dramatically

reduce or reduce the duration of work up to 50% of the set duration (Tarore and Mandagi, 2006). Extending work time helps reduce the overall time of an activity. Workers are employed up to 10-12 hours/day, this can reduce the duration of an activity by up to 33%. Additional costs for providing work service facilities as well as declining productivity of workers continue to occur. The most common method used to shorten project duration is assigning additional labor and equipment to each activity. However, it also has advantages and disadvantages. The speed gained, however, remains limited even if adding more workers doubling the size of the workforce will not reduce project completion time by half. Additional costs for providing work service facilities as well as declining productivity of workers continue to occur. The most common method used to shorten project duration is assigning additional labor and equipment to each activity. However, it also has advantages and disadvantages. The speed gained, however, remains limited even if adding more workers doubling the size of the workforce will not reduce project completion time by half. Additional costs for providing work service facilities as well as declining productivity of workers continue to occur. The most common method used to shorten project duration is assigning additional labor and equipment to each activity. However, it also has advantages and disadvantages. The speed gained, however, remains limited even if adding more workers doubling the size of the workforce will not reduce project completion time by half.

To further analyze the relationship between costs and the time of an activity, several terms are used, namely: normal period / Normal Duration (ND), shortened period / Crash Duration (CD), Normal cost / Normal Cost (NC), and Cost for time. shortened/Crash Cost (CC). Below is a graph of the normal and abbreviated time-cost relationship for an activity.
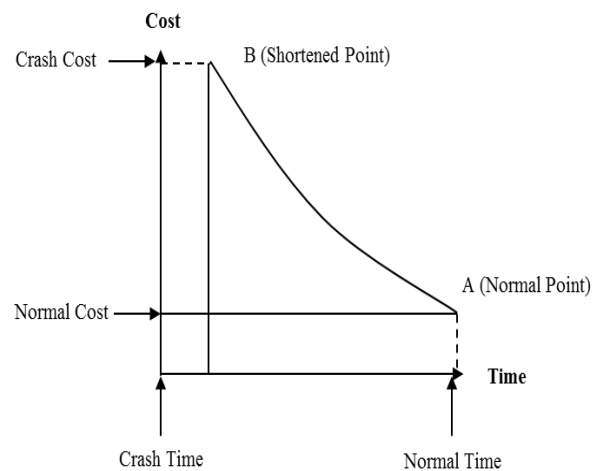
Gbr.3: Graph of normal and shortened time-cost relationship for an activity (Soeharto, 1997)

On Figure 3 point A shows the normal point, while point B is the shortened point. The line connecting point A with B is called the time-cost curve. In general, this line can be considered as a straight line, if not (for example, concave) then the calculation of a segment consisting of several straight lines is carried out. If you know the shape of the time curve for the cost of an activity, it means that by knowing what the slope or angle of inclination is, you can calculate how much it will cost to shorten the time of one day.

The additional direct cost of accelerating an activity per unit time is called the cost slope.

Pethe cost slope formula is as follows:

$$Cost\ Slope = \frac{Crash\ Cost - Normal\ Cost}{Normal\ Durasi - Crash\ Durasi}$$

2.6.2 Cost-Time Relationship

feea total project is the sum of the direct costs and indirect costs used during project implementation. The amount of this cost is highly dependent on the length of time (duration) of project completion, both of which change according to the time and progress of the project. Although it cannot be calculated by a certain formula, in general, the longer the project runs, the higher the cumulative indirect costs required. Figure 4 shows the relationship of direct costs, indirect costs and total costs in a graph and it can be seen that the optimum cost is obtained by finding the smallest total project cost.
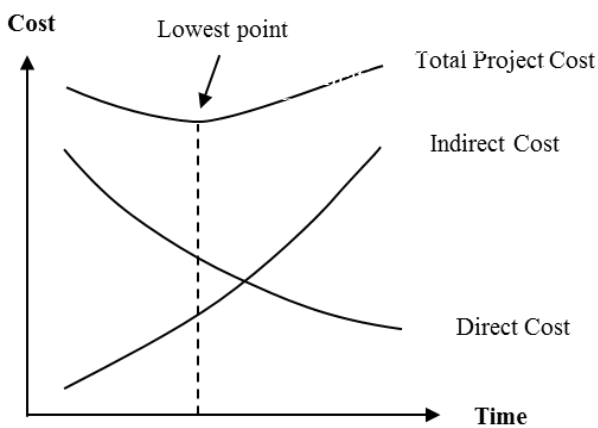

Fig.4: Graph of the relationship of time with total costs, direct costs, and indirect costs(Soeharto, 1997)

PThe procedure for shortening the time is described as follows:

1. calculate project completion time and identify floats using normal timeframes.
2. determine the normal cost of each activity.
3. determine the accelerated cost of each activity.
4. calculate the cost slope of each component of the activity.

5. shorten the period of activity, starting with the critical activity that has the lowest cost slope.
6. Billa in the process of accelerating the project time a new critical path is formed, then accelerate the critical activities that have the lowest combination of cost slopes.
7. continue to shorten the activity time until the project point is shortened
8. Btabulate the cost versus time, plot it in a graph and connect the normal points (normal cost and time), the points that are formed each time the activity shortens, up to the TPD points (Shortened Project Points).
9. HitTake the indirect costs of the project and depict them in the graph above.
10. JAdd up direct costs and indirect costs to find the total cost before the desired timeframe.
11. Pecheck the total cost graph to achieve the optimal time, namely the project completion period with the lowest cost (Soeharto, 1997).

III. METHODOLOGY

3.1. Research sites

StThis case study was conducted on the IAIN Ambon Library Rehabilitation and Renovation Project which is located in the Ambon City IAIN Ambon Campus Area. PT. Laleva Indah Lestari who is the Executing Contractor.

Fig.5: Research Site Map

3.2. Data collection technique

to obtained data that can be verified, relevant, and complete, then the author uses a method or technique in collecting the data. The data collection methods used in this research are

1. Field Observation

Field Observation intake was carried out to obtain primary data by conducting a direct survey on the IAIN Ambon Library Rehabilitation and Renovation Project Work which became the object of research, namely to obtain information or documentation through interviews with implementing contractors, and workers at the project site and related parties in the room. the scope of the project. Project documentation and project data archives obtained from the contractor, namely PT. Laleva Indah Lestari

2. Literature Study

Studiesbibliography is carried out to obtain secondary data to support the primary data obtained. This secondary data collection was carried out by reading and studying books, lecture notes, browsing the internet and journals related to the problem of implementing additional working hours and labor in the IAIN Ambon Library Rehabilitation and Renovation Project Work.

3.3. Data Type

The types of data used in this writing are:

1 Primary data

Represents data that can only be obtained from the original or first source. This primary data is formenget information or documentation of the project work process to be observedin the form of interviews with parties involved in project implementation such as the components of indirect costs and the causes of delays in implementation

2 Secondary Data

Secondary data is data that is already available obtained from the relevant agencies as follows:

a) S . curve
b) Budget plan
c) Price list for wages and materials
d) Shop Drawing

3.4. Data source

The data obtained for this writing is sourced from the library method, journals and documents from the project planner.

3.5. Research Stages

The stages that need to be carried out in this research are as follows:

1. Secondary data collection.
2. Network Diagram Preparation
   The steps for compiling a network diagram are:
   – Define / describe each work item
   – Determine interrelated activities, activities that precede other activities (predecessors)

– Compile the duration of each work item based on the scheduling data of each activity
– Determine the critical path

3. Calculate the normal cost of each activity
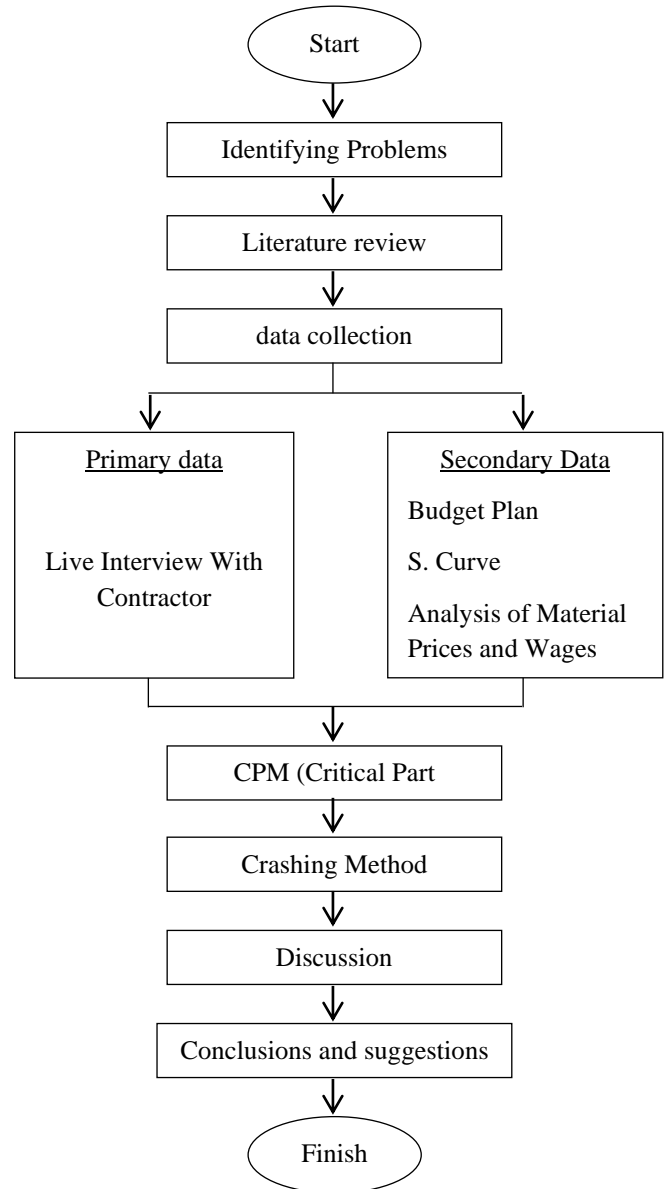4. Implementing Crashing Scenarios

3.6. Research Flowchart

Fig.6: Research Flowchart

IV. ANALYSIS AND DISCUSSION

4.1. Project Data

The project used as a case study in this research is the IAIN Ambon Library Rehabilitation and Renovation Development Project, which is located at the Ambon City IAIN Campus Area, Ambon City. This project was chosen as a case study in this research because its

implementation was delayed, so it was necessary to accelerate so that the project could be completed on time or even faster than the normal duration of planning. In this study, only activities that are accelerated on the critical path are accelerated. The project data are as follows:

1. Project name   :Rehabilitation Development and IAIN Ambon Library Renovation
2. Peproperty of Project   : PUPR Service
3. Pelike Project   :PT. Anugrah Putra Perkasa Jo PT. Laleva Indah Lestari
4. Peproject plans   : CV. Data Teknik
5. Supervise Project   : PT. Bintang Perkasa Sejati Jo CV. Pesona Consultant
6. Project Location   : IAIN Ambon City Campus Ambon
7. Project Duration   : 70 calendar days
8. Ssource of funds   : DAK APBN 2020

4.2. Determination of the Critical Path using CPM

In calculating the Critical Part Method (CPM), the job description, activity code, and duration must first be determined which can be seen in the table below.

Table.2: Jobs on the Critical Path

No.	Job description	Activity Code	Normal Duration (Day)
1	Termite work	A	7
2	K1. Column Work	B	21
3	B1. beam work	E	14
4	G1. beam work	F	14
5	Floor Plate Work Elev+0.00 S2	I	14

(Source: Analysis Results)

Table.3:Dependency Calculation

ACT.	DUR.	ES	EF	LS	LF	TF	FF	DESC.
A	7	0	7	0	7	0	0	Critical
B	21	7	28	7	28	0	0	Critical
C	14	7	21	28	42	21	0	Non Kritis
D	7	28	35	35	42	7	0	Non Critical
E	14	28	42	28	42	0	0	Critical
F	14	42	56	42	56	0	0	Critical
G	14	35	49	42	56	7	0	Non Critical
H	14	21	35	42	56	21	0	Non Critical
I	14	56	70	56	70	0	0	Critical

(Source: Analysis Results)

4.3. Accelerate Duration By Adding Working Hours

The productivity of each worker per day has been known from the previous analysis with a normal working hour duration of 8 hours/day. So that the duration of crashing will be calculated by adding two hours of work per day by considering the decrease in labor productivity during overtime hours.

Calculation of Crashing Duration on termite-proof work that is on the Critical path is as follows:

Normal Daily Productivity $= \dfrac{volume}{normal\ normal}$

$= \dfrac{1\ m3}{7\ hari}$

$= 0.14 \text{m3/day}$

Productivity per hour $= \dfrac{daily\ productivity}{working\ hours}$

$= \dfrac{0,14\ m3/day}{8\ jam}$

$= 0.02 \text{ m}^3\text{/hour}$

Overtime productivity $= 2 \times$ Productivity per hour $\times 0.80$

$= 2 \times 0.02 \text{ m}^3\text{/hour} \times 0.80$

$= 0.03 \text{ m}^3\text{/hour}$

Daily productivity acceleration $=$ Normal daily productivity $+$ Overtime hours

$= 0.14 \text{ m}^3\text{/day} + 0.03 \text{ m}^3\text{/day}$

$= 0.17 \text{ m}^3\text{/day}$

Crash duration $= \dfrac{volume}{productivity\ after\ crash}$

$= \dfrac{1\ m3}{0,17\ m3/days}$

$= 6 \text{ days}$

4.4. Calculation using the crashing method

In accelerating the duration of the project, it is usually carried out on jobs that have a critical path. Because the activities that have a major influence on the project on the critical path.

The stipulations on the plan for the alternative of adding working hours are as follows:

1. Normal working time is 8 hours of work per day (08-00-17.00) with 1 hour (12.00-13.00), while overtime work is done after normal working time of 2 hours per day (18.00-20.00).
2. In the decision of the Minister of Manpower Number KEP.102/MEN/VI/2004 article 3, article 7 and article 11 the standard overtime pay is:
   a. Overtime work can only be done for a maximum of 4 (four) hours in 1 (one) day and 14 (fourteen) hours in 1 (one) week.
   b. Provide food and drinks of at least 1,400 calories if overtime work is carried out for 3 hours or more.
   c. For the first overtime work must be 1.5 times the hourly wage.
   d. For each subsequent hour of overtime work must be paid wages equal to 2 times the wages of 1 hour.
3. Productivity for overtime hours can be seen in table 1.

4.4.1 Daily, Normal and Accelerated Productivity Calculation

Accelerated daily productivity is obtained from the number of normal daily productivity with work productivity during overtime hours per day. The addition of overtime hours according to applicable regulations is carried out for 2 hours per day, while the productivity of overtime workers has decreased and is calculated at 80% of the productivity of regular working hours.

For more details on the amount of labor wages in this project, see the following table:

The steps for calculating daily productivity for critical work acceleration are as follows:

a. Calculating the volume of work
b. Calculating normal duration
c. Calculating normal daily productivity
d. Calculating normal cost
e. Normal productivity/hour
f. Overtime productivity
g. Accelerated daily productivity

Example :

Calculation of normal daily productivity onTermite work

a. Job volume   = 1 m3
b. Unit price   = IDR. 5,000,000
c. Normal Duration   = 7 days
d. Normal Cost   = unit price × volume
                                 = IDR 5,0000.00 × 1 m3
                                 = IDR 5,000,000
e. Normal daily productivity $= \dfrac{job\ volume}{Normal\ Duration}$

$= \dfrac{1\ m3}{7\ Day}$

= 0,14 m3/day

f. Normalproductivity/hour $= \dfrac{Normal\ daily\ productivity}{normal\ working\ time}$

$= \dfrac{0,14\ m3/day}{8\ Hour}$

= 0,02 m3/hour

g. Overtime productivity   = 2 × normal productivity/hour × 0.80

= 2 × 0.02 m3/h × 0.8

=0.03 hours

h. Accelerated daily productivity = daily normal productivity + overtime productivity

= 0.143 m3/day + 0.029 m3/hour

= 0,17 hours

4.4.2 Calculation of Crash duration, Crash cost, and Cost slope

After knowing the daily productivity of critical work acceleration, the next step is to calculate the duration of the acceleration (crash duration) and the direct cost of acceleration (crash cost). This crash duration calculation is used to get the maximum time limit for an activity to be able to crash. While the crash cost calculation is used to find the cost slope of each activity.

To determine the Crash cost can be done with the following steps:

a. Calculating normal daily wages, i.e. daily productivity × price of one working wage
b. Calculating normal work wages, i.e. productivity per hour × unit price of work wages
c. Calculating overtime work per day
   For 2 hours of overtime = (1.5 × normal hourly wage) + 2(2 × normal hourly wage)
d. Calculating crash cost per day, i.e. daily wage acceleration × crash duration

An example of calculating crash duration for an Anti-Termite job that is on a critical path is as follows:

Anti termite work

a. Normal cost   =IDR 5,000,000
b. Normal duration   = 7 days
c. Normal productivity/day   =0.143 days
d. Normal productivity/hour   = 0.02 hours
e. Productivity overtime/hour   = 0.029hours
f. Accelerated daily productivity = 0.017m2/day
g. Crash Duration=$\dfrac{job\ volume}{daily\ productivity\ acceleration}$

$= \dfrac{1.00}{0,017}$

= 6 days

h. Normal wage/hour   =unit price × normal productivity/hour

      = IDR 5.000.000 × 0,02

hours

      = IDR 90,000

i. Normal wage/day   = normal wage/hour × 8
hours

      = IDR 90,000 × 8 hours

      = IDR 720,000

j. Wage 2 hours overtime/day = (1.5 × normal wage/hour) + 2×(2×normal wage/hour

      = (1.5 × IDR 90,000) + 2 (2× IDR 90,000)

      = IDR 495,000

k. Acceleration fee/day   = normal wage/day + 2 hours overtime wages

      = IDR 720,000 + IDR 495,000

      = IDR 1,215,000

l. Crash cost   = acceleration wage/day × crash duration

      = IDR 1,215,000 x 6 days

      = IDR 7,290,000.00

m. Cost Slope$=\dfrac{crash\ cost-normal\ cost}{Normal\ Duration\ -Crash\ duration}$

$=\dfrac{IDR\ 7.290.000-\ IDR\ 5.000.000}{7-6}$

= IDR 2,290,000.00

Table.4: Calculation results of crash duration, crash cost and cost slope

Job description	Normal	Normal Cost (IDR)	Crash	Crash Cost (IDR)	Cost Slope (IDR)
Termite Work	7	5,000,000	6	7,290,000	2,290,000
1 floor structure					
K1. Column Work	21	145,994,542	14	169,907,441	11.007.525
B1. Beam Work	14	109,582,798	7	166.221.098	.87,737,128
G1. Beam Work	14	245,464,482	12	345,184,427	130,731,566
Floor Plate Work Elev+ 0.00 S2	14	177.211.607	12	303,169,791	140,855,650

(Source: Analysis Results)

4.5. Cost Analysis

After completing the acceleration analysis process and getting the duration of the acceleration, it will then calculate the total and project costs under normal conditions and in conditions after acceleration. The total cost of the project consists of direct costs and indirect costs as follows:

Project duration   : 70 calendar days

Total project cost   : IDR 1,456,082.119

a. Profit   = Total project cost x 10%
= IDR 1,456,082,119 x 10%

      = IDR 145,608,212

b. Overhead costs   = Total Project cost x 5%
= IDR 1,456,082,119 x 5%

      = IDR 72.804.106

c. Overhead per day $=\dfrac{feea\ overhead}{Normal\ Duration}$

$=\dfrac{72.804.106}{70\ days}$

= IDR 1,040,059

After getting the value of profit and overhead costs, then the next step is to calculate the direct costs and indirect costs.

Normal Condition

1. Direct cost   = 85 % × total project cost

      = 85 % × Rp. 1,456,082.119

      = IDR 1,237,669,801

2. Indirect costs   = profit + overhead cost

      = IDR 145,608,212+ IDR 72.804.106

      = IDR 218,412,318

3. Total cost   = Direct Cost + Indirect Cost

      = IDR 1,237,669,801+ IDR 218,412,318

      = IDR 1,456,082.119

Crash Condition

1. Direct cost   = normal cost + total cost slope

      = Rp.1,237,669,801+ Rp.611,905,321

= Rp1,849,575,122

2. Indirect costs = (crashing duration × overhead per day) + profit

= (51 × IDR 1,040,059) + IDR 145,608,212

= IDR 198,651,203

3. Total cost after crash = direct cost + indirect cost

= IDR 1,849,575,122+ IDR 198,651,203

=IDR 2,048,226,325

Table.5: Smallest to Largest Cost Slope

ID	JOBDESCRIPTION	NORMAL DURATION	CRASH DURATION	COST SLOPE (IDR)
1	TERMITE WORK	7	6	2,290,000
2	K1. COLUMN WORK	21	14	11.007.525
3	B1. BEAMWORK	14	7	87,737,128
4	G1. BEAMWOK	14	12	130,731,566

7	FLOOR PLATE Elev+0.00 S2	14	12	140,855,650

(Source: Analysis Results)

Table.6: Comparison of Project Duration and Costs

	Duration (Days)	Direct Cost (IDR)	Indirect Cost(IDR)	Total Cost (IDR)
Normal Project	70	1,237,669,801	218,412,318	1,456,082.119
Accelerated Project	51	2,048,226,325	198,651,203	2,246,877,528
Difference	19	810,556,524	19,761.114	790,795,409

(source: Analysis Results)

Table 5 shows that the shorter the project duration, the greater the direct costs and indirect costs decreased. The total cost is obtained from the sum of the direct and indirect costs.
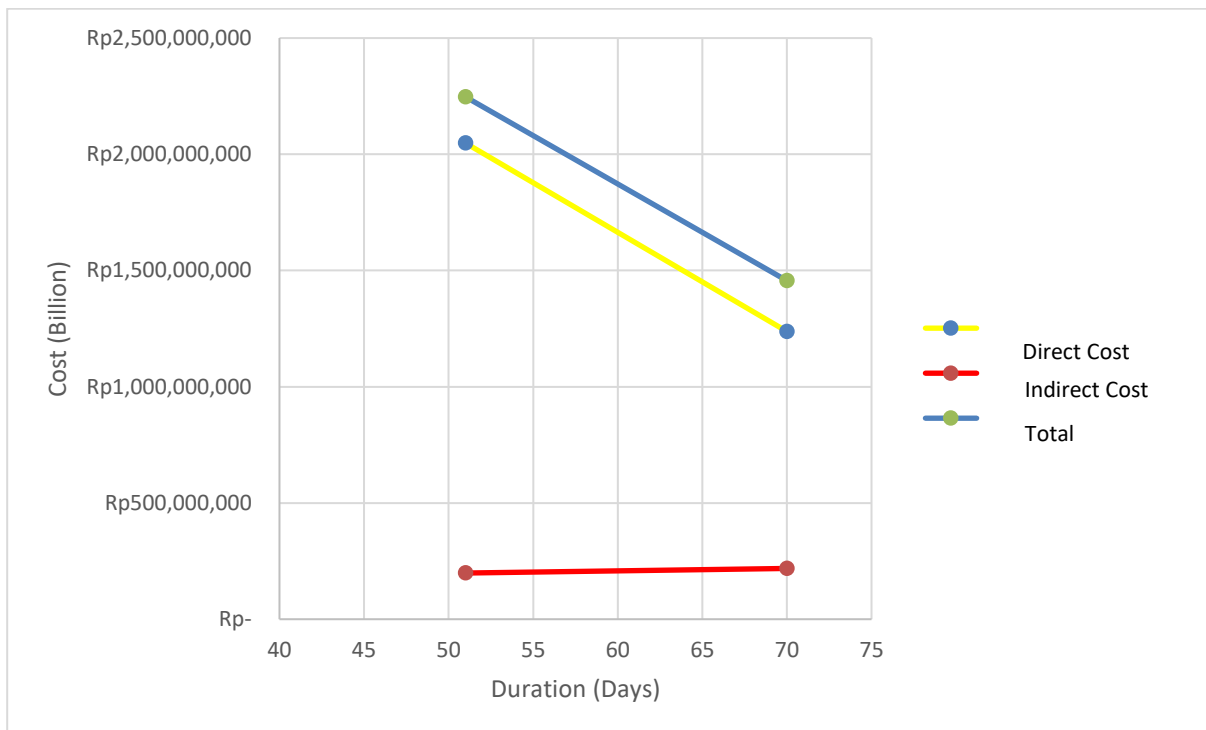

Fig.5: Time-Cost Relationship Graph

From the analysis above, the crashing time is 51 days with an acceleration time of 19 days from the normal 70 days, with a direct cost of Rp.2,048,226,325and the indirect costs are Rp198,651,203Accelerated project

duration not only affects direct costs but also indirect costs under normal conditions. This effect causes a decrease in indirect costs of Rp19,761.114and an additional direct cost of Rp.790,795,409

V. CONCLUSIONS AND SUGGESTIONS

5.1. Conclusions

Based on the results of the analysis and discussion, this study can draw the following conclusions:

1. After accelerating the duration, the duration obtained when accelerating is 51 working days from the normal duration of 70 working days

2. The total cost of the project under normal conditions is IDR 1,456,082,119 with a project implementation duration of 70 working days. From the results of the analysis in this study, the total cost of the project in post-crashing conditions with the alternative of additional working hours for 2 hours was IDR 2,246,877,528 or more expensive than the project cost under normal conditions and the duration of project implementation was 51 working days or faster.of normal duration.

3. The critical steps in the IAIN Ambon Library Rehabilitation and Renovation development project using the CPM Method are Termite Anti-termite Work, K1. Column Work, B1. Beam Work, G2. Beam Work, G3. Beam Work, Floor Plate Work Elev+4.00 S1 and Floor Plate Work Elev + 0.00 S2

5.2. Suggestions

Based on the results of the research that has been done and the conclusions above, the authors provide the following suggestions:

1. WhenIf there is a delay, it should be accelerated by speeding up work on the critical path to make it more efficient. Acceleration can be in the form of adding overtime hours, adding tools, adding work groups, or by working ship.

2. This study only analyzes the time and cost of structural work, so for further research, this research would be better if time and cost analysis were carried out on all project work items, both architectural work, mechanical work and electrical work.

REFERENCES

[1]   Anggraeni, 2016. Analysis of Project Acceleration Using the Crashing Method with Additional Manpower and Work Shifts. Thesis. (Unpublished), Eleven March University.

[2]   Azzam, 2016. Analysis of Java Village Resort Development Project Acceleration By Adding Working Hours. Thesis. (Unpublished), Indonesian Islamic University.

[3]   Budiono, 2006. Simulation of Time and Cost of PIER Construction on the Suprapto Jakarta Flyover. Jakarta : University of Indonesia.

[4]   Ervianto, 2002. Construction Project Management, First Edition. Yogyakarta :SalembaEmpat.

[5]   Ervianto, 2003. Construction Project Management, Revised Edition. Yogyakarta :Andi.

[6]   Ervianto, 2004. Construction Project Management Application Theory. Yogyakarta SalembaEmpat.

[7]   Ervianto, 2005. Construction Project Management, Revised Edition. Yogyakarta :Andi.

[8]   Frederika, 2010. Analysis of Acceleration of Implementation by Increasing Optimum Working Hours on Construction Projects (Case Study: Super Villa Development Project, Pet Tenget-Bandung), (JournalOnline). (Unpublished)

[9]   http://www.scribd.com/document/205836025/Jurnal-Analisis-Percepatan-Percepatan-Percepatan-Percepatan-Percepatan-Percepatan- Implementing-With-Menambah-Jam-Optimum-Kerja-Optimum-Pada-Proyek-Construction, accessed on 23 April 2017.

[10] Hanna, 2008. Impact Of Shift Work On Labor Productivity For Labor Intensive Contractor. Journal of Construction Engineering And Management.

[11] Husen, 2009. Project Management: Planning, Scheduling, and Project Control. Yogyakarta :Andi.

[12] Iramutyn, 2010. Optimization of Time and Cost with Crash Method. Thesis. (Unpublished), Eleven March University.

[13] Kerzner, 2000. Project Management A System Approach to Planning, Scheduling and Controlling.Singapore.

[14] Decree of the Minister of Manpower No. KEP-102/MEN/VI/2004 concerning Overtime Working Time and Overtime Wage (online). (Unpublished), https://www.scribd.com/doc/131149015/KEPMEN-102-MEN-VI-2004 accessed on 23 April 2017.

[15] Ningrum, 2016. Application of the Crashing Method in Accelerating Project Duration With Alternatives to Adding Overtime and Shift Work. Thesis. (Unpublished), Eleven March University.

Air Quality Analysis in a Public Building in the Municipality of Olinda/PE

Alaide Maria Peixoto Pereira[1], Luiz Filipe Alves Cordeiro[2], Daniele de Castro Pessoa de Melo[3], Waléria Guerreiro Lima[4], Amanda Peixoto Pereira[5]

[1]Technological Institute of Pernambuco, Recife, Pernambuco, Brazil
[4]University Guararapes, Recife, Pernambuco, Brazil
[5]University of Pernambuco, Recife, Pernambuco, Brazil;

Abstract— *The analysis of air quality is directly related to the health preservation of individuals who attend closed environments, climatized or not, and this factor can be linked to the place (un)salubrity. Certain polluting factors are potentiated by the lack of natural ventilation; in other cases, depending on the region, the natural circulation of wind is what brings pollution to the place. Considering that all environments can be affected by a sanitary decrease promoted by low air quality, the present work aims to analyze the air contamination indices of the Forum Lourenço José Ribeiro, located in the municipality of Olinda/PE. The methodology uses exploratory research in a case study to be carried out by obtaining quantitative data on carbon dioxide (CO_2) indices, internal temperature and relative air humidity that were measured between february and june/2021, in the morning shift of the aforementioned building. The present work is limited to the breadth of the data to be researched, and it should also be considered that the researched period faced the limitation of face-to-face activities motivated by the Coronavirus pandemic, which substantially reduced the amount of exposed and polluting people in the premises Results obtained indicate a good indoor air quality in the evaluated rooms, both for users, servers and occupants of sealed and artificially air-conditioned spaces, with good air renewal. Future work should be guided by the search for solutions capable of improving the natural ventilation of the researched environments, in addition to research carried out during the face-to-face working hours of the servers of the Forum Lourenço José Ribeiro.*

I. INTRODUCTION

The environment is a collective good of individual and general entertainment at the same time. In this way, the right to the environment belongs to each person, but not only to them, presenting a trans-individual dimension. For this reason, the right to a healthy environment enters the category of diffuse interest and integrates as guarantees belonging to the entire current and present generation. Among the institutes covered by Environmental Law, the air stands out in this matter (MACHADO, 2016).

The maintenance of this legal protection consists of the maintenance of this environmental asset for the maintenance of life on the planet. Considered a good for use by the people and protected by the range of diffuse rights,

whether those belonging to the current and future generations, the clean air is positive as a right provided for in the National Environmental Policy (Law n. 6.938/1981) and it must be guaranteed for all through the work of the Government and civil society (YOSHIDA; GUERRA, 2017).

Within urban scenarios with intense human activity, the properties of the air are severely compromised by the pollution factor. This finding demands greater rigor in initiatives aimed at implementing environmental guarantees of clean air. In the Judiciary context, Brazilian courts are socially relevant actors at the forefront of environmental banners and must therefore adopt sustainability policies that carry out environmental precepts, including those related to clean air, to exalt socio-environmental responsibility practices and also on behalf of preserving the health of public servants and civil society that access these public buildings.

It is well known that the various environmental emergencies aimed at the degradation and pollution of natural resources require from all of us greater rigor in the conduct of attitudes that can generate harmful results to the environment and ensure the healthy quality of life of human beings, so that the creation of a sustainable and socio-environmentally correct place is among the most relevant factors in the contemporary scenario, and the Public Power is a strategic figure in the socio-environmental agenda (TEIXEIRA; BRESSANE; NÓBREGA, 2019).

The concern with the quality of the air must be especially conducted in places of great human circulation. The greater the collectivity presence, the greater the reflection in the degradation of an environment, since every human action causes some repercussions on natural factors. Thus, preventive and restorative initiatives must go hand in hand in the search for a balance between social interests and environmental standards (CUNHA; AUGUSTIN, 2014).

That said, the case study proposed here goes back to analyzing the air quality at the Lourenço José Ribeiro Forum, located in Olinda city and an organ that makes up the structure of the Pernambuco Judiciary (CORDEIRO, 2019). As it is a public building and with intense circulation of servers, jurisdictions and other employees, the air quality in a place with these characteristics has the power to affect unspeakable people, which requires the State - represented here by the Judiciary State of Pernambuco - to act in accordance with the diffuse protection recommended by the Federal Constitution.

Among the objectives of the present work, the general objective is to analyze the air contamination rates of the Forum Lourenço José Ribeiro, located in the municipality of Olinda/PE.

II. BIBLIOGRAPHIC REVIEW

Air pollution is one of the major causes of human deaths in the world today, and the monitoring of air quality is one of the main tools to produce public policies for pollution control, in order to maintain safe levels of pollutants in the atmosphere. (TEIXEIRA *et al.,* 2019)

By protecting the health of the air, the right natural conditions for the development and maintenance of human life will automatically be guaranteed, taking into account that there have never been so many sources of pollution in progress.

Air pollution, both environmental (outdoor) and domestic (indoor), is the biggest environmental health risk, leading to responsibility for about one in nine deaths annually. (TEIXEIRA *et al.,* 2019)

Silva and Mendes (2006) advocate that, in urban areas, the typical anthropogenic polluting sources are, especially, car traffic and, when existing, industrial activity. Subsequently, Almeida *et al.* (2019) conclude that monitoring air pollution indices can be a useful tool for the safety of human health and the environment, as it ensures public planning aimed at controlling humanly healthy levels.

Garcia and Aquino (2019) assert that the social function of the State has come to the point of being urged to guide the feasibility for the development of urban policies in Brazil (CORDEIRO, 2015).

2.1 Legal Protections of the Right to Clean Air and the Sick Building Syndrome (SED)

Everyone has the right to an ecologically balanced environment, good for common use by the people and essential to a healthy life quality, imposing on the Public Power and the community the duty to protect and preserve it for present and future generations (BRAZIL, 1990).

The balanced work environment is a topic of profound importance and relevance, whose systematization and normative construction was provided by the 1988 Constitution of Brazil Federative Republic (BRAZIL, 1990), as a result of the broad and comprehensive constitutional protection given to the environment, housing all its innumerable aspects, whether of the natural environment, or of the artificial environment, including work (MARTINS; BERTOTTI, 2019).

Resolution n. 09 of the National Health Surveillance Agency (ANVISA), sought to improve the reference standards of Indoor Air Quality in artificially air-conditioned environments for public and collective use, based on the knowledge and experience acquired in the country in both first years of its validity, considering the sanitary interest in the dissemination of the subject; in

addition to the concern with the health, safety, well-being and comfort of the occupants of air-conditioned environments; the current state of knowledge of the international scientific community in the area of indoor environmental air quality, which establishes reference standards and/or guidelines for this control, among others (BRAZIL, 2003).

It should be noted that despite the legal provision referring to internal environments, external environments are also exposed to polluting factors. However, for human health purposes, the greatest risk occurs when there is no natural circulation of wind, which underlies the concern of the legislator with such spaces. In these terms, Comin (2016) highlights that air quality is directly associated with human health and environmental pollution is a fatal indicator for man. The aforementioned notion was appropriated by science from episodes of acute air pollution in European cities and the United States since the beginning of the 20th century. The author records that the most drastic example of human harm from air pollution occurred in 1952, in England, after a thermal inversion in the winter period that prevented the dispersion of particulate matter resulting from industrial activity and home fireplaces. In three days, 4,000 citizens lost their lives due to a cloud of sulfur-rich pollution parked over the city.

The same Comin (2016) teaches that, since the mid-1970s, there have been studies on indoor air quality (QAI). In this period, civil construction had already reliably adopted the verticalization of urban centers, which increased the number of sealed buildings, buildings with low capacity for air exchange between internal and external environments, which leads to an increase in concentration of chemical and microbiological pollutants inside these buildings.

The deficiency in ventilation, according to the author, caused the so-called Sick Building Syndrome (SED), a problem recognized by the World Health Organization (WHO) since the mid-1980s. The international entity shows concern with SED because the social routine demands that people spend about 50 to 70% of their day indoors, between residence, transport and work environment.

In the 1980s, a working group from the World Health Organization (WHO) sought to systematize these signs and symptoms and encompassed them in what became known as the Sick Building Syndrome (SED) or Sick Building Syndrome. This syndrome is classified as a public health problem by the WHO, and is characterized by situations of discomfort at work and/or acute health problems, reported by workers, which seems to be related to staying inside some buildings (SILVA, 2017).

Abrava (2021) details that, in sealed environments, indoor air conditioning systems aim at the concomitant control of temperature, humidity, renewal to reduce CO_2, movement and air quality of the place, as well as influencing the control of internal pressure in relation to the close environments and that cold air does not mean good quality air. Based on these data, environmental monitoring becomes a top priority action in public and private initiatives, given the concentration of people who circulate daily in these places.

It derives from this that environmental criteria are maxims to be observed by all sectors of society in the name of a common interest. Based on the growing concern with sustainability and taking into account the overcoming of the predatory model of facing the natural heritage, which warns about the depletion of nature's capacity to restore the standard of environmental balance, human societies need to adapt their demands to the leading role of the environment cause, which will never be surpassed. Framing man as an animal that needs balance in its habitat requires that new criteria and social configurations be implemented so that life on earth continues to be possible.

In this support, the Public Power has been gathering efforts in order to be an actor that leads the ecologically correct example and remodels the gears of public administration to adapt to this new standard of reverence for environmentally adequate conditions. Regarding the protection of the air, the guardianship was inaugurated with Resolution n. 05 of the National Environment Council (CONAMA, 1989), which instituted the National Air Quality Control Program (PRONAR) when taking into account the increase in atmospheric pollution, the growing use of urban spaces and of vehicles and the need to establish guidelines for the control, preservation and recovery of air quality at the national level.

The strategies adopted by CONAMA (1989) Resolution n. 05 determine the maximum emission limits of pollutants, the standardization of air quality at the national level, the prevention of air deterioration, the monitoring of air quality, the management of the polluting sources licensing and the national identification of all air polluting sources.

Once the normative and scientific bases that revolve around the matter are understood, it is worth noting that all public buildings must be operating in accordance with the aforementioned environmental rules, which allows an analysis of air quality indicators at the Lourenço José Ribeiro Forum, located in the city of Olinda/Pernambuco and a building belonging to the patrimony of the Court of Justice of Pernambuco.

As mentioned elsewhere, the public building in

question shares the structure of a sealed building, which makes possible points of pollution and environmental degradation due to the poor exchange of air. On the subject, Schirmer *et al.* (2011) draws attention to the threats of closed places, as pollutants based on carbon, ammonia, sulfur and nitrogen are substances present in buildings from construction and cleaning materials, in addition to those triggered by activities carried out on site, such as drying clothes and preparing food. People's breathing and perspiration also directly influence the creation of these air-degrading factors, such as the contagion of respiratory diseases.

According to the above comment, research on air quality is capable of identifying risks of harm to human health derived from factors never considered in everyday life and that constantly expose people to their tasks.

Some microorganisms cause allergic reactions, the symptoms of which include sneezing, watery eyes, coughing, respiratory failure, lethargy, fever and digestive problems, in addition to causing pneumonia, rhinitis and asthma. In general, the main diseases associated with biological pollutants are Legionnaires' Disease (or legionellosis, as its agent is the gram-negative bacterium of the *Legionella* genus); humidifier fever (a disease that develops from exposure to toxins from microorganisms, especially those that grow in building ventilation systems); bronchial asthma (spasms associated with inhalation of biological aerosol); allergic pneumonitis or extrinsic alveolitis; pneumonia (pulmonary infection associated with bacteria such as *Streptococcus pneumoniae*, *Mycoplasma pneumoniae*, *Staphylococcus aureus*, *Legionella* and *Haemophilus influenzae*, viruses and some types of fungi) (SCHIRMER *et al.,* 2011).

Furthermore, the non-biological contaminants mentioned by Schirmer *et al.* (2011) that tarnish air quality are carbon dioxide, carbon monoxide, nitrogen dioxide, nitrogen oxide, sulfur dioxide, particulate matter, smoke from cigarettes and volatile organic compounds.

The dangers drew the attention of the World Health Organization (WHO), which conceptualized the sick building syndrome (SED) as a situation in which the occupants or users of a specific building present symptoms without a specific origin and without the possibility of finding an etiology and is, therefore, unknown (SCHIRMER *et al*., 2011).

Sick Building Syndrome comprises several non-specific signs and symptoms that occur in the occupants of a given building. This feeling of ill health increases absenteeism at work and causes a decrease in worker productivity. This syndrome is increasingly becoming an occupational health problem, so it is of special importance

to understand its cause, treatment and prevention (SILVA, 2017).

The global health entity considers the existence of SED when at least 20% of the occupants of the place present symptoms such as: mucosal irritation, neurotoxic effects, respiratory and cutaneous symptoms, and changes in the senses, for at least two weeks, and these disappear when the individual walks away from the building (SCHIRMER *et al.*, 2011).

2.2 The Q.A.I. Impact in Human Life

Complex historical factors of civilization, such as the industrial revolution, the mechanization of agriculture, the revolutions in information technology and services, oblige the modern human being to live most of the time inside buildings. With the concentration of people in cities, the salubrity conditions of the buildings interior environments began to acquire increasing importance as influencers of the health status of populations (CARVALHO, 2017).

The issue of air pollution is of great importance to Brazilian society due to its social, economic and environmental potential impacts. It gains complexity from synergies and overlaps with major contemporary challenges of Brazilian public policy, such as improving public health, sustainable economic development, reducing fires and mitigating climate change (SANT'ANNA *et al.*, 2021).

The discussion about the impacts of atmospheric pollutants in internal places of buildings, both in Brazil and in the world, is widespread and consolidated, as there is already a knowledge about their effects on human health (MATOS, 2020).

The statement that the environment is largely responsible for the state of human health is not new and goes back to the Greeks, particularly Hippocrates who, in his work Dos Ares, Águas e Lugares, defends the notion of health as a state of balance between the man and his environment. The built environment, with its artificial character, can clearly express this mutual influence because, with the increasing technological domain, it became possible to create spaces with subtle and deceiving imbalances (CARVALHO, 2017).

The impacts of air pollution on human health are linked to the incidence of premature deaths, lung and cardiovascular diseases, stroke, cancer and diabetes disposition, as well as impaired cognitive development in children and dementia in the elderly (SANT'ANNA *et al*., 2021).

The vast majority of the population spends a large part of their time inside buildings, such as homes, schools, workplaces and other public and commercial

establishments, so these spaces must have the necessary conditions to have a positive influence on health, well-being, comfort and productivity of individuals. There are numerous factors that affect this well-being, including indoor air quality, ambient temperature, light, tobacco smoke and relationships with colleagues. Dysfunction of one of these factors is associated with several signs and symptoms, covering a wide range of clinical manifestations (SILVA, 2017).

III.   METHODOLOGY

In order to carry out the present research, documentary and bibliographic data were collected, which allowed the theoretical analysis of the parameters of indoor air quality that has the power to affect the health of people who transit or work in places with low natural circulation in artificially air-conditioned environments.

In addition to the theoretical stage, the indoor air quality indices (QAI) were collected in the field, via study case, in some rooms located at the Lourenço José Ribeiro Forum, located at Avenida Pan Nordestina, s/n, Vila Popular, Olinda city, metropolitan region of Recife/PE.

In this vein, Mazucato *et al.* (2018) teaches that field research "is the process in which the researcher is directly articulated with the space (source) from which his information derives".

The qualitative-quantitative approach intends to explore the forum's air indicators in a study case supported by the legal-environmental literature and regulations produced within the Pernambuco Court of Justice, as a public actor committed to adequate socio-environmental practices.

3.1 Building Description

The Forum Lourenço José Ribeiro building (Figure 1) has 7,500.00 m² of built area, spread over four floors, with a ground floor with a parking area for magistrates and service vehicles, and three upper floors with closed rooms. The Forum also has a jury room, bank, four cells, four elevators, access for the disabled, an event room and parking for 120 vehicles in the outdoor area. See front and aerial view images:

Fig.1: Fórum Lourenço José Ribeiro front view.
Source: *Google Earth* (2018).

Intending to detect the potentially harmful factors to the traffickers at the Olinda Forum health, the Cemando rooms (Writing Center - space destined to the demands of Justice Officers who work in the Olinda district), Jury (large courtroom, with public monitoring space), Refrigeration Room and the Domestic and Family Violence Court at the Lourenço José Ribeiro Forum, located in the Olinda city, State of Pernambuco.

The first measurements took place between February 25 and March 25, 2021. The second round of measurements took place between June 10 and June 28, 2021. All measurements were carried out at 9 am and 12 pm on the current mentioned days.

It is worth noting that the 2021 forensic office went through different formats due to the Coronavirus pandemic, which imposed teleworking as the official format for performing the functions of most servers. This meant that the different months were affected by different stages of the presence return and use of measured spaces.

The rooms analyzed were:

- Refrigeration control room, measuring 12 square meters with four servers working, located on the ground floor of the Lourenço José Ribeiro Forum.

- Technical Room or Warrant Center (Cemando), measuring 66 square meters, with an average stay of two people. It is possible for up to four people to visit at the same time on some occasions.

Located on the ground floor of the building.

- Domestic and Family Violence Court Room, measuring 72 square meters, operated by 4 fixed servers. It occupies the second floor of the forum.
- Jury's Private Court Room, measuring 66 square meters, regularly used by 4 servers working on the ground floor.

3.2 Research Instrument

Data on polluting factors will be collected through the device Carbon dioxide detector Indoor environment Air quality monitor Digital gas meter Plug USA 100-240 V with storage. This tool will be able to detail the QAI (air quality index) indicators, in addition to temperature, CO_2 and humidity.

With this, it will be possible to study the statistics of air quality in environments cooled by the Modular Configuration System External Unit - Set free, electronic system of artificial refrigeration known for air control in external installations that controls several internal units simultaneously in the Forum Lawrence Jose Ribeiro. The obtained analyzes during the experiment were processed by the SPSS statistical program developed by International Business Machines (IBM) Corporation.

The chosen places to carry out the measurements are the jury room, forum reception and other environments of restricted use with similar spatial dimensions. The air assessment period will take place in the first half of 2021, between the months of February to June, during daytime hours, from 9:00 to 12:00.

Regarding the statistical method, Mazucato (2018) says that it "basically consists of quantifying data on phenomena, processes, facts, so that they can be analyzed. By using the statistical method, researchers can be able to analyze the different phenomena, processes and facts in relation to each other".

The measurements of the present research object items were integrated Input data into the statistical program (SPSS 2019). For the input data, the first line corresponds to the day, followed by the time, the internal temperature, the internal relative humidity and the CO_2 concentration.

For each measurement situation performed, the data are entered into the program as illustrated. The day and time were defined as nominal data, while temperature, relative humidity and CO_2 concentration were designated as scale data.

In IBM's SPSS statistical program, data analysis begins with the configuration of input variables, where input or output variables are defined and in nominal, scale, and/or ordinal data groups. For this work, data were only divided into nominal and scale groups. The day and time were defined as nominal data, while temperature, relative humidity and CO_2 concentration were designated as scale data.

In the sequence, the definition of the input variables is carried out later. To enter the data, the numbers of digits were defined, and whether the data are ordinal such as time and day, and scale data such as temperature, relative humidity and CO_2 concentration. The important variables are internal temperature (Internal Temp), internal relative humidity (Internal Urinary) and CO_2 (carbon dioxide). Descriptive statistics provide a simple summary about the samples and about the observed data and measurements that were made. These summaries can form the basis of the initial description of the data.

Descriptive statistics for the various measurement conditions which are VVDF, Refrigeration Room, Cendo and Jury Room. For the input data of the first part, measurements were taken between February 25th and March 25th, 2021. For each day, two measurements were taken at 9 am and at noon (12:00). However, for the first part of this work, data were collected over a period of 20 days. The important variables are internal temperature (Internal Temp), internal relative humidity (Internal Hum) and CO_2 (carbon dioxide). Descriptive statistics provide a simple summary about the samples and about the observed data and measurements that were made. These summaries can form the basis of the initial data description. Descriptive statistics analyze the maximum and minimum values of the data, the mean and error of the deviation. The Tables 1, 2, 3 and 4 illustrate the average, error of deviation and standard average error for all rooms evaluated.

Table 1: VVDF Descriptive Statistics

	N.	Minimum	Maximum	Average	Deviation Error
InternalTemp	40	20,0	26,9	23,255	1,6407
InternalHum	40	48,9	68,3	58,783	4,2170
CO_2 ppm	40	437	666	518,90	50,338

Source: The author

Table 2: Refrigeration Room Descriptive Statistics

	N.	Minimum	Maximum	Average	Deviation Error
InternalTemp	40	20,3	27,1	23,812	1,6738
InternalHum	40	47,6	74,5	58,743	6,5636
CO_2 ppm	40	474	710	555,28	65,638

Source: The author

Table 3: CEMANDO Descriptive Statistics

	N.	Minimum	Maximum	Average	Deviation Error
InternalTemp	40	20,	24,7	22,803	1,2198
InternalHum	40	49,9	60,8	54,140	2,7656
CO_2 ppm	40	480	778	619,30	78,607

Source: The author

Table 4: Jury Room Descriptive Statistics

	N.	Minimum	Maximum	Average	Deviation Error
InternalTemp	40	19,7	24,9	22,710	1,4300
InternalHum	40	49,6	58,6	53,908	2,6134
CO_2 ppm	40	454	689	562,10	56,745

Source: The author

It can be seen that the average CO_2 for VVDF is 518.9 ppm, the average indoor humidity 58.8 and the average indoor temperature 23.4°C. In this condition, there was a maximum of 666 ppm of CO_2 and a minimum of 437 ppm. The analyzes were collected for VVDF, for the Refrigeration Room, for Cendo and for the Jury Room.

Employers must adopt corporate sustainability policies and practices, which must include the protection of the work environment, incorporating strategies and businesses that are economically, environmentally and socially dimensioned for the development of decent and sustainable work. Thus, future development is linked to economic and social development that is compatible with the protection of workers and the environment (MARTINS; BERTOTTI, 2019).

For the statistics of a sample, each variable (internal temperature, relative humidity and CO_2 concentration) is analyzed, where N corresponds to the number of analyzed data, remembering that there are two per day, at 9 am and at noon.

IV. RESULTS AND DISCUSSION

4.1 Measurement Results - 1st Part

One of the criteria for evaluating the balance of the work environment is the health and environment of the place, understood in an integral way, both of the workplace and its employees (MARTINS; BERTOTTI, 2019).

For the statistics of a sample, each variable (internal temperature, relative humidity and CO_2 concentration) is analyzed, where N corresponds to the number of analyzed data, noting that two analyzes were performed per day, at 9 am and at noon. The Tables 5 and 6 illustrate the means, error of deviation and standard error of the mean for VVDF and the Refrigeration Room.

Table 5: VVDF Sample Statistics

	N.	Average	Deviation Error	Standard Average Error
InternalTemp	40	23,255	1,6407	0,2594
InternalHum	40	58,782	4,2170	0,6668
CO_2 ppm	40	518,90	5,338	7,959

Source: The author

Table 6: Refrigeration Room Sample Statistics

	N.	Average	Deviation Error	Standard Average Error
InternalTemp	40	23,813	1,6738	0,2647
InternalHum	40	58,743	6,5636	1,0378
CO_2 ppm	40	555,28	65,638	10,378

Source: The author

4.2 Interaction between Temperature, Humidity and Measurement Time Analysis

For the interaction between temperature, humidity and measurement time analysis, 4 graphs were also generated according to each measurement situation of the obtained data. On the X axis is the relative humidity; the Y axis shows the time and the Z axis deals with the CO_2 concentration.

It can be observed that for the hours, the measurements performed at noon obtained the highest values of carbon dioxide concentration. The Jury Room showed the lowest CO_2 concentrations, while the Refrigeration Room and Cemando demonstrated the highest CO_2 concentrations, as illustrated in Figure 2.
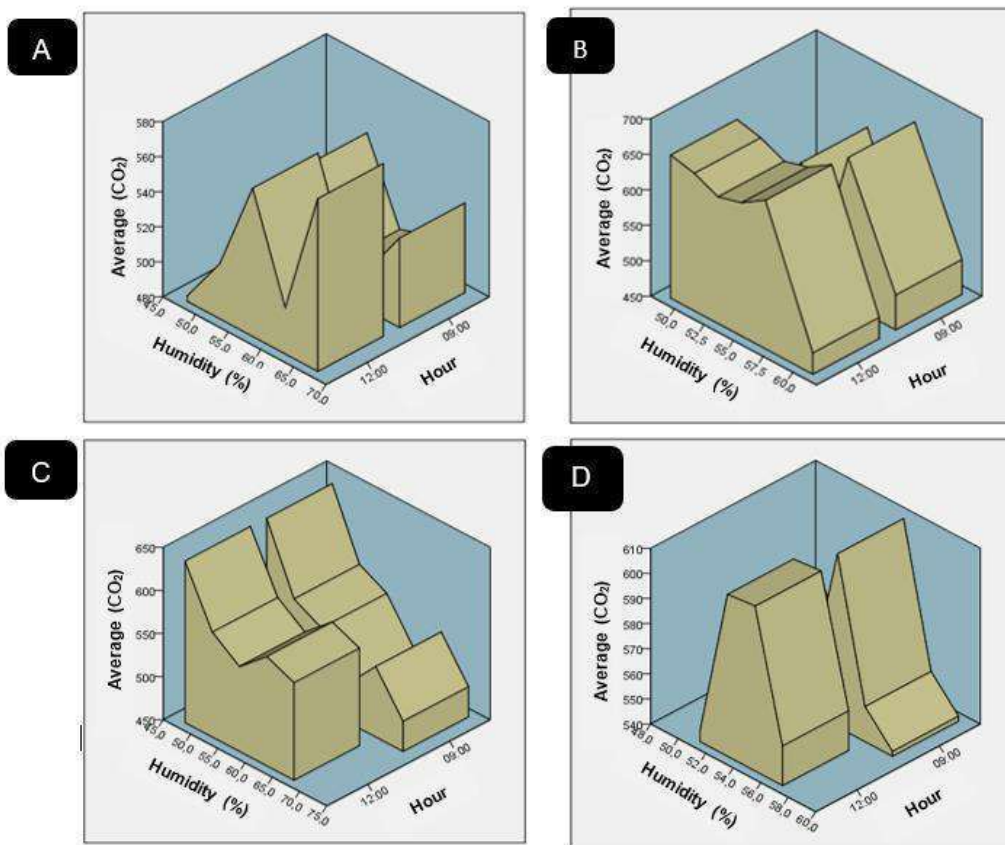

Fig.2 CO_2 Interaction, Indoor Humidity and Time on the VVDF(A), Refrigeration Room(B), Cemando(C) and Jury Room(D).

Source: The author

To verify the connection between the levels of CO_2 concentration according to the day of data collection, graphs were constructed illustrating the concentration of CO_2 on the X axis and the days of data collection on the Y axis in Figure 2. In the VVDF room (2A) and Refrigeration Room (2B), the CO_2 concentrations were relatively low, the averages were 518 and 555 ppm as illustrated in Figures 2A and 2B respectively, while the temperatures of these environments were the highest found, 23.3 and 23 .8°C respectively in VVDF and Cooling Room.

For Cemando (2C) and Sala do Juri (2D), the average concentrations of CO_2 reached 619 and 562 ppm

respectively, which are relatively higher than those found in the first two previous rooms. The maximum temperatures in these places in contrast are the lowest found, 22.7 and 22.8°C respectively. The CO_2 concentration in relation to

the measurement days in the environments: VVDF, Refrigeration Room, Cendo and Jury Room can be observed in Figure 3, 4, 5 and 6 respectively.
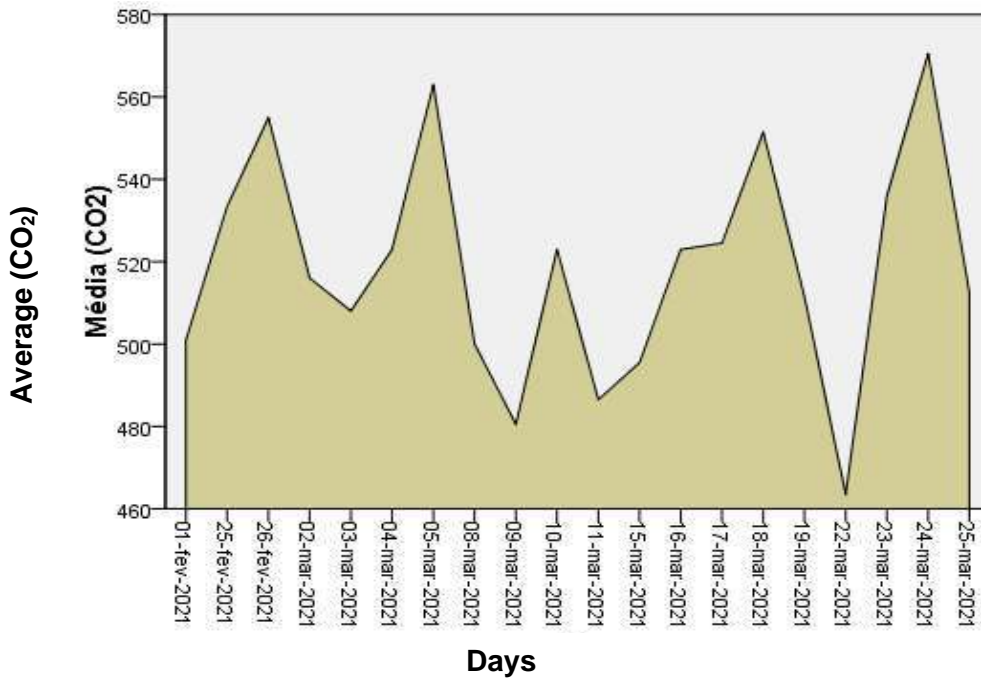

Fig.3 CO_2 in relation to VVDF measurement days
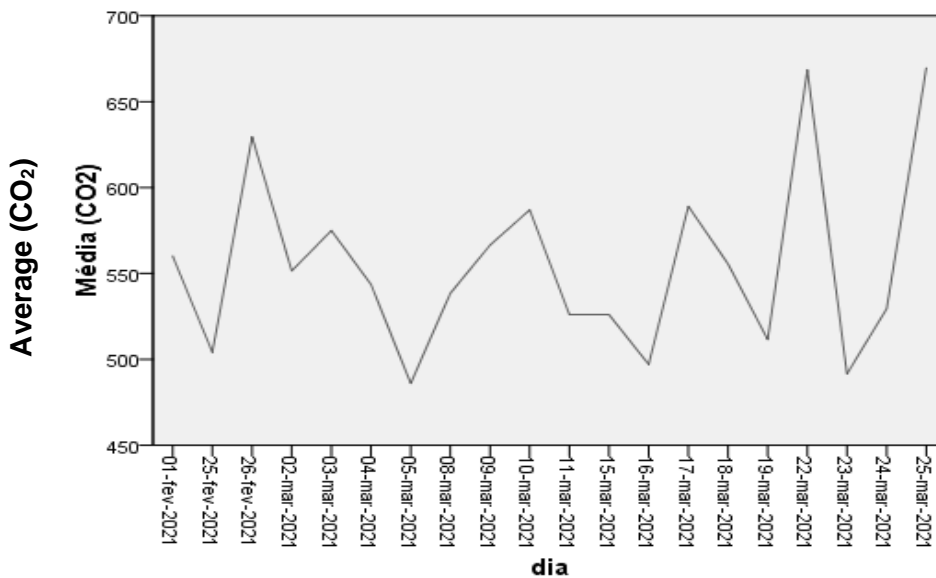
Source: The author

Fig.4 CO_2 in relation to Cooling Room measurement days
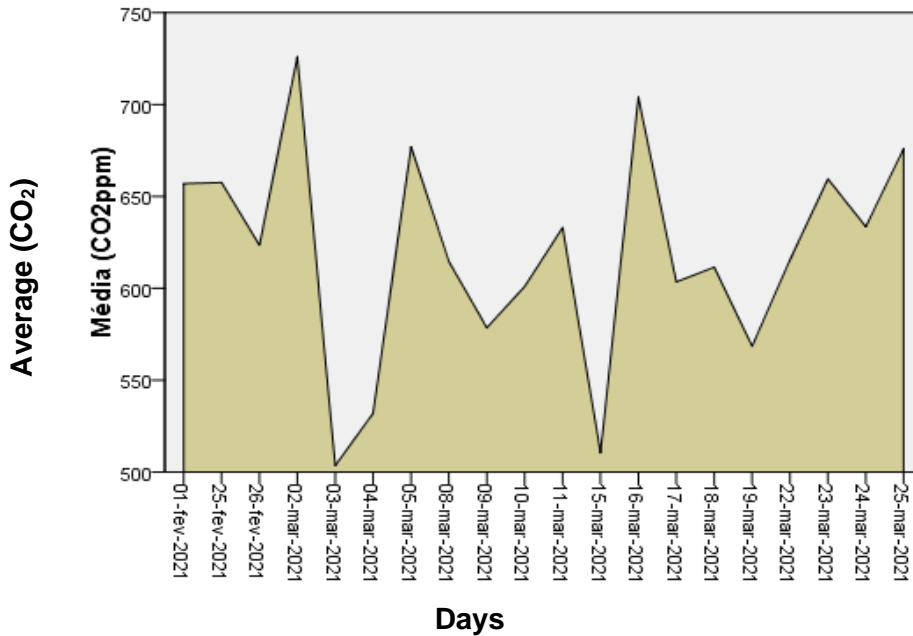
Source: The author

Source: The author

Fig.5 CO₂ in relation with Cemando measurement days
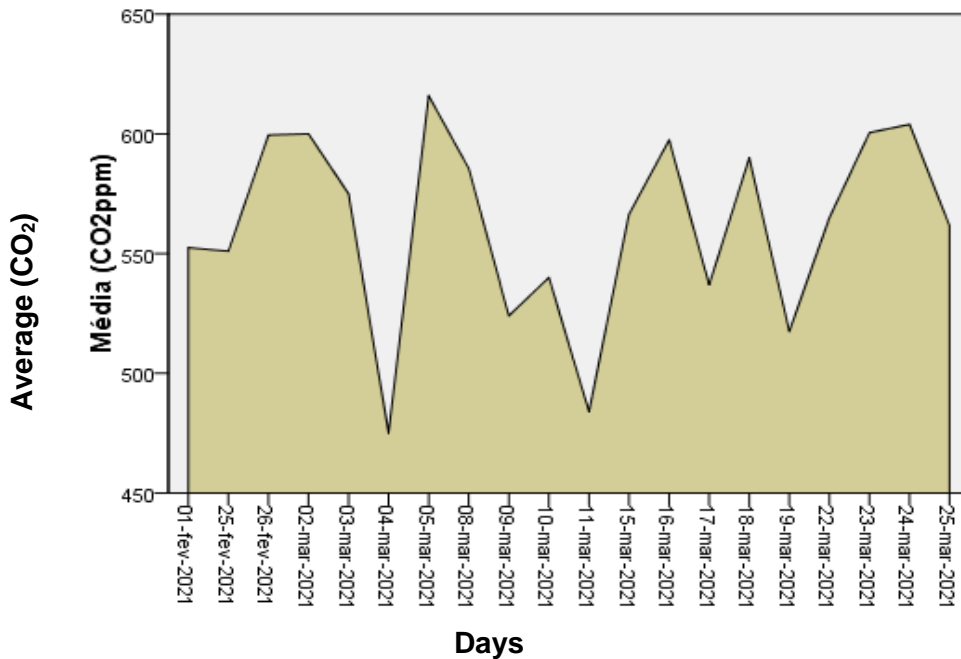
Fig.6 CO₂ in relation with Jury Room measurement days

Source: The author

4.3 Comparison of the two parts of the experiment

In comparison with the measurements carried out in the first part of the experiment, it can be observed that the average concentration of CO_2 in the first part of the work was similar to what was obtained in the second part. The highest concentrations were observed in Cendo (778 ppm) in the first part and in the second part the highest

concentration was found in the Refrigeration Room (775 ppm). Regarding internal temperatures and internal relative humidity, in the first part the highest temperature was found in the Refrigeration Room with 27.1°C, in the second part of the experiment, the highest temperature was found in the Room of the Court of Domestic and Family Violence (VVDF) at 27°C. The highest indoor relative humidity was

found in the Cooling Room also for both cases, 74.5% and 68.4% respectively.

Analyzing the first four tables of the Descriptive Statistics, referring respectively to VVDF, Refrigeration Room, Cemando, Jury Room, it was found that the measurements made at the Lourenço José Ribeiro Forum indicated an adequate level of indoor air quality in the inspected environments. The maximum values of CO_2 and temperature were not exceeded, according to the standards established by ANVISA (BRAZIL, 2003). The exception was in relation to relative humidity, which in Table 2, Descriptive Statistics Refrigeration Room, was 74.5% when, according to ANVISA, the acceptable standard is 40% to 65% with a maximum value of 70 % in access areas during the summer.

Regarding the analysis of tables 7 to 13 of the Descriptive Statistics of the VVDF, Refrigeration Room, Cendo and Jury Room, it was proved that the measurements referring to the variables: temperature, relative humidity and carbon dioxide indicated, according to the standards defined by ANVISA (BRAZIL, 2003), an adequate level of indoor air quality in the studied location. According to Lyra (2015), QAI problems are related to environmental comfort and the levels and types of air pollutants. Environmental comfort involves physical variables related to the comfort or discomfort felt by the occupants, such as temperature and air temperature distribution uniformity, lighting, relative humidity and air velocity. Recent studies suggest that the ideal temperature, in terms of comfort and minimum spread of disease, is 20°C. This statement corroborates the study carried out. As a result, according to Teixeira (2019), a correct diagnosis of air quality is essential for the Government to promote improvements in the monitoring structure. It is also essential that, in addition to disseminating information and making it available in reports and electronic addresses, educational programs to raise awareness of air pollution are carried out, bringing the community information about how pollution occurs, with 77% from mobile sources, how measurement of air quality occurs and also what to do to improve these indices, which tend to increase with urban growth. The increase in the air quality monitoring network, as well as the replacement by automatic stations or even more advanced technologies, are prioritized by the public authorities, as they promote the availability of data for the academic environment and for the management itself, which will have a more accurate picture of the air quality in their region, as well as propose solutions that are more adhering to the real needs of cities.

The statement by Schirmer (2011) also reinforces the study, which reports that the concern with Indoor Air Quality (QAI) arose mainly with the tendency to build sealed buildings for aesthetic reasons, noise control and even air conditioning, which ended up causing an increase in cases of problems related to air quality in such environments. The interest in QAI studies arose after the discovery that the decrease in air exchange rates in these environments was largely responsible for the increase in the concentration of biological and non-biological pollutants in indoor air. This concern is justified since most people (around 80-90%) spend most of their time inside these buildings and, consequently, are exposed to pollutants in these environments.

Also according to Schirmer (2011), it is known that ventilation systems, when poorly operated and without adequate maintenance, become potential sources of pollutants, mainly particulate materials and microorganisms (due to the accumulation of moisture in these systems). Therefore, in order to have a healthy building, good indoor air quality must be achieved, through the use of adequate ventilation rates, building automation systems and, mainly, continuous monitoring of these facilities.

V. CONCLUSION

The initial objectives were met with the analysis of the Olinda Forum air quality carried out. For this, the indoor air quality was verified, the indicators were investigated and through statistical interference, the temperature, humidity and carbon dioxide in the building were analyzed and discussed.

The results obtained in this study show that the measurements made at the Lourenço José Ribeiro Forum indicated an adequate level of indoor air quality in most of the inspected environments. It is worth mentioning that the year 2021 was crossed by different stages of return of the servers, employees and users of the Judiciary to the physical office. The months of pandemic that followed prevented the verification of a traditional routine of access to public buildings.

In this sense, it is recommended for the future that more work on the carbon dioxide (CO_2), temperature, and relative air humidity measurement be carried out so that it can be possible to monitor the return to the forum's face-to-face working hours in its normal transit capacity of people and particles in the air that could be harmful to human health and the environment.

Observing these determinations, the Quality of Life at Work (QVT) has been gaining ground in terms of organizational well-being. In this way, more than the relationship between man and architecture, it is worth emphasizing the importance that the built space establishes for the individual in working conditions.

Problems related to the work environment are not recent, so much so that in 1982, the Technical Committee of the World Health Organization defined sick building syndrome (SED) as the set of the following symptoms: headache; fatigue; lethargy; itchy and burning eyes, nose and throat irritation; skin abnormalities and lack of concentration in office workers.

The objective is to guarantee user productivity, a fundamental part of this process. Therefore, based on the premise that air quality interferes with the worker's health status, and consequently in their activities, through architecture it is possible to provide the safety and well-being of users, preventing the development of pathologies associated with the permanence indoors, especially with artificial air conditioning.

REFERENCES

[1] BRAZIL. National Environment Council (CONAMA). **Resolução n. 5, de 15 de junho de 1989**. Provides for the National Air Pollution Control Program – PRONAR. Available in: <http://www.suape.pe.gov.br/images/publicacoes/resolucao/Resolu%C3%83%C2%A7%C3%83%C2%A3o_CONAMA_005.1989.pdf> Accessed on: December 18, 2020.

[2] BRAZIL. [Constitution (1988)]. **Constitution of the Federative Republic of Brazil:** proclaim on October 5, 1988. 4. ed. São Paulo: Saraiva, 1990.

[3] BRAZIL. Ministry of Health. National Health Surveillance Agency. **Resolution No. 9**, of January 16, 2003, Brasília, 2003. 14p.

[4] BRAZIL. **Law No. 6,938**, of August 31, 1981**.** Provides for the National Environmental Policy, its purposes and mechanisms of formulation and application, and other measures, 1981. Available in:< http://www.planalto.gov.br/ccivil_03/leis/l6938.htm> Accessed on: January 13, 2021.

[5] BRAZILIAN ASSOCIATION OF REFRIGERATION, AIR CONDITIONING, VENTILATION AND HEATING (ABRAVA). **Cuidando da Qualidade do Ar em Edificações**. Available in: <https://abrava.com.br/departamentos-nacionais/dn-qualindoor-qualidade-do-ar-interno/15125-2/> Accessed on: February 10, 2021.

[6] CARVALHO, A. P. A. O edifício doente e o edifício saudável. **Revista SUSTINERE**, Rio de Janeiro, v. 5, n. 1, p.135-152, 2017.

[7] COMIN, T. T. **Avaliação da qualidade do ar em interiores e ambientes abertos de uma universidade em São Carlos**. 2016. 123p. Thesis (Doctorate) – Graduate Program in Chemical Engineering, Federal University of São Carlos, São Carlos, 2016.

[8] CORDEIRO, L. F. A. **Eficiência energética no controle inteligente de sistemas de bombeamento**. Recife: Universidade Federal de Pernambuco, 2008. (Dissertação de mestrado).

[9] CORDEIRO, L. F. A. **Planejamento do setor elétrico brasileiro com foco nas emissões de CO2**. Recife: Universidade Federal de Pernambuco, 2015. (Tese de doutorado).

[10] CORDEIRO L. F. A;, SOUZA, A. A.. **Reuso de água de um sistema de climatização: estudo de caso em um prédio público**, Congesta, João Pessoa, 2019.

[11] COSTA, R. F. W.; RODRIGUES, M. A; ROSA, T. C.; SILVA, L. L.; GARCIA, H. G.; MELO, J. S.; SOUZA, M. P. A qualidade do ar em ambientes comerciais fechados: prevenindo patologias associadas à permanência diária em espaços climatizados artificiais. **Revista Científica Doctum Multidisciplinar,** Caratinga, v. 2, n. 1, p.1-9, 2019.

[12] CUNHA, B. P.; AUGUSTIN, S. **Sustentabilidade ambiental**: Estudos jurídicos e sociais. 2 ed. Caxias do Sul: Educs, 2014. 486p.

[13] GARCIA, M. L.; AQUINO, S. R. F. Sustentabilidade e Crise Ambiental: A Necessidade de uma Função Ecológica no Estado na Pós-Modernidade. **Revista de Direito e Sustentabilidade**, Goiânia, v. 5, n. 1, p. 22–39, 2019.

[14] LYRA, C.; ALVES, D.; MELO, S. B.; RODRIGUES, S. A. G.; BENCHIMOL, J. S.; GORDO, P.; GASTALDONI, I.; TONIETTO, R.; JAROVSKY, M.; GIODA, A.; LEON, A. P. Poluição em ambientes fechados como fator de risco para a saúde: o uso da lenha como fator agravante. **Prêmio GLP de Inovação e Tecnologia**, Rio de Janeiro, 2015.

[15] MACHADO, P. A. L. **Direito Ambiental Brasileiro**. 15 ed. São Paulo: Malheiros, 2016, 1408p.

[16] MARTINS, C. C.; BERTOTTI, J. L. F. A necessidade da proteção ao meio ambiente do trabalho frente a desregulamentação da onda neoliberalista mundial: o caso da Síndrome do Edifício Doente. In: INTERNATIONAL SEMINAR ON GOVERNANCE AND SUSTAINABILITY UNIVERSIDAD DE ALICANTE, 15., 2019, Alicante. **P**roceedings... Alicante, 2019.

[17] MATOS, L. **Monitoramento da Qualidade do Ar em Áreas de Movimentação Pública do Aeroporto de Londrina:** análise da legislação brasileira. 2020. 62p. Dissertation (Master's) - Graduate Program in Environmental Engineering, Federal Technological University of Parana, Londrina, 2020.

[18] MAZUCATO, T, P, S.; SOARES, A. G; TAUIL, C. E.; DONZELLI, C. A.; FONTANA, F; CHOTOLLI, W. P. **Metodologia da Pesquisa e do Trabalho Científico**. 1 ed. Penápolis: FUNEPE, 2018. 96p.

[19] SANT'ANNA, A.; ALENCAR, A.; PINHEIRO, B.; ARAÚJO, C.; VORMITTAG, E.; WICHER, H.; BORGES, K.; FARIA, M.; ANDRADE, M.; PORTO, P.; ARTAXO, P.; ROCHA, R.; ESTURBA, T; SIMONI, W. F. O estado da qualidade do ar no Brasil. **WRI Brasil** *Working Paper*, São Paulo, p.1-32, 2021.

[20] SILVA, L. T.; MENDES, J. F. G. Determinação do índice de qualidade do ar numa cidade de média dimenção. **Revista de Engenharia Civil**, Guimarães, n. 27, p.63-74, 2006.

[21] SCHIRMER, W. N.; PIAN, L. B.; SZYMANSKI, M. S. E.; GAUER, M. A. A poluição do ar em ambientes internos e a síndrome dos edifícios doentes. **Ciência saúde coletiva**, Rio de Janeiro, v. 16, n. 8, p.3583-3590, 2011.

[22] SILVA, A. E. S. **Síndrome do Edifício Doente**. 2017. 28p. Dissertation (Master) – Faculty of Medicine Lisbon, University of Lisbon, Lisboa, 2017.

[23] TEIXEIRA, L. S.; BRESSANE, S. B; NÓBREGA, M. J. R. Monitoramento da Qualidade do Ar: Diagnóstico das tecnologias e da rede de monitoramente da Região Metropolitana do Rio de Janeiro. **TEC-USU**, Rio de Janeiro, v. 2., n. 1, p.73-86, 2019.

[24] YOSHIDA, C. Y. M; GUERRA, I. F. O direito difuso ao meio ambiente ecologicamente equilibrado: educação, participação e mobilização social na promoção da tutela ambiental. **Revista Internacional Consinter de Direito**, Porto, v. 5, n. 3, 2017.

Analyze Condensed Water Quality: A Case Study in a Public Building

Pauline De Albuquerque Gulde[1], Luiz Filipe Alves Cordeiro[2], Liliana Andrea Santos[3], Rafael Rodrigues da Silva[4]

[1,2,3]Technological Institute of Pernambuco, Recife, Pernambuco, Brazil

[4]University Federal Pernambuco, Recife, Pernambuco, Brazil;

Abstract— The reuse of water from air conditioners has proved to be a valuable alternative to the water waste promoted by the excessive use of drinking water in activities that would not necessarily require clean water, such as washing external areas and windows. In this sense, the general objective of the present work is based on evaluating the thematic pertinence of the adequacy of the network implementation for the reuse of water from the dripping of the Forum Lourenço José Ribeiro (Fórum de Olinda) air conditioners, an organ that is part of the Tribunal of Justice of Pernambuco, located in the city of Olinda/PE. The case study is shown as a sufficient methodological apparatus to obtain results, which were evaluated through qualitative and quantitative techniques, intending to achieve a correct understanding of the cost savings with the implementation of drip water treatment of air conditioners in this building that is part of the Pernambuco Court of Justice. Results obtained indicate that the alkalinity of the water from the air condensers could not be used for human consumption, but it is suitable for use in non-noble purposes, such as washing the Forum patios. With this, the reuse of water resources resulting from the dripping of air conditioners is efficient to promote the yield of a natural asset that needs to be used within its maximum capacity, through the appropriate treatment that allows the reuse of the hydric matrix.

I. INTRODUCTION

The imminence of the Earth's most precious natural resource impoverishment puts society in a position to seek efficient alternatives for maximum use of what is available for human use. In this perspective, there are studies that seek the reuse of potable or non-potable water that were discarded in residential, industrial, business and agricultural environments. According to Sousa *et al.* (2021), the reuse of water, as well as its use, as they are reputable and reliable procedures, have been established as one of the most beneficial alternatives for saving water.

Among the water resources commonly discarded, the reuse of condensed water from the dripping of air conditioners could guarantee the reduction of a certain use of drinking water and contribute to the sustainability that has been revealing itself as the great promoter of the balance between the environment and humanity (CORDEIRO, 2019).

Taking into account the immense human population and the scarce percentage of fresh water available in the world – in addition to countless other examples that indicate the increasing decrease of natural resources available in nature – human society needs to adapt

its needs to the awareness of ecological finitude, especially in the concerning water resources. In this vein, Silva and Santos (2019) add that the uncontrolled use, the scarcity of rain and pollution bring a reflection on the sustainable use of water.

The different purposes and use of water resources are not at the same level of social and human relevance. In this sense, there are purposes considered noble, such as drinking water for human consumption, and purposes called non-noble, where the use of water is not intended for people, but for washing, toilets and landscaping (such as and water features).

Therefore, it is possible to scale the applications of this water resource and ensure that its reuse saves potable springs from being used in services that could easily be supplied by non-noble sources. Carvalho *et al* (2016) explains that reuse of water from air conditioners needs to undergo a qualitative assessment of the water, where physical-chemical standards (such as pH, alkalinity and hardness) are analyzed and compared with parameters established by the Ministry of Health, to find out if it is possible to reuse this water in a safe and healthy way.

As of the different uses of water, it is imperative to reflect on the application of water resources and the likely reuse of this in the so-called non-noble purposes. This reflection dialogues with the principles of sustainable development, as water is a natural resource that is on the verge of scarcity and demands solutions and technologies capable of increasing its chance of use and reuse.

Over the years, in favor of the rational use of water, the need arises to rethink the ways of using water resources, adopting sustainable practices that aim to guarantee the future of the new generations. The ways to mitigate the impacts can be the reuse and use of water, which includes the use of water from air conditioning devices (SOARES, SOUZA JÚNIOR and SILVA, 2021, p.1).

In the support of the public example that has been preached in recent years, the State has become the main example of acting with socio-environmental responsibility, so that it is pertinent to verify the feasibility of using the condensed water produced by air conditioners in buildings where the activities of the Court of Justice of Pernambuco are carried out. Even in public buildings that have subsidized water costs and that do not have large expenses with the purchase of drinking water, the incorporation of environmental sustainability criteria is of great value (CARDOSO, 2018, p.90).

As the Pernambuco Court of Justice is a component body of the Brazilian public administration, it is committed to promoting sustainability at the entire scale of its activity by virtue of the legislative provisions and resolutions formulated by the National Council of Justice (CNJ), in order to promote sustainability practices (CORDEIRO, 2015).

The present study aimed to evaluate the relevance and suitability of implementing a network for the use of wastewater from the dripping air conditioners of the Forum Lourenço José Ribeiro (Forum de Olinda - building that is part of the structure and competence of the Court of Justice of Pernambuco).

II.   BIBLIOGRAPHIC REVIEW

The motivations for the search for solutions and alternatives that may reduce water stress are evidently important. Even if renewable, quality and potable water resources are scarce. As an alternative, reuse can help reduce the use of potable water for activities that do not require potability (MOURA *et al*., 2020, p.791).

The water used for human consumption and for socio-economic activities is taken from rivers, lakes, dams and aquifers, also known as inland waters. The development of cities without proper environmental planning results in significant damage to society. One of the consequences of urban growth was the increase in domestic and industrial pollution, creating inadequate environmental conditions and favoring the development of diseases, air and noise pollution, temperature increase, groundwater contamination, among other problems. Brazilian urban development is concentrated in metropolitan regions, in the state capital and in regional hub cities. The effects of this reality are felt on all urban equipment related to water resources, water supply, transport and treatment of sewage and rainwater. The development and growth of cities generates an increase in domestic and industrial pollution, leading to an increase in sediments and solid material, as well as contamination of springs and groundwater. (CETSB/SP, 2020).

Population growth, responsible for the growing demand for drinking water, linked to pollution and the non-rational use of water, results in a scenario of water scarcity in certain regions of all continents, especially in regions with low rainfall. Seeking to reduce the consumption of drinking water for less noble purposes, reduce the pressure on water reservoirs and combat water scarcity, the concept of rational use of water emerges. Based on the principles of minimization, separation and reuse, this concept brings the suggestion of using alternative sources of water, one of which is condensed water from the operation of air conditioners. Such devices work in such a way that water condensation occurs, and this effluent, for the most part, is discarded. (MARINHO, ATHAYDE JÚNIOR and QUARESMA, 2021, p.1)

2.1 The environmental crisis and the new demands for water efficiency

Human existence has its continuity associated with the need to preserve available sustainable natural resources. These resources represent everyone's right, being indispensable for the preservation and continuity of the human species itself. In view of this, it is urgent that groups structured in cities and communities pay attention to the needs of future generations. These needs are increasingly linked to environmental issues, essential to human life. (GOULART and PIETRAFESA, 2019, p.734)

The large-volume production of consumer items began to generate demands and, as a result, the extraction of natural resources was intensified. Even agriculture, which was once intended for subsistence, became large-scale, with crops for sale in various markets around the world. Currently, this model of consumption, production, and unbridled natural extraction threatens not only nature, but its very existence. We can see the depletion of essential resources for the various human activities and the extinction of animals that were once abundant on the planet. For these reasons it is necessary for human beings to adopt a more sustainable posture. (RODRIGUES *et al.*, 2019, p.4).

In terms of water, Brazil is a rich country, which allows wide availability of water resources, with 13.7% of all freshwater available on the planet, and shelters enormous water biodiversity in the Pantanal region, considered the largest continental wetland in the world, and the Amazonian floodplain, the most extensive flooded forest on Earth. However, although privileged in terms of quantity and quality of water, these resources have been used irresponsibly. Overexploitation, lack of concern for water sources, poor distribution, pollution, deforestation and waste demonstrate the lack of care for this valuable asset. Misuse endangers the lives of all living beings. (CAPELLARI and CAPELLARI, 2018, p.3).

The contemporary discussion about the water crisis goes beyond the simple finitude of drinking water, encompassing the failures of public policies, based on economic models that prioritize immediacy. These policies are based on monetary parameters rather than the conscious use of resources, compromising biodiversity and the balance of ecosystems. With the disruption and imbalance of natural habitats, pollution, contamination and scarcity of water were inevitable, forcing human beings to rethink their relationship with nature. Although the problem of capturing and distributing water has worsened mainly in urban centers, in rural areas it has been pronounced in the face of agribusiness policy and its political, economic and industrial dominance over the land (FISCHER *et al.*, 2021, p.226).

Currently, the world population grows by an average of 0.9% per year, and will reach 9.7 billion people in 2050. Such growth results in an increase in the demand for water resources, which, because they are finite, can generate a supply crisis on a global scale, imposing permanent water rationing on society. (MARINHO, ATHAYDE JÚNIOR and QUARESMA, 2021, p.1)

Water scarcity is already a problem faced by many countries in the world, since some factors have caused the reduction of its quality and distribution, such as: disorderly development of cities, pollution, poor management of water resources and high population and industrial growth. These factors generate an increase in the demand for water, which can cause the depletion of this resource. (SIMES *et al.*, 2020, p.181)

In Brazil, the water crisis has been affecting the population of several states, with water rationing for human supply, reduction of available water for irrigation, animal watering, among other problems. (FERREIRA and TOSE, 2016, p.182)

So that this natural resource does not run out and that there is no damage to the quality of the world's reserves currently available, it is essential that water is not wasted, polluted or poisoned and its use must be carried out consciously. Data on water consumption is provided by the United Nations: worldwide, agriculture accounts for 70% of all water consumption, compared to 20% for industry and 10% for domestic use. In industrialized countries, however, industries consume more than half of the water available for human use. (CAPELLARI and CAPELLARI, 2018, p.2)

Water scarcity can occur in two ways: by quantity, normally caused by natural causes, such as prolonged regional droughts; and by quality, generally caused by human action, such as pollution processes triggered by the release of urban and industrial effluents into surface waters, intensification of individual consumption, waste in public and building systems due to leaks and inadequate procedures related to the water usage. (SIMES *et al.*, 2020, p.181)

Expectations regarding the availability of water in the coming years only decrease. The scarcity of drinking water will affect more than half of the world's population in up to 50 years, due to current global trends, such as deforestation, population increase, urban growth, among others. This situation occurs due to pollution of water sources, misuse of natural resources, deforestation, planet climate change, disorderly population growth, increasing consumption, waste, lack of public policies that encourage sustainable use, in addition to irregular distribution. (FERREIRA and ALVES, 2018, p.9)

According to Law 9,433/97, which establishes the National Water Resources Policy (PNRS), water is a public domain good, a limited natural resource, with economic value, which is why the management of water resources must always provide the multiple use of water. (SILVA and PINTO, 2019, p.4)

Sustainable development is the means capable of meeting the needs of the current generation, ensuring the ability to meet the needs of future generations. The rational use of water can be defined as the practices, techniques and technologies that improve the efficiency of its use, and the search for efficient processes for the reuse of water has been highlighted in recent years. (FERREIRA and ALVES, 2018, p.9)

The measures announced to face the water crisis bring the recommendation that the Public Power adapts, as a matter of urgency, its governmental codes of posture with a view to restricting activities notably recognized as promoting water waste, such as the use of hoses for washing automobiles, sidewalks, facades, floors, walls and windows; irrigation of gardens and lawns; roof cooling; washing of streets and avenues, unless the source is water from reuse or another recovery technique. (FERREIRA and TOSE, 2016, p.182)

Access to safe drinking water and sanitation is an essential human right for the full enjoyment of life, and is intrinsically linked to the rights to life, health, food and housing. In Brazil, urban water supply is experienced differently by different social strata. Although the common citizen is not aware, Brazilian legislation, at the federal level, has the Resolution of the National Water Resources Council that provides guidelines, criteria and modalities for reusing water. The modalities are: reuse for urban purposes, reuse for agricultural and forestry purposes, reuse for environmental purposes (recovery of degraded areas), reuse for industrial purposes and reuse in aquaculture. (SILVA and PINTO, 2019, p.1)

Water is a commodity widely used by everyone and is irreplaceable, for this reason it is necessary to develop skills, knowledge and procedures for the rational use of water, acting in the conservation of this resource so necessary for the existence of all. The term water conservation means the controlled and efficient use of the resource and, in this way, contemplating both rational use and reuse. (ORTIZ *et al.*, 2021, p.25135)

The general perception, still common among populations, is that fresh and renewable water is an infinite resource. However, it is known that it is indispensable to life, renewable, but relatively scarce and, in many regions of our planet, it is possible to observe the decreasing supply of water in terms of quantity and/or quality, being able to

cite as main factors the poor distribution and changes in the hydrological regime that lead to reduced rainfall and aquifer recharge; and the increase in demand, resulting from the accelerated growth of the population, the expansion of productive activities such as agriculture and industry, whether for grain production or economic growth. Its waste and inappropriate use such as pollution and degradation of water sources can also contribute to the decrease or, in the not too distant future, to deplete this resource. (SOUSA *et al.*, 2016, p.37-38)

The main factors that may affect the availability of water resources are population growth, economic growth, changes in production and consumption patterns and increased demand for water, both for domestic, industrial and agricultural purposes. To change this scenario, it is necessary to use sustainable policies and measures that promote the rational use of water. (MARINHO, ATHAYDE JÚNIOR and QUARESMA, 2021, p.2)

Except for a few exceptions motivated by the individuality of water use in some regions, actions that maintain the quantity and quality of water use are of great importance in large urban centers, because as the level of water availability increases, so does the level of economic development in the region, considering that countries that have a stabilized government management seek to meet their water demands while preserving the quantity and quality of the water used. (SILVA, 2018, p.15)

Environmental catastrophes, such as the collapse of mining dams, also highlights the dependence that living beings have on water resources. Water is essential in the most diverse spheres, passing through economic, social and cultural resources, to the right to a dignified life. There is a fragility of environmental laws in Brazil that creates social disparities and the unequal distribution of environmental risks, causing environmental injustice. (MORAIS *et al.*, 2021, p.143)

Water, as a natural resource, needs to be used fairly and coherently, so that there is a balance between the availability of this resource and its demand, thus reducing conflicts over its use. Water must be understood as a legal, economic and social asset, it is a limited natural resource, in the public domain and endowed with economic value, which requires proper management. (CAPELLARI and CAPELLARI, 2018, p.10)

Humanity needs to build new ethical values placing water as an indispensable good for life, a fundamental human right, ensuring a healthy environment for all species and guaranteeing the sustainability of the planet. The ethical use of water demands moral conditions that enable global health and mitigate environmental, moral and health vulnerabilities with the collective awakening to

social, environmental and individual injustices (FISCHER *et al.*, 2021, p.227).

2.2 Condensed water reuse

The importance of alternatives for the reuse of water, for non-potable purposes, in order to avoid its waste, is based on the principles of sustainability. (FERREIRA and ALVES, 2018, p.7)

It is necessary and essential to implement alternatives in the reuse of water, in addition to the search for viable technologies of use, given the problem of water scarcity in numerous areas around the world. (SILVA and PINTO, 2019, p.2)

The focus of water for people's daily lives ranges from direct to indirect consumption; since there are several ways in which water is being used, it can facilitate and guarantee human life, and ensure that some needs are met, without the depletion of this resource. According to this context, it is interesting to create measures to minimize the waste of water, and consequently its reuse or reuse, since the effectiveness in this task brings more positive effects than any other water use policy, thus attesting to its sustainable use. (GOMES *et al.*, 2018, p.1)

In this sense, the water from condensation in air conditioners stands out for its high potential for use, and can be used for washing floors and watering plants and even other nobler uses. The amount of water produced by the air conditioner depends on the brand, power and climatic conditions of the place. (MARINHO, ATHAYDE JÚNIOR and QUARESMA, 2021, p.3)

Air conditioners suck the air existing in a given environment, which, when passing through the evaporator coil, suffers a drop or increase in temperature due to contact with the coil. The air is then returned to the environment at a hot or cold temperature, depending on the user's need. When there is a variation in temperature, the sensor activates the compressor again, responsible for circulating the refrigerant gas. When traveling through the evaporator coil, the air undergoes a change in temperature and thermal exchange occurs. Finally, the distilled water that has been condensed is directly directed to the device's drainage system. (NASCIMENTO *et al.*, 2019, p.137)

The water released from the air conditioning units comes from the air conditioning drains, that is caused due to its condensation process and it has a random destination, thus generating a great water waste. This waste is caused by consequences that can affect both the users of the devices and the place itself. Among these consequences is the accumulation of water puddles, which can lead to possible breeding foci of the dengue mosquito. (FERREIRA and ALVES, 2018, p.21)

Air conditioners are classified according to their use - which can be residential, automotive, commercial, hospital or industrial - and as to their capacity - small, medium or large - which will depend on the appliance's cooling power, which is supplied in BTU (British Thermal Unit). In the case of machine technologies, these can be conventional or inverter, which is developed aiming to minimize the cost of energy during its operation. In addition, the appliances are classified according to the type of system, whether it is direct expansion – operating with the direct use of a refrigerant gas to cool the air to be conditioned – or indirect – using the secondary refrigerant, which is cold water. Common, small-scale residential and commercial appliance types are: window, hi-wall, cassette, floor-to-ceiling and ducted; they vary in terms of installation method, formats and cooling power. While large commercial appliances are known as fan-coils and have the following lines: hi-wall, cassette, console (similar to the flooring) and the duct (built-in). These are found with a capacity, in BTU, greater than the small ones. (CALDAS;CAMBOIM, 2017, p.176)

It is necessary to search for strategic techniques for water reuse, through changes in the habits of the whole society, for the sustainable use of this resource, aiming to reduce the demand on springs. The Air-Conditioning appliances, when in operation, produce water by dripping through the drainage pipe, derived from the moisture in the air, condensed by the appliance when it cools the air in the internal environment. This water in most cases is not used, considering the large-scale use of air conditioners in commercial and residential buildings, the volume that drips is significant. (FERREIRA and TOSE, 2016, p.182)

Air conditioners promote the generation of water resulting from condensation, which most of the time is wasted to the ground or to the sewer. This way, the use of this water depends on the efficient collection of each drainage system of the devices that can be directed to a collection and storage system. (FERREIRA; ALVES, 2018, p.22)

One of the alternatives for the use or reuse of water is the use of condensed water in air conditioning systems, which are widely used in commercial and residential buildings. Air conditioning is defined as the process of conditioning the air aiming at controlling its temperature, humidity, purity and distribution in order to provide comfort to the occupants of the conditioned room. (SILVA and PINTO, 2019, p.1)

Water reuse is understood as a technology developed to a lesser or greater degree, depending on the purposes for which the water is intended and how it has previously been used. Air conditioners are used on a large

scale, from public buildings (schools, public agencies, etc.) to residential buildings. The use of these devices generates water dripping, derived from the humidity in the air, condensed by the device when it cools the air in the internal environment. The air conditioners, when in use, remove the existing humidity in the place where they are installed and carry out the condensation. The existing drains in this device, in turn, release the water produced by the equipment, which in most cases is wasted, when it could be reused for other purposes, and also generates constructive pathologies in buildings that cause physical and aesthetic damage to the building. (NASCIMENTO and VIEIRA, 2021, p.2)

There is an urgent need to implement constructive and efficient programs that allow for the rational use of water with the consequent conservation of water resources, acting with sustainability. It is important to highlight that some of the factors that greatly contribute to the worsening of this situation are excessive human consumption, pollution and waste. (MORAIS *et al.*, 2021, p.144)

Water from air conditioning is an example of a simple, sustainable alternative to reduce waste. Despite the variety of devices, the operating principle for refrigeration follows the same pattern, in which the evaporation of a refrigerant fluid is used to provide refrigeration. This volume of condensed water from the air conditioners can be used for so-called non-potable uses, such as watering the garden, and general cleaning (washing floors, cars, etc.). (VIEIRA *et al.*, 2021, p.366)

"Less noble" waters should be used for "less noble" purposes. And, given that the water crisis was classified by the World Economic Forum as one of the greatest global risks (WEF, 2016), actions aimed at conservation and sustainability in the use of water resources are of fundamental importance. (PRADO, SOARES and SILVA, 2021, p.2)

It is known that air conditioners perform condensation when they remove moisture from the air, generating a certain amount of water that is released through the drain and goes to the ground or sewer. The reuse of water from devices that release a certain flow contributes significantly to the rational use of potable water. Thus, collection projects in buildings that use drinking water in large proportion, add up to a productive and effective portion in the general aspect. (CAMPOS *et al.*, 2019, p.59)

It is essential that, for future constructions, a system for the reuse of water coming from air conditioning devices must be included in the project, aiming at a good economic and environmental performance of the buildings. Reusing water provides benefits because it reduces its demand, in addition to preserving the environment, saving

energy, reducing investments in infrastructure and enabling the improvement of industrial processes. (CAMPOS *et al.*, 2019, p.67)

The permanent management of water demand in buildings, especially in urban centers in regions with water vulnerability, is an emergency issue in Brazil, regardless of possible lack of rain at a given time or region (CÁCERES, 2018 p.27).

In buildings where there are large amounts of high power appliances, the production of condensed water becomes relevant. (SOARES, SOUZA JÚNIOR and SILVA, 2021, p.3)

In the midst of an increasing unavailability of drinking water on planet Earth, it is necessary to take mitigating measures so that this scenario begins to change. Given this, measures such as water reuse are a solution to achieve this goal, above all, in the name of environmental sustainability. (SIMES *et al.*, 2020, p.192)

III.   METHODOLOGY

In search for the scientific rigor of the present research, the case study is shown as a sufficient methodological apparatus to obtain results. These will be evaluated through qualitative and quantitative techniques, with a view to achieving a correct understanding of the possible savings in expenses with the implementation of the collection and reuse of condensed water from the air conditioning units installed in the Forum Lourenço José Ribeiro building, an integral building the structure and jurisdictional powers of the Pernambuco Court of Justice.

The present work was initially built through a bibliographic, legislative and documentary survey that aimed to understand the state of the art on the reuse of condensed water and the possibility of applying this tool in a public building that is part of the jurisdiction of the Pernambuco Judiciary.

The bibliographic survey carried out now comprises especially the production of scientific articles published in electronic journals in recent years (as a rule, in the time frame between 2016 and 2021) that address the reuse of condensed water, as well as the socio-environmental responsibility of the Judiciary as a component of public administration and information structure about the water crisis in the world, which demands the creation of solutions and technologies for reuse and maximum savings of water resources.

Among the documentary contributions, the reports produced by the Court of Justice of Pernambuco and by the National Council of Justice regarding the monitoring of socio-environmental practices that have been encouraged in

the Brazilian Judiciary were relevant. The relevance of the data and graphs extracted from the TJPE Sustainable Logistics Plan (base year 2021) and from Resolutions n. 201 and 400 of the CNJ, which guide environmentally appropriate actions for all component bodies of the Brazilian justice sphere.

Among the references extracted from the United Nations, the documents on the Millennium Development Goals (SDGs), Agenda 21 and A3P were relevant, being in all cases the focus on environmental goals that must be implemented by the Brazilian public administration.

The methodology used sought the bibliographic, legislative and documentary contribution to understand the subject and integrated the theoretical knowledge with the collection and laboratory analysis of the water quality produced by the dripping of the Lourenço José Ribeiro Forum (Olinda Forum) air conditioners, in order to understand the potential of its use in activities specific to the public building in question.

The research in question has an exploratory nature and is anchored in a quali-quantitative approach.

For this purpose, Test Report No. 187,353, prepared by the Laboratory of Analytical Chemistry - LQA/ITEP, was used.

The Olinda Forum has 293 VRF System type air conditioners, and the research aimed at the physical-chemical analysis of 01 (one) sample (code 29840) of water expelled from the air conditioner (VRF System type) of the

Vara do Jury/Administration/Board of Directors of the Olinda Forum.

Some data were observed about the presented report, namely: a) According to the Ryznar stability index, the water in question presents a high incidence of corrosion in relation to $CACO_3$, at a temperature of 28.9° C; b) the collection of samples and field tests when carried out by ITEP, follows the LQA-PT-03 procedure, and the environmental conditions recorded in a field worksheet; c) the pH, conductivity, dissolved solids and temperature parameters were analyzed at the Forum's facilities; d) environmental conditions: sun.

The obtained results indicate that the alkalinity of the water from the air condensers could not be used for human consumption, but it is suitable for use in non-noble purposes, such as washing patios and windows of the Forum.

3.1 Research Locus

The study consists of applied research in loco at the Lourenço José Ribeiro Forum (commonly known as the Olinda Forum), located at Av. Pan Nordestina, s/n - Vila Popular, Olinda - PE, CEP 53010-210, regarding the possibility of reusing wastewater from the air conditioners installed in this public building for non-noble purposes, such as washing external patios, washing panes and windows of that building. Figure 1 shows an image of the Olinda Forum.

Fig.1 - The Lourenço José Ribeiro Forum (Olinda Forum) image
Source: Google Earth (2021)

Olinda city is 16 kilometers high above sea level and is 6 kilometers away from the state capital, in addition to possessing a surface area of 43,548 km2, integrating the

micro-region of Recife, in the Metropolitan mesoregion. (TJPE, 2010, p.333). The location of the Forum of Olinda on the map can be seen in the figure.

In the municipal limits of Olinda are the Atlantic Ocean to the east; Recife city to the west and south, and Paulista city to the north. The local climate is hot and humid, with an average annual temperature of 27° C, and its territory is located between the Beberibe and Paratibe Basins. (OLINDA CITY HALL, 2021)

The hydric matrix of Olinda city is composed of the coastal coast with the Atlantic Ocean, the Beberibe River, the following tributaries in the Beberibe Basin: Lava Tripa Channel, Azeitona Channel, Malaria Channel, Lagoas de Jardim Brasil 3, Lagoa de Santa Tereza and Lagoa da Pulsação, and in the Paratibe Basin it has the tributaries Riacho da Mirueira, Riacho Fragoso (Piaba de Ouro), Riacho Ouro Preto, Bultrins Channel, Bultrins Fragoso Channel, Tintas Channel and Fragoso Lagoon. (OLINDA CITY HALL, 2021)

Fig.7 - Split Cassette air conditioning type used in the Lourenço José Ribeiro Forum

Source: Own collection (2021)

The Olinda Forum has a built area of 7,500.00 m², spread over four floors, comprising a ground floor - with a parking area for magistrates and service vehicles - and another three upper floors. The venue has a Jury room, bank, four cells, four elevators, access for the disabled, event room, and parking for 120 vehicles in the outdoor area. (SILVA, 2020)

In addition to the administrative facilities, there are three Criminal Courts, five Civil Courts, three Family and Civil Registry Courts, a Succession and Public Registry Court, two Public Treasury Courts, a Court of Domestic and Family Violence against Women, a Jury Court, a Childhood and Youth Court, in addition to a Judicial Center for Conflict Resolution and Citizenship (CEJUSC). (TJPE, 2021)

3.2 Analysis of the water quality of air conditioning condensers

The present case study is based on the laboratory verification of the physical-chemical properties of the water produced by the air conditioners of the Lourenço José Ribeiro Forum (Olinda Forum), in an attempt to understand the possible reuse applications of this water resource. It was necessary to verify the degree of nobility of the condensed water, so that its reuse can be in line with the chemical adaptations.

The Olinda Forum has 293 VRF System type air conditioners, and the research aimed at the physical-chemical analysis of 01 (one) sample (code 29840) of water expelled from the air conditioner (VRF System type) of the Vara do Jury/Administration/Board of Directors of the Olinda Forum.

Qualitative analysis included the physicochemical parameters and followed the requirements of the procedures established by the Standard **Methods for the Examination of Water and Wastewater (2017)** as described in Table 1X.

Parameter	Unity	Method
Bicarbonate alkalinity	mg/LCaCO3	2320 B
Carbonate alkalinity	mg/LCaCO3	2320 B
Alkalinity of hydroxides	mg/L CaCO3	2320 B
Total alkalinity	mg/L CaCO3	2320 B
Total calcium	mg/L Ca	Normative Instruction No. 30, of June 26, 2018
Chlorides	g/100g	3120 B
Conductivity	µg/cm	2510-B

Free carbon dioxide	mg/L CO_2	4500-CO2-C
Total hardness	mg/L CaCO3	2340 B
Total iron	mg/L Fe	Método 330 K
Ryznar Index	-	Cálculo
Total magnesium	mg/L Mg	2340 B
pH	-	4500- H+B
Total dissolved solids	mg/L	2510 A
Temperature	°C	2550 B

IV. RESULTS AND DISCUSSION

Once in possession of the qualitative-quantitative surveys indicated above, it is important to discuss the results of this work and elaborate possible discussions according to the general and specific objectives mentioned above.

The potential reuse of condensed water is linked to the physical-chemical results, because the applications of this water resource need to be suitable for an use that supports the components of cooling water, such as pH and alkalinity, among others. In this sense, in chorus with the majority doctrine, the reuse of condensed water must be destined for the so-called non-noble purposes, which is exemplified as those that are used in cleaning services for external environments and decorative purposes, such as water mirrors and fountains. There are also less common industrial applications for the reuse of water dripped from air conditioners; in these cases, they can be useful in the cooling of boilers, or in the heating of vats in restaurants in the self-service format.

The motivations for the search for solutions and alternatives that can reduce water stress are evidently important. Even if renewable, quality and potable water resources are scarce. Alternatively, reuse can help reduce the use of potable water for activities that do not require potability. (MOURA *et al.*, 2020, p.791)

In Brazil, reused water is being used in several non-potable activities, such as agriculture, landscape irrigation, urban cleaning, vehicle washing and toilets in shopping malls. (MOURA *et al.*, 2020, p.792)

It is known that air conditioners perform condensation when they remove moisture from the air, generating a certain amount of water that is released through the drain and goes to the ground or sewer. The reuse of water from devices that release a certain flow contributes significantly to the rational use of potable water. Thus, collection projects in buildings that use drinking water in large proportion, add up to a productive and effective portion in the general aspect. (RIGOTTI, 2014; CAMPOS *et al.*, 2019, p2)

In addition to the evident softening of the water stress that affects the planet, it is necessary to remember that the uncontrolled dripping of air conditioning water is capable of causing structural damage to facades and sidewalks, in addition to infiltration problems, depending on the location of the condensers. Add to that the water waste from a source that could be reused if it had the necessary storage technology.

The collection of waste water in air conditioners is of paramount importance, because in addition to promoting the economy of this substance essential for life, it probably avoids the early deterioration of masonry, especially in public buildings, generating savings for public coffers. Furthermore, not allowing water to pool on the sidewalks contributes to the work of combating the proliferation of disease vectors, such as urban pigeons *(Columba livia)*. (ORTIZ *et al.*, 2021, p.25140)

Air conditioning equipment is used on a large scale in school, commercial and residential buildings, making the amount of water generated by the total number of appliances considerable, allowing the collection and reuse of the same in its various purposes, such as washing floors and flushing toilets. The technique of water reuse will depend on the medium from which the water was generated and its final destination, whether or not it is for human consumption. For such, it must meet criteria established by the Ministry of Health through Ordinance No. 2914 of December 2011, which aims to have procedures related to the control and surveillance of the water quality for human consumption and its potability standard. (CALDAS and CAMBOIM, 2017, p.168)

Despite the fact that Brazil does not have specific legislation that deals with the reuse of water from air conditioning units, it is worth noting that the reuse of water sources for non-potable purposes has already been dealt with in a more elaborate way in recent years by the Brazilian Association of Technical Standards (ABNT) through NBR 16782, NBR 16783 and NBR 15527.

In this sense, the efficient use of water was contemplated, in 2019, with a consistent increase in the normative reference framework. Two new ABNT standards were published, namely: ABNT NBR 16782:2019, which deals with water conservation in buildings, with requirements, procedures and guidelines; and ABNT NBR 16783:2019, which provides for the use of alternative sources of non-potable water in buildings. These documents, together with the ABNT NBR 15527:2019 standard, which endorses rainwater for the use of roofs in urban areas for non-potable purposes, in addition to disciplining its requirements, whose revision was published in April 2019, support the application concepts of conservation and replacement of water sources in buildings. (ZANELLA and ALVES, 2020, p.1)

NBR 16782 defines water conservation in buildings as the set of actions that, in addition to optimizing the operation of the building system in order to reduce the amount of water consumed (demand management), also promote the use of water from alternative sources to potable water provided by the public or private system (supply management). In general, water demand management seeks to promote actions directly in the hydraulic system so that less water is used in carrying out the same activities. Supply management, in turn, focuses on reducing consumption of potable water by replacing sources in specific processes. (ZANELLA and ALVES, 2020, p.1)

NBR 16782 cites as fundamental steps for the adoption of water conservation practices, the water characterization of the building, which is based on the understanding of the water cycle in the building from the water balance, and the elaboration of the supply and demand matrix of potable and non-potable water, bases for carrying out the technical and economic feasibility study that will guide the selection of applicable technologies and practices. (ZANELLA and ALVES, 2020, p.2)

Notwithstanding the aforementioned ABNT NBR are silent on condensed water and lists various sources of non-potable water such as rainwater; pluvial water; water table lowering; gray waters; dark gray waters; black water

and sanitary sewage. It is imperative to point out that the dripping water from the air conditioners can serve the same hydric purposes and also collaborate with the reduction of the potable sources uses for non-noble applications. Naturally, the physicochemical composition admits variations of compounds, however, its use for non-potable purposes is adequate.

The main uses provided for by the NBR 16782, NBR 16783 and NBR 15527 standards for water from non-potable alternative sources are: flushing toilets and urinals; washing floors, patios, patios, garages; vehicle washing; irrigation for landscape purposes; ornamental use (fountains, fountains and lakes); water cooling systems and roof cooling. As for other unforeseen uses, the standards recommend that specific quality parameters must be evaluated for each situation by the professional responsible for the system design. The new regulations establish quality standards for water from alternative sources so that it can be used for the specified non-potable purposes. In order to reach the values of the required quality standards, the waters must undergo adequate treatment. (ZANELLA and ALVES, 2020, p.2)

Bearing in mind that the scarcity of drinking water is a topic on the agenda in contemporary environmental discussions, it is necessary that all contributions are considered economically. In this sense, the reuse of condensed water from air conditioners can contribute to the reduction of potable water resources in activities that do not directly depend on the potability of water to be carried out.

4.1 Test report and technical comments on sample results

The results of the cooling water examination considered the following variables: bicarbonate alkalinity, carbonate alkalinity, hydroxide alkalinity, total alkalinity, total calcium, chlorides, conductivity, free carbon dioxide, total hardness, total iron, Ryznar index, total magnesium, pH, total dissolved solids and temperature. Figure 9 shows the result of this examination of the cooling water, as well as its parameters and units.

Fig.9 - Condensed water results from the Jury Room of the Fórum Lourenço

Parameter	Results	Unity
Bicarbonate alkalinity,	6,75	mg/LCaCO3
Carbonate alkalinity	0,00	mg/LCaCO3
Hydroxide alkalinity	0,00	mg/L CaCO3
Total alkalinity	6,75	mg/L CaCO3
Total calcium	1,01	mg/L Ca
Chlorides	<0,5	g/100g

Conductivity	36,1	µg/cm
Free carbon dioxide	2,2	mg/L CO_2
Total hardness	3,59	mg/L CaCO3
Total iron	<0,05	mg/L Fe
Ryznar index	14,6	-
Total magnesium	<0,5	mg/L Mg
pH	6,55	-
Total dissolved solids	17	mg/L
Temperature	28,9	ºC

Source: LQA (2021); Author/ITEP (2021)

Cunha and Faria (2012) developed a qualitative-quantitative survey of condensed water from air conditioners at the Information Technology Department and the Administration and Planning Department. A physical-chemical analysis was carried out, where parameters such as ph, alkalinity and hardness were observed. It was also inferred that the water that is usually discarded has a high possibility of reuse for non-potable uses, such as landscape irrigation.

Melo (2020) elaborated his study on air conditioning units in a hospital typology building located in the city of Recife-Pe. It was found that the result of water collection presented a pH content below the standard that the law requires for human consumption (pH of 5.60), which would require a simple pH change through lime hydrated to reach the values imposed by the Ministry of Health Ordinance No. 2,914/11. However, the physical-chemical parameters satisfy non-potable needs, such as floor washing and water replenishment in the cooling tower of the air conditioning system.

Carvalho *et al* (2016) had as mainstay for their study elements collected from the air conditioners of Block "B" of the Catholic University of Pernambuco (Unicap). The parameters of pH, alkalinity, chlorides, conductivity, hardness and turbidity were analyzed. Two samples were taken for the research where it was obtained in sample 1 and in sample 2, the pH 6.68 and 6.7, respectively. Thus, such values are not within the standards required by the Ministry of Health Ordinance No. 2,914/11 for human consumption, but can be used for cleaning the institution and sanitary discharge.

It appears that the electrical conductivity is related to the presence of ions dissolved in the water, which are electrically charged particles. The greater the amount of dissolved ions, the greater the conductivity. Conductivity depends on the following factors: presence, concentration, mobility and valence of ions, as well as temperature. This parameter does not specifically determine which ions are present and only the amount of ions in the water, but it may contribute to the recognition of the water quality pattern, depending on the destination to which it is given. (SOUSA, ROCHA and MORAES, 2016, p.45)

Chloride ions are present in raw and treated water in concentrations that can vary from small traces to hundreds of mg.L-1. They are usually present in the form of sodium, calcium and magnesium chlorides. Conventional water treatment methods do not remove chlorides. Its removal can be done by demineralization or evaporation. (FUNASA, 2009; SOUSA, ROCHA and MORAES, 2016, p.45)

The final data from the laboratory examination presented here also indicate that, according to the analyzed sample, the water collected from the air conditioning has a high incidence of corrosion in relation to CaCO3, at a temperature of 28.9ºC. Furthermore, it is necessary to note that the pH, conductivity, dissolved solids and temperature factors are data captured *in loco*, that is, they are the conditions verified in the facilities of the Olinda Forum building, which still does not have any adequate capture and storage system of condensed water, despite its capacity to do so, given the high number of air conditioners installed in the building. Figure 10 shows the final data from the laboratory exam.

Taking this guideline into account, the study carried out by Souza (2019), taking into account the minimum volume of storage, for a period of 12 (twelve) months, identified a possible reduction, in reais, in water consumption at the Lourenço José Ribeiro Forum, based on the tariff structure of Companhia Pernambucana de Saneamento (COMPESA) practiced at the time.

Table 1 - Total annual volume of the air conditioning system of the building under study

number of months per year (12 months)	Total annual volume (l)		
	Minimum	estimated	Maximum
Total monthly volume (l)	45.463,00	47.713,60	49.970,80
total annual volume (l)	545.556,00	572.563,20	599.649,60

Source: Souza (2019).

Table 2 – Anual Reduction

Consumption			Value R$
up to	1	62,67	62,67
Above	545,556	9,50	5.182,78
		Annual economy	5.245,45

V. FINAL CONSIDERATIONS

The search for alternatives that offer efficiency in the (re)use of water resources must be shared by all civil society, companies and the State. The excessive wear and tear of the water matrix in the world triggers the need to seek new alternatives and solutions to meet the needs for water with the maximum efficiency and the minimum possible waste. In this sense, the reuse of some water sources is presented as a valuable alternative to the efficient and rational application of water.

Condensed water from dripping air conditioners is on the list of plausible sources to be reused along with rainwater and gray and black water.

In buildings that have complex cooling systems, equipped with numerous units of air condensers, the reuse of residual condensed water is shown as an enabler of reducing the use of drinking water in activities that, despite demanding the consumption of that water resource, would not necessarily need to be supplied by potable water.

These water purposes are considered non-noble and can be exemplified in the water use for washing floors and patios, cleaning windows, flushing toilets and landscaping equipment such as fountains and water features. It should be noted that in addition to the common applications set out here, condensed water is also possible for reuse in commercial and industrial activities such as boiler cooling and disposal in self-service restaurant vats.

The use of the water that drips from the air conditioners reveals itself, therefore, as a valuable matrix of hydric resource that would not require consumption of potable water. In the name of this relevance, State Law n.16.584 was published in Pernambuco in 2019, which determines the mandatory collection, storage and use of condensed water in private buildings for public use, such as malls, markets, etc.

Although the aforementioned normative forecast does not link this reuse of drip water in buildings owned by the Public Power of the State of Pernambuco, it is certain that government spheres have their own links to environmental sustainability initiatives that place the reuse of condensed water in the planning and future strategies of the Brazilian public administration. Thus, the trend of normative advancement is directed towards the standardization of the condensed water reuse as a rule to be observed both by the private sector and by the public sector so that the whole society contributes to the improvement of consumption and reuse of all available water inputs.

It is also worth noting that the Brazilian Association of Technical Standards (ABNT) has published in recent years some technical standards related to the reuse of water for non-potable sources, namely: NBR 15527:2019 - Use of rainwater from roofs for non-potable purposes - Requirements; NBR 16783:2019 Use of alternative sources of non-potable water in buildings; and NBR 16782:2019 - Water conservation in buildings - Requirements, procedures

and guidelines. Despite the lack of mention of the condensed water reuse, it is worth mentioning the existence of normative instruments that improved the standardization of reuse for various wastewater, as an example of what happens with rainwater; water table lowering; gray waters; dark gray waters; black water and sanitary sewage.

In this sense, the reuse of condensed water from the Lourenço José Ribeiro Forum is aligned with the environmental preservation proposals that currently link public administration decisions and projects, but which need to advance on the subject. The constitutional basis gives the environment the prerogative of defense by the Public Power and, therefore, any and all initiatives aimed at promoting sustainability must be taken into account.

The measures recommended by the United Nations on sustainable development that are mentioned in the TJPE Strategic Plan for the 2021-2026 years, and also in the Sustainable Logistics Plan make up the dialogue between international and local guidelines for environmental protection and improvement of decisions that weigh the sustainability factor in the decision-making of the Pernambuco Judiciary. In both documents, the consideration of reducing consumption and improving the reuse of water resources used in justice buildings remains through smarter systems that can guarantee a balanced use that does not demand from the environment anything more than what is due at the moment of application of this natural good and, when possible, that the inputs already used are reused in order to reduce the level of waste produced by public buildings.

The intention of the Judiciary is to become a house of sustainability promotion. Since the Public Power sets the example that companies and civil society must follow, the vanguard of adaptations of the daily life of public buildings to socio-environmental reverence seeks to bring to the heart of Brazilian society the consideration of such premises. Therefore, every forum can be a catalyst and an example to be followed in good practices, environmental technology and sustainable governance.

The present case study, dedicated to evaluating the potential for reuse of dripped water from air conditioners at the Forum Lourenço José Ribeiro (Olinda Forum), sought to promote reflection on the waste of an opportune source of non-potable water that, even offering the appropriate physical-chemical conditions to be reapplied in non-noble water activities, it is not being spared or considered as a valid alternative of financial and environmental savings to the Olinda Judiciary.

It should be reiterated that the wastewater reuse from the air conditioners of the Olinda Forum has an intrinsic relationship with the normative provisions listed in

the TJPE Strategic Plan for the 2021-2026 years and also in the TJPE Sustainable Logistics Plan to promote the reduction of water consumption and reuse of water sources that supply the Brazilian courts, worth ratifying that such documents are a direct result of the guidelines coming from the National Council of Justice and also from the Sustainable Development Goals of the 2030 Agenda promoted by the United Nations on the indispensable improvement in the use, reuse and reduction of goods extracted from nature consumption.

In this way, socio-environmental responsibility brings together both environmental and material interests regarding a possible reduction in the drinking water bill, if the wastewater from the air conditioners were reused in the Olinda Forum.

REFERENCES

[1] ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS. **ABNT NBR 15527:2019** - Aproveitamento de água de chuva de coberturas para fins não potáveis - Requisitos. Disponível em: https://www.normas.com.br/visualizar/abnt-nbr-nm/26536/abnt-nbr15527-aproveitamento-de-agua-de-chuva-de-coberturas-para-fins-nao-potaveis-requisitos Acesso em: 28 dez. 2021.

[2] ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS. **ABNT NBR 16782:2019** – Conservação de água em edificações – Requisitos, procedimentos e diretrizes. Disponível em: https://www.normas.com.br/visualizar/abnt-nbr-nm/11513/abnt-nbr16782-conservacao-de-agua-em-edificacoes-requisitos-procedimentos-e-diretrizes Acesso em: 28 dez. 2021.

[3] ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS. **ABNT NBR 16783** - Uso de fontes alternativas de água não potável em edificações. Disponível em: https://www.normas.com.br/visualizar/abnt-nbr-nm/11516/abnt-nbr16783-uso-de-fontes-alternativas-de-agua-nao-potavel-em-edificacoes Acesso em: 28 dez. 2021.

[4] BOLZAN, C. B. **Sistema de reuso de água cinza originária de aparelhos de ar condicionado em um prédio comercial.** Porto Alegre: junho 2017.

[5] BRASIL. Câmara dos Deputados. **Projeto de Lei Federal n. 8.277/2017**. Dispõe sobre o reuso de água para fins não potáveis em novas edificações públicas federais e privadas residenciais, comerciais e industriais, e dá outras providências. Autor: Senador Cajar Nardes. Disponível em: https://www.camara.leg.br/proposicoesWeb/prop_mostrarint egra?codteor=1592540 Acesso em: 06 jan. 2022.

[6] BRASIL. Conselho Nacional de Justiça. **Resolução nº 198 de 01/07/2014**. Dispõe sobre o Planejamento e a Gestão Estratégica no âmbito do Poder Judiciário e dá outras providências. Disponível em: https://atos.cnj.jus.br/atos/detalhar/2029 Acesso em: 07 nov. 2021.

[7] BRASIL. Conselho Nacional de Justiça. **Resolução nº 201 de 03/03/2015**. Dispõe sobre a criação e competências das

unidadesou núcleos socioambientais nos órgãos e conselhos do Poder Judiciário e implantação do respectivo Plano deLogística Sustentável (PLS-PJ). Disponível em: https://atos.cnj.jus.br/files/resolucao_201_03032015_22032 019155446.pdf. Acesso em: 07 nov. 2021.

[8] BRASIL. Conselho Nacional de Justiça. **Resolução nº 400 de 16/06/2021** - Dispõe sobre a política de sustentabilidade no âmbito do Poder Judiciário. Disponível em: https://atos.cnj.jus.br/atos/detalhar/3986 Acesso em: 12 nov. 2021.

[9] BRASIL. Ministério da Saúde. **Portaria n. 2.914, de 12/12/2011** - Dispõe sobre os procedimentos de controle e de vigilância da qualidade da água para consumo humano e seu padrão de potabilidade. Disponível em: https://bvsms.saude.gov.br/bvs/saudelegis/gm/2011/prt2914 _12_12_2011.html Acesso em: 05 jan. 2022.

[10] BRASIL. Ministério do Meio Ambiente (MMA). **Agenda Ambiental na Administração Pública – A3P**. Brasília: MMA,2009. 100p.

[11] BRANSKI, R. M. *et al*. Metodologia de estudo de casos aplicada à logística. **XXIV ANPET Congresso de Pesquisa e Ensino em Transporte**, 2010.

[12] CÁCERES, P. S. **Modelo de governança de água não potável pelo aproveitamento da água pluvial e reuso de água cinza em edificações residenciais do Distrito Federal**. 2018. xxii, 189 f., il. Dissertação (Mestrado em Arquitetura e Urbanismo) — Universidade de Brasília, Brasília, 2018.Disponível em: https://repositorio.unb.br/handle/10482/32856. Acesso em: 25/09/2020.

[13] CALDAS, J.; CAMBOIM, W. L. N. **Aproveitamento da Água dos Aparelhos Condicionadores de Ar para Fins não Potáveis: Avaliação da Viabilidade de Implantação em um Bloco do Unipê**. Revista Inter Scientia, v. 5, n.1, p.166-188, 2017.

[14] CALMON, J. L.; BASTOS, C. S. Conservação de água em *shopping centers*: análise das percepções dos atores envolvidos nos projetos e gestão, com o uso do processo de hierarquia analítica. **Revista Engenharia Sanitária e Ambiental – ABES** 26 (3). May-Jun 2021.

[15] CAMPOS, J. G. *et al*. Sistema de Captação para Aproveitamento da Água Condensada de Aparelhos de Ar Condicionado. **Revista RENEFARA (Online)**, Goiânia, v. 14, n. 3, p.58-69, set./dez. 2019.

[16] CAPELLARI, A.; CAPELLARI, M. B. A água como bem jurídico, econômico e social: A necessidade de proteção das nascentes. **Revista Cidades (online)**, Varia, v.36, 2018.

[17] CARDOSO, R. N. C.**Viabilidade econômica de sistemas de captação de água da chuva para fins não potáveis em dois prédios da Universidade Federal do Pará**. Universidade Federal do Pará. Dissertação de Mestrado. 8-Mar-2018.

[18] CARVALHO, C. B. et al. Mobilidade de contaminantes em solos arenosos após a aplicação de águas residuárias tratadas produzidas em indústria siderúrgica. Artigo Técnico. **Revista Engenharia Sanitária e Ambiental – ABES. Rio de Janeiro:** Nov-2021.

[19] CARVALHO, I. M. et al. **Análise quantitativa e qualitativa da água proveniente de aparelho de ar condicionado visando o seu reaproveitamento.** Aracaju: 2016.

[20] CARVALHO, M. T. C. et al. **Caracterização quali-quantitativa da água da condensadora de aparelhos de ar condicionado.** Instituto Brasileiro de Estudos Ambientais-IBEAS. Goiânia: 2012.

[21] CETESB SÃO PAULO. **Águas Interiores**. Disponível em: <https://cetesb.sp.gov.br/aguas-interiores/informacoes-basicas/tpos-de-agua/> Acesso em: 12/12/2021.

[22] CORDEIRO, L. F. A. **Eficiência energética no controle inteligente de sistemas de bombeamento**. Recife: Universidade Federal de Pernambuco, 2008. (Dissertação de mestrado).

[23] CORDEIRO, L. F. A. **Planejamento do setor elétrico brasileiro com foco nas emissões de CO2**. Recife: Universidade Federal de Pernambuco, 2015. (Tese de doutorado).

[24] CORDEIRO L. F. A;, SOUZA, A. A.. **Reuso de água de um sistema de climatização: estudo de caso em um prédio público**, Congesta, João Pessoa, 2019.

[25] COSTA, E. S.; VAZ, A. P. M. Desvelando ideias socioambientais no Judiciário brasileiro. *Research, Society and Development*, v. 10, n. 7, 2021.

[26] COSTA, R. P. **Estudo do reaproveitamento da água proveniente dos condicionadores de ar na UTI do Hospital Osvaldo Cruz em Palmas-TO, um estudo de caso.** Palmas: 2017.

[27] FERNANDES, A. F.; SOUZA, J. C. D'. e; MACIEL, M. J. S.. Reuso de Água de Ar Condicionado Utilizando Internet das Coisas e Computação em Nuvem: Um Estudo de Caso na Empresa de TIC no Amazonas. *In*: **Meio ambiente, recursos hídricos e saneamento ambiental** [recurso eletrônico] / Organizador Helenton Carlos da Silva. – Ponta Grossa, PR: Atena, 2020.

[28] FERREIRA, A. S.; ALVES, T. G. **Reaproveitamento de Água Condensada de Aparelhos de Ar Condicionado**. Trabalho de Conclusão de Curso - Graduação em Engenharia Civil. Centro Universitário CESMAC, Maeió/AL, 2018, 39f.

[29] FERREIRA, E. P.; LOSS, J. B.; ROSADO, T. L.; FERREIRA, J. T. P.; SILVA, W. C. Uso alternativo de água condensada por aparelhos de ar condicionado na produção de mudas de pimentão. *Brazilian Journal of Development*, Curitiba, v. 5, n. 7, p. 9127-9136 jul. 2019.

[30] FERREIRA, E. P.; TOSE, M. Uso Sustentável da Água Produzida por Aparelhos de Ar Condicionado - Um Estudo de Caso**. Revista de Engenharia e Tecnologia**, V. 8, N. 3, P. 181-190, Dez/2016.

[31] FISCHER, M. L. *et al*. Crise hídrica: a culpa é de quem? A percepção das responsabilidades em espaço de deliberação virtual. **Revista Brasileira de Diálogo Ecumênico e Inter-religioso - Caminhos de Diálogo**, Curitiba, ano 9, n. 15, p. 225-247, jul./dez. 2021.

[32] GIL, A. C. **Como elaborar projetos de pesquisa**. 4 ed. São Paulo: Atlas, 2002.

[33] GODOY, S. M.; MOREIRA, R. M. F. A Responsabilidade Socioambiental dos Órgãos Públicos - Um Olhar Sobre a Justiça Federal da 5ª Região. **Revista Direito e Desenvolvimento**, João Pessoa, v. 12, n. 2, p. 150-168, jul./dez. 2021.

[34] GOMES, J. A. C.; SALES, J. S.; MEDEIROS, T. H. F.; COELHO, R. C. Reuso da Água Condensada por Aparelhos de Ar Condicionado nos Laboratórios do IFPI, Campus Teresina Central. **IX Congresso Brasileiro de Gestão Ambiental (ConGeA)**, São Bernardo do Campo/SP – 26 a 29/11/2018.

[35] GOULART, C. R.; PIETRAFESA, P. A. Gestão ambiental e a política pública de sustentabilidade do Poder Judiciário de Goiás, Brasil. **Revista Brasileira de Gestão Ambiental e Sustentabilidade**, v.6, n.14, p.733-748, Dez/2019.

[36] MARINHO, D. S.; ATHAYDE JÚNIOR, G. B.; QUARESMA, I. N. Estimativa de vazão da água condensada proveniente de aparelhos condicionadores de ar. *Research, Society and Development*, v. 10, n. 13, p. 1-12, Out/2021.

[37] MELO, A. J. N. **Aproveitamento da água gerada por condicionadores de ar para fins não potáveis: estudo de caso em um hospital na cidade do Recife.** Recife: 2020.

[38] MINISTÉRIO DO MEIO AMBIENTE. **Agenda 21 Global**. Disponível em: https://antigo.mma.gov.br/responsabilidade-socioambiental/agenda-21/agenda-21-global.html   Acesso em: 30 dez. 2021.

[39] MORAIS, B. R. et al. A Implantação e Uso na Educação Ambiental de um Sistema para Reutilização de Água de Refrigeração de Destilador. **Revista Brasileira de Educação Ambiental - Revbea**, São Paulo, V.16, N.3, p.142-152, 2021.

[40] MOURA, P. G.*et al*. Água de reuso: uma alternativa sustentável para o Brasil. **Revista Engenharia Sanitaria e Ambiental**, Rio de Janeiro, v. 25, n. 6, p. 791-808, Dez.2020.

[41] NAÇÕES UNIDAS BRASIL. **Plataforma Agenda 2030 - 17 Objetivos de Desenvolvimento Sustentável**. Disponível em: <http://www.agenda2030.org.br/ods/6/> Acesso em: 06 out. 2021.

[42] NASCIMENTO, I. S.; VIEIRA, Z. C. Avaliação Financeira do Reuso da Água de Condicionadores de Ar em Condomínio. **Congresso Técnico-Científico de Engenharia e Agronomia (CONTECC)**, SOEA CONNECT, 2021.

[43] NASCIMENTO, P. C. B. *et al*. Reaproveitamento da Água Gerada do Ar Condicionado para Atividades Comerciais em Restaurante. **Revista Augustus**, Rio de Janeiro, v. 24 n. 48, p. 134-145, jul./out. 2019.

[44] ORTIZ, G. F.; CALDO, M. A.; SOUZA, A. R. S.; CALADO, D. C.; NANTES, M. M. Descarte da água residual em aparelhos de ar condicionado – possíveis danos, soluções sustentáveis. *Brazilian Journal of Development*, Curitiba, v.7, n.3, p.25133-25142, Mar/2021.

[45] PERNAMBUCO. Assembleia Legislativa. **Lei nº 14.572, de 27 de dezembro de 2011** - Estabelece normas para o uso racional e reaproveitamento das águas nas edificações do Estado de Pernambuco e dá outras providências. Disponível em: https://legis.alepe.pe.gov.br/texto.aspx?tiponorma=1&numero=14572&complemento=0&ano=2011&tipo=&url= Acesso em: 28 dez. 2021.

[46] PERNAMBUCO. Assembleia Legislativa. **Lei nº 16.584, de 10 de junho de 2019** - Altera a Lei nº 14.572/2011, que estabelece normas para o uso racional e reaproveitamento das águas nas edificações do Estado de Pernambuco e dá outras providências, a fim de dispor sobre a coleta e o reaproveitamento da água do sistema de climatização das edificações.   Disponível   em: https://legis.alepe.pe.gov.br/texto.aspx?tiponorma=1&numero=16584&complemento=0&ano=2019&tipo=&url=Acesso em: 28 dez. 2021.

[47] PERNAMBUCO. Prefeitura de Olinda. **Olinda em Dados**. Disponível em: http://www.olinda.pe.gov.br/a-cidade/olinda-em-dados/ Acesso em: 04 jan. 2022.

[48] PERNAMBUCO. Tribunal de Justiça de Pernambuco.**Comarca de Olinda**. Disponível em: https://www2.tjpe.jus.br/falecomjud/Comarcas/consulta2comarca.asp?cod=226 Acesso em: 02 jan. 2022.

[49] PERNAMBUCO. Tribunal de Justiça de Pernambuco.**História das Comarcas Pernambucanas.** 2ª ed. Recife: TJPE, 2010.

[50] PERNAMBUCO. Tribunal de Justiça de Pernambuco.**Plano Estratégico TJPE 2021-2026**.Disponível em: http://www.tjpe.jus.br/documents/90471/2748851/Plano+Estrategico+TJPE+2021-2026+v2.pdf/0e53d026-2b7a-72c4-2a8a-6031b054d680 Acesso em: 05 nov. 2021.

[51] PERNAMBUCO. Tribunal de Justiça de Pernambuco.**Plano de Logística Sustentável TJPE 2021-2021**. Disponível em:http://www.tjpe.jus.br/web/planejamento/pls-2020/2021 Acesso em: 06 jan. 2021.

[52] PERNAMBUCO. Tribunal de Justiça de Pernambuco. **Programa Sustentabilidade Legal**. 2017. Disponível em: Acesso   em: https://www.tjpe.jus.br/web/sustentabilidade/programa   12 dez. 2021.

[53] PRADO, A. R. M.; SOARES, A. E. P.; SILVA, S. R. Potencial de redução do consumo de água potável na sede do Tribunal Regional Eleitoral de Pernambuco – TRE/PE. **Revista Nacional de Gerenciamento de Cidades**, volume 09, número 73, 2021.

[54] RODRIGUES, T. A.; LEANDRO NETO, J.; GALVÃO, D. O. (organizadores). **Meio ambiente, sustentabilidade e agroecologia 2** [recurso eletrônico] Ponta Grossa (PR): Atena Editora, 2019.

[55] SAMORA, P. R.; SILVA, J. L. Os impactos da crise hídrica sobre a população do município de Campinas/SP (2012-2016). **Urbe - Revista Brasileira de Gestão Urbana**, V.11, 2019.

[56] SILVA, A. B. et al. **Análise físico-química da água utilizada para consumo nas escolas municipais da zona urbana de Esperança/PB.** Macapá, v.8, n.3, p. 49-52, 2018.

[57] SILVA, A. F. A. **Análise de viabilidade técnica e econômica de medidas de conservação da água em prédios públicos administrativos do estado de Pernambuco**. Dissertação (Mestre em Engenharia Civil) – Escola Politécnica de Pernambuco, Universidade de Pernambuco, Recife/PE, 2018, 149f.

[58] SILVA, A. R. **Sustentabilidade ambiental aplicada a partir do reuso de água de aparelhos de ar condicionado segundo a Lei nº 10.446 de 03/10/2016.** Cuiabá, 2017.

[59] SILVA, B. T. et al. Desenvolvimento de mudas de Mimosa caesalpiniifolia Benth e Amburana cearensis (Fr. All) A.C Smith. irrigadas com esgoto doméstico tratado. Artigo Técnico. **Revista Engenharia Sanitária e Ambiental –**

ABES. Rio de Janeiro: Nov-Dec 2021.

[60] SILVA, E. D.**Sustentabilidade hídrica no serviço público : Estudo do Fórum Rodolfo Aureliano, Recife – PE**. Dissertação (Mestrado) – Associação Instituto de Tecnologia de Pernambuco, Programa de Pós-Graduação em Tecnologia Ambiental – Recife, BR-PE, 2020, 51 f.

[61] SILVA, J. N.; PINTO, F. R. Sistema de Reuso de Água Condensada Advinda de um Aparelho de Ar Condicionado para o Abastecimento de Bacia Sanitária por Meio de Microcontrolador. **Semana Acadêmica Revista Científica**, Fortaleza, ed. 0185, v. 01, p.1-17, Nov/2019.

[62] SILVA, A. P. S. et al. **Proposta de reutilização da água derivada de condicionadores de ar para reuso no Laboratório de Ciências da Escola José Luiz Neto.** Campina Grande, 2019.

[63] SIMÕES, F. A. F.; FREITAS, C. A. S.; FEITOSA, R. G. F.; SANTOS, Y. Potencial Reuso das Águas de Resfriamento de Destiladores Laboratoriais. **Revista Eletrônica de Gestão e Tecnologias Ambientais (GESTA)**, v. 8, n. 1, p. 180-194, Jul/2020.

[64] SOARES, M. C. D. M.; SILVA, A. F. A.; SILVA, S. R. Análise de viabilidade do aproveitamento de água dos aparelhos de ar condicionado para fins não potáveis em um prédio público situado no Recife - PE. **Periódico Técnico e Científico Cidades Verdes**, v.06, n.13, p.62-75, 2018.

[65] SOARES, M. C. D. M.; SOUZA JÚNIOR, G. D.; SILVA, S. R. Aproveitamento de água de aparelhos de ar condicionado em prédio público do estado de Pernambuco. *Research, Society and Development*, v. 10, n. 16, Dez/2021.

[66] SOUZA, A. A. **Reuso De Água Condensada De Um Prédio Público Do Poder Judiciário De Pernambuco: Estudo De Caso**. Dissertação (Mestrado) 2020.

[67] SOUZA, C. M. et al. Reuso de água de Drenagem Subterrânea em Canteiro de Obras e para Irrigação de Jardins: Um Estudo de Caso em Fortaleza-CE. Rev. bras. meteorol. 36 (3 suppl). Jul-Sep 2021.

[68] VIEIRA, Z. C.; LIMA, E. J. S.; NOVAIS, R. A.; SILVA JÚNIOR, C. G.; CARVALHO, P. C. J. Potencial de captação de água de aparelho de ar condicionado: um estudo de caso na secretaria de infraestrutura de São Cristovão/SE. *In*: **Águas e Florestas: desafios para a conservação e utilização (livro eletrônico).** Organizador: Robson José de Oliveira. Guarujá, SP: Científica Digital, 2021.

[69] ZANELLA, L.; ALVES, W. C.. **Normas brasileiras de Reuso de água**. Associação Paulista de Municípios, Jun./2020.

Analysis nonlinear vibrations of the three - phase composite shallow cylindrical shell

Huyen TTH, Luot QT

Department of Mechanics, Le Quy Don Technical University, Hanoi City 100000, Vietnam

Email: huonghuyen.hvktqs@gmail.com

Abstract— This paper presents the results the study nonlinear vibrations of the three-phase composite shallow cylindrical shell. The differential equation describing the nonlinear vibrations of the shell is solved by the Newmark direct integration method combined with the Newton Raphson iterative method. Numerical simulation by finite element method is used to calculate the vibration of the structure. The results of the digital survey allow to make quantitative comments, technical recommendations, help the designers and users to orient effective applications in technical fields.

I. INTRODUCTION

Three-phase composite is a material consisting of a matrix phase, a fiber phase and a particle phase, which has been studied by Vanin G.A and Duc N.D. (1996a, 1996b)[7,8]. In the 1997 publications, Vanin G.A. and Duc N.D determined the elastic modulus for three-phase composite materials 3Dm (Vanin G.A. and Duc N.D., 1997) and 4Dm (Duc N.D., 1997a). An overview of three-phase composite materials was also found in the study of Minh D.K. (2011). Recently, Duc N.D. et al. (2011) also studied the nonlinear stability of three-phase polymer composite panels under thermal and mechanical load conditions (Duc N.D. et al., 2013; 2014). In this report, the authors studied the nonlinear dynamic response of the multilayer three-phase composite shallow cylindrical shell. The formulas are based on classical shell theory, taking into account geometric nonlinearities.

II. MATHEMATICAL MODELS AND ASSUMPTIONS

The cylindrical shell is considered as the shell with the ratio $\dfrac{f_0}{l_{min}} \leq \dfrac{1}{5}$, where f_0 - the curvature of the shell, $l_{min} =$

$min(a, L)$, a, L- the equal projection dimensions of the shell (Fig.2). According to the finite element method, the cylindrical shell can be discretized by flat elements, whereby the shell is a finite combination of 9 node-pointed flat elements, called the flat shell element, where each "flat shell element" can be seen as a combination of two types of elements: a 9 node flat element, each with 2 degrees of freedom (u_i, v_i) and a 9 node flat shell element subjected to combined bending - torsion, each node has 4 degrees of freedom (w_i, θ_{xi}, θ_{yi}, θ_{zi}), as shown in Fig.2. In the report, the authors use the thick-shell theory, which satisfies the Reissner-Mindlin theory.
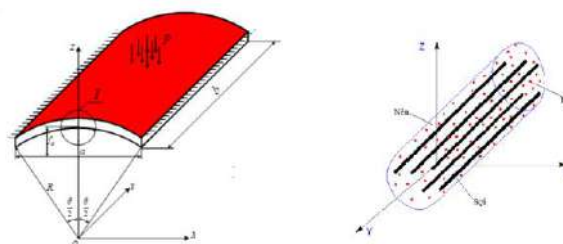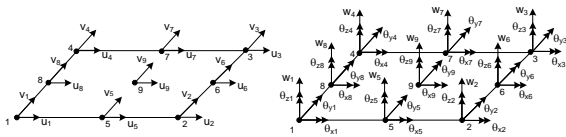

a, Shell model, b, Three-phase polymer composites model

Fig. 1(a,b): The model of the problem
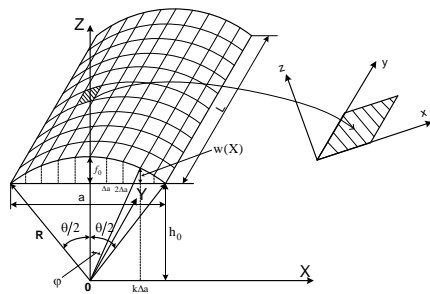
a, Finite element model of the shell

b, Flat element in tension (compression)and flat shell element in combined bending - torsion

Fig. 2 (a,b): Finite Element Model

III. DETERMINATION OF ELASTIC COEFFICIENTS FOR THREE-PHASE COMPOSITE

For three-phase composite materials (polymer matrix, fiber and particle). According to [2], the elastic coefficient of three-phase composites Vanin G.A. determined in 2 steps:

The first step: Considering a two-phase composite consisting of the initial matrix phase and particles, such a composite is considered to be homogeneous, isotropic, and has two elastic coefficients. The determination of the elastic coefficients for composites filled with spherical particles is determined, taking into account the interaction between the particles and the matrix. The elastic coefficients of the grain-reinforced composite are now called hypothetical composites.

Second step: determine the elastic coefficients of the composite between the assumed foundation and the reinforcing fibers.

Assuming the components of the composite (matrix, fibers, particles) are all homogeneous, isotropic, then we will denote: E_n, G_n, ν_n, ψ_n; E_s, G_s, ν_s, ψ_s; E_h, G_h, ν_h, ψ_h are denoted by the modulus of elasticity, modulus of elasticity of shear, modulus of volume deformation, Poisson's coefficient, and composition ratio (by volume) of the matrix and particles, respectively. From here on, the quantities related to the matrix will have the *n*-index; relative to the particle is the *h*-index. According to [3], the elastic modulus of the assumed composite as follows:

$$\bar{E} = \frac{9\bar{K}\bar{G}}{3\bar{K}+\bar{G}} \;;\; \bar{\nu} = \frac{3\bar{K}-2\bar{G}}{6\bar{K}-2\bar{G}} \qquad (1)$$

Where:

$$\bar{G} = G_n \frac{1-\psi_h(7-5\nu_n)H}{1+\psi_h(8-10\nu_n)H} \;;\; \bar{K} = K_n \frac{1+4\psi_h G_n L(3K_n)^{-1}}{1-4\psi_h G_n L(3K_n)^{-1}} \quad (2)$$

with

$$L = \frac{K_h - K_n}{K_h + (4G_n/3)} \;;\; H = \frac{(G_n/G_h)-1}{8-10\nu_n + (7-5\nu_n)(G_n/G_h)} \;;$$

$$G_i = \frac{E_i}{2(1+\nu_i)} \;;\; i=n,s,h.$$

The modulus of elasticity for the three-phase homogeneous fiber-reinforced composite is calculated according to Vanin's formula [1]:

$$E_{11} = \psi_s E_s + (1-\psi_s)\bar{E} + \frac{8\bar{G}\psi_s(1-\psi_s)(\psi_s-\bar{\nu})}{2-\psi_s+\bar{\chi}\psi_s+(1-\psi_s)(\chi_s-1)(\bar{G}/G_s)}$$

$$E_{22} = \left[\frac{\nu_{21}^2}{E_{11}} + \frac{1}{8\bar{G}} \left(\frac{2(1-\psi_s)(\bar{x}-1)+(x_s-1)(\bar{x}-1+2\psi_s)(\bar{G}/G_s)}{2-\psi_s+\bar{x}\psi_s+(1-\psi_s)(x_s-1)(\bar{G}/G_s)} + 2\frac{\bar{x}(1-\psi_s)+(1+\psi_s\bar{x})(\bar{G}/G_s)}{\bar{x}+\psi_s+(1-\psi_s)(\bar{G}/G_s)} \right) \right]^{-1}$$

$$G_{12} = \bar{G}\frac{1+\psi_s+(1-\psi_s)(\bar{G}/G_s)}{1-\psi_s+(1+\psi_s)(\bar{G}/G_s)} \;;$$

$$G_{23} = \bar{G}\frac{\bar{x}+\psi_s+(1-\psi_s)(\bar{G}/G_s)}{(1-\psi_s)\bar{x}+(1+\bar{x}\psi_s)(\bar{G}/G_s)} \;;\; x_s = 3-4\nu_s \;;$$

$$\nu_{23} = \left[\frac{-\nu_{21}^2 E_{22}}{E_{11}} + \frac{E_{22}}{8\bar{G}} \left(2\frac{(1-\psi_s)\bar{x}+(1+\psi_s\bar{x})(\bar{G}/G_s)}{\psi_s+\bar{x}+(1-\psi_s)(\bar{G}/G_s)} - \frac{2(\bar{x}-1)(1-\psi_s)+(x_s-1)(\bar{x}-1+2\psi_s)(\bar{G}/G_s)}{2+\bar{x}\psi_s-\psi_s+(1-\psi_s)(x_s-1)(\bar{G}/G_s)} \right) \right]$$

$$\nu_{21} = \bar{\nu} - \frac{(\bar{x}+1)(\bar{\nu}-\nu_s)\psi_s}{2-\psi_s+\bar{x}\psi_s+(1-\psi_s)(x_s-1)(\bar{G}/G_s)} \;;$$

$$\nu_{12} = \frac{E_{11}}{E_{22}}\nu_{21} \;;\; \bar{x} = 3-4\bar{\nu} \;;$$

IV. DOMINANT EQUATION

4.1. The relationship between strain and displacement

When taking into account the deformation of the mean surface of the element, the strain vector components are related to the displacement field according to the expression:

$$\begin{Bmatrix} \varepsilon_x \\ \varepsilon_y \\ \gamma_{xy} \end{Bmatrix} = \begin{Bmatrix} \varepsilon_x^o \\ \varepsilon_y^o \\ \gamma_{xy}^o \end{Bmatrix} + z\begin{Bmatrix} \kappa_x \\ \kappa_y \\ \kappa_{xy} \end{Bmatrix} + \begin{Bmatrix} \varepsilon_x^N \\ \varepsilon_y^N \\ \gamma_{xy}^N \end{Bmatrix}, \qquad (3)$$

Where:

$$\begin{Bmatrix} \varepsilon_x^o \\ \varepsilon_y^o \\ \gamma_{xy}^o \end{Bmatrix} = \begin{bmatrix} \dfrac{\partial}{\partial x} & 0 & -\dfrac{1}{R_x} \\ 0 & \dfrac{\partial}{\partial y} & -\dfrac{1}{R_y} \\ \dfrac{\partial}{\partial y} & \dfrac{\partial}{\partial x} & 0 \end{bmatrix} \begin{Bmatrix} u_0 \\ v_0 \\ w_0 \end{Bmatrix}$$ is the linear strain vector,

R_x, R_y are the radius of curvature in the x and y directions, respectively

$$\{\kappa\} = \begin{Bmatrix} \kappa_x & \kappa_y & \kappa_{xy} \end{Bmatrix}^T = \left\{ \frac{\partial \theta_y}{\partial x} \quad \frac{\partial \theta_x}{\partial y} \quad \frac{\partial \theta_x}{\partial y} + \frac{\partial \theta_y}{\partial x} \right\}^T$$ is the bending and torsion curvature vectors,

$$\begin{Bmatrix} \varepsilon_x^N \\ \varepsilon_y^N \\ \gamma_{xy}^N \end{Bmatrix} = \frac{1}{2} \begin{bmatrix} \dfrac{\partial w_0}{\partial x} & 0 \\ 0 & \dfrac{\partial w_0}{\partial y} \\ \dfrac{\partial w_0}{\partial y} & \dfrac{\partial w_0}{\partial x} \end{bmatrix} \begin{Bmatrix} \dfrac{\partial}{\partial x} \\ \dfrac{\partial}{\partial y} \end{Bmatrix} w_0$$ is the nonlinear strain vector.

4.2. Relationship between stress and strain

$$\begin{Bmatrix} \sigma_x \\ \sigma_y \\ \sigma_{xy} \end{Bmatrix}_k = \begin{bmatrix} Q_{11}' & Q_{12}' & Q_{16}' \\ Q_{12}' & Q_{12}' & Q_{26}' \\ Q_{16}' & Q_{26}' & Q_{66}' \end{bmatrix}_k \begin{Bmatrix} \varepsilon_x \\ \varepsilon_y \\ \gamma_{xy} \end{Bmatrix}_k \tag{4}$$

Where:

$Q_{11}' = Q_{11}\cos^4\theta + Q_{22}\sin^4\theta + 2(Q_{12} + 2Q_{66})\sin^2\theta\cos^2\theta$

$Q_{12}' = Q_{12}(\cos^4\theta + \sin^4\theta) + (Q_{11} + Q_{12} - 4Q_{66})\sin^2\theta\cos^2\theta$

$Q_{16}' = (Q_{12} - Q_{22} + 2Q_{66})\cos\theta\sin^3\theta + (Q_{11} - Q_{12} - 2Q_{66})\sin\theta\cos^3\theta$

$Q_{22}' = Q_{11}\sin^4\theta + Q_{22}\cos^4\theta + 2(Q_{12} + 2Q_{66})\sin^2\theta\cos^2\theta$

$Q_{26}' = (Q_{11} - Q_{12} - 2Q_{66})\cos\theta\sin^3\theta + (Q_{12} - Q_{22} + 2Q_{66})\sin\theta\cos^3\theta$

$Q_{66}' = Q_{66}(\cos^4\theta + \sin^4\theta) + (Q_{11} + Q_{22} - 2(Q_{12} + Q_{66}))\sin^2\theta\cos^2\theta$

$Q_{11} = \dfrac{E_{11}}{1 - (E_{22}/E_{11})v_{12}^2}$; $Q_{22} = \dfrac{E_{22}}{1 - (E_{22}/E_{11})v_{12}^2} = \dfrac{E_{22}}{E_{11}}Q_{11}$;

$Q_{12} = v_{12}Q_{22}$ $Q_{66} = G_{12}$

4.3. Internal force components

The surface force vector $\{N\} = \{N_x \; N_y \; N_{xy}\}^T$, bending moment, torsion moment, $\{M\} = \{M_x \; M_y \; M_{xy}\}^T$ in the shell element with n composite layers are determined as follows:

$$\begin{Bmatrix} \{N\} \\ \{M\} \end{Bmatrix} = \begin{bmatrix} [A] & [B] \\ [B] & [D] \end{bmatrix} \begin{Bmatrix} \{\varepsilon_0\} + \{\varepsilon_N\} \\ \{\kappa\} \end{Bmatrix} \tag{5}$$

Where:

$$[A] = \left(\sum_{k=1}^{n} \left[Q_{ij}' \right]_k \left(z_{k+1} - z_k \right) \right),$$

$$[B] = \left(\frac{1}{2} \sum_{k=1}^{n} \left[Q_{ij}' \right]_k \left(z_{k+1}^2 - z_k^2 \right) \right),$$

$$[D] = \left(\frac{1}{3} \sum_{k=1}^{n} \left[Q_{ij}' \right]_k \left(z_{k+1}^3 - z_k^3 \right) \right),$$

4.4. Differential equation of vibration of a three phase composite shell

After building the finite element model of the structure is built, the structural analysis is performed. This work includes:

- Build element equations (element stiffness matrix, element load vector);

- Connect elements to create the overall stiffness matrix;

- Set up the general equation;

- Solve the general equation;

- Calculate the necessary results from the solutions of the general equation.

The nonlinear differential equation which describes the vibration of the shell:

$$\left[M_g \right]\{\ddot{q}\} + \left[C_g \right]\{\dot{q}\} + \left[K_g \right]\{q\} = \{F\} \tag{6}$$

Where: $\left[M_g \right]$ - Matrix of the overall mass of the shell; $\left[K_g \right]$ - the the overall stiffness matrix of the shell; $\left[C_g \right]$ - The overall resistance matrix of the shell, calculated by the formula: $\left[C_g \right] = \left(\alpha\left[M_g \right] + \beta\left[K_g \right] \right)$.

Equation (6) is a nonlinear differential equation that is solved by the Newmark method combined with the Newton-Raphson iterative method.

V.   NUMERICAL RESULTS AND DISCUSSION

5.1. The starting problem:

Structural parameters: Three - phase composite pillar panel, rectangular projection size, total thickness h = 0,0025m, radius of curvature R = 1,0m, length L = 0,30 m, opening angle $\theta = 30^0$. The composite shell consists of 5 layers, the composite layers are made of Graphite/Epoxy T300/976, each layer has a thickness of $h_1 = 0,0005$m; the ratio of grain and matrix is 0,3. Considering the case of composite layers arranged symmetrically [-α/ α /0/ α /- α], with α = 45^0,

Material characteristics of Graphite/Epoxy T300/976 are as follows: Graphite-Epoxy T300/976 : $E_{11} = 150.10^9$ N/m², $E_{22} = E_{33} = 9.10^9$ N/m², $G_{12} = G_{13} = 7,1.10^9$ N/m²,

$G_{23} = 2,5.10^9$ N/m², $\nu_{12} = \nu_{23} = \nu_{32} = 0.3$, $\rho_{GE} = 1600$ kg/m³.

Load parameters: a short-term load in the form of a shock wave distributed on the upper surface of the shell, the load is as follows:

$$p(t) = p_{max}F(t),$$

$$F(t) = \begin{cases} 1 - \dfrac{t}{\tau_\theta} : & 0 \le t \le \tau_\theta \\ 0 : & t > \tau_\theta \end{cases} \quad (7)$$

In which: $p_{max} = 1.10^5$ N/m², $\tau_\theta = 0,025$s. The shell was clamped along two straight edges: u = 0, v = 0, w = 0, $\theta_x = 0$, $\theta_y = 0$, $\theta_z = 0$ at x = 0 and x = a. The center point on the upper surface of the shell (point A (Fig.3)) was considered. The finite element model of the problem is shown in Fig.4.
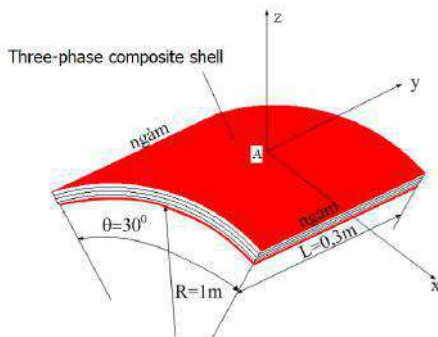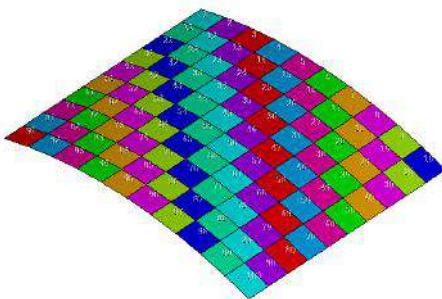

Fig. 3: Real model of the problem

Fig. 4: Finite element model of the problem

5.2. The influence of some factors on the nonlinear vibration of the shellI

5.2.1. Effect of nonlinear properties

To examine the effect of nonlinearity, the linear problem was compared with the solved nonlinear problem. Fig. 6 and Fig.6, Fig.7, Fig.8 and table 1 show the displacement and stress variations at point A in two cases. The time response of displacement, stress at the calculation point of the linear problem is different from the nonlinear problem both in amplitude and cycle. In particular, the response values of the nonlinear problem are much larger than that of the linear problem, which shows that the calculation by

the nonlinear method is more stable and safer. According to the authors, this is the advantage of solving nonlinear problems for this particular case.
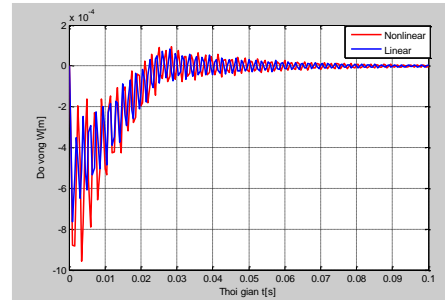
Fig. 6: Time history response of vertical displacement W at point A
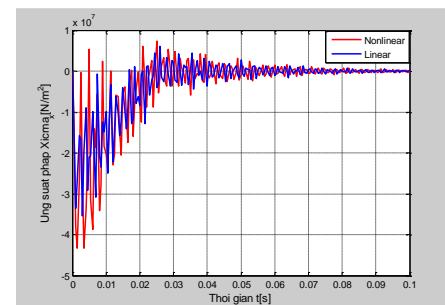
Fig. 7:. Time history response of stress σx at point A
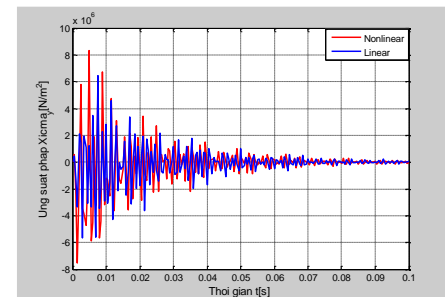
Fig. 8: Time history response of stress σ_y at point A

Table 1. Maximum displacement and stress at point A

		W_{max} (m)	σ_x^{max} (N/m²)	σ_y^{max} (N/m²)
Cases	**Nonlinear**	0,00096	4,302.10⁷	0,8305.10⁷
	Linear	0,00077	3,540.10⁷	0,6470.10⁷
Compare (%)		24,68	21,53	28,36

5.2.2. Effects of particles ratio

To consider the influence of particles ratio, the author proceeds to solve the problem with 3 cases of different particles ratio.

Fig. 9: Vertical displacement variation at point A with different particles ratio

The time response of displacement at the shell point in the cases of different particles ratio is different in both amplitude and period. In which, the deflection response values in the case of 0.2 is the largest, in the case of 0.4 is the smallest in the 3 cases. This shows that in the reasonable range of the ratio between the particles and the matrix, when increasing the ratio of the particles, the response to the maximum displacement will decrease.
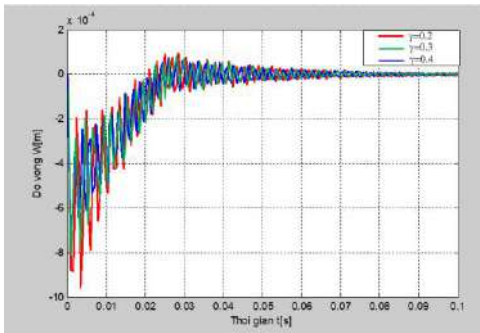
5.2.3. Effect of load amplitude

Investigate the problem with load amplitude pmax varying from $0.5,105N/m^2$ to $1,66,105N/m^2$. The results of the variation of the maximum values of displacement and stress at point A of the shell are shown in graphs in Fig.10, Fig.11, Fig.12.
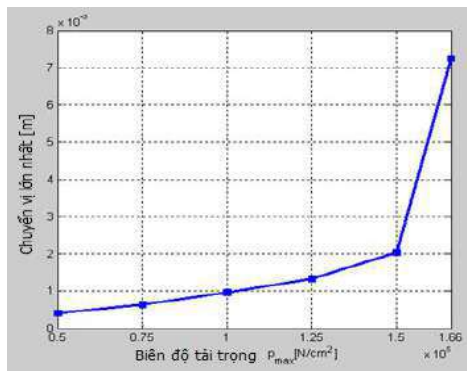

Fig. 10: Displacement W_{max} by amplitude pmax of load
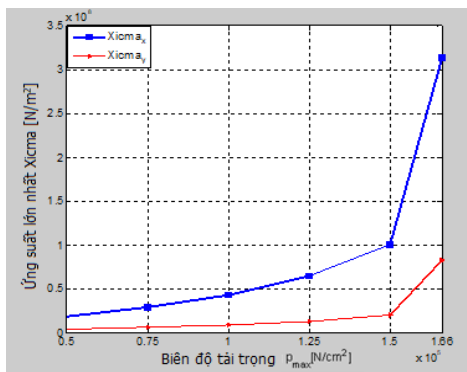

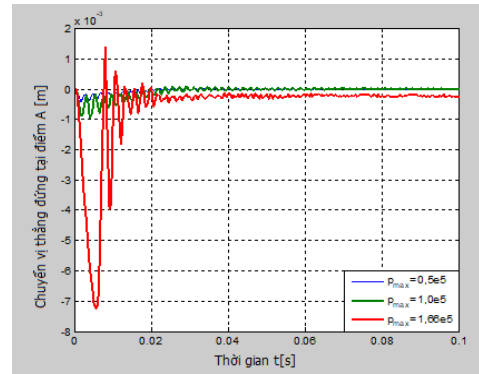*Fig. 11: Maximum stress by amplitude pmax of load*

Fig. 12: Time history response of vertical displacement W at point A

The load amplitude has a great influence on the dynamic response of the shell. For the survey problem, when the load amplitude increases, both the maximum displacement and the maximum stress at point A increase nonlinearly. The rate of increase of the maximum values of displacement and stress is large when pmax is greater than $1.25.105N/m2$. When the load amplitude pmax = $1,66,105N/m2$, both displacement and stress increase very strongly, the shell oscillates and balances to another position, with hysteresis. According to the dynamic stability criterion of Budiansky, B and Roth, R.S [1], the shell is destabilized and the critical amplitude value.

VI. CONCLUSIONS

This paper presents a finite element method to analyze the dynamic response of a 3-phase composite cylindrical shell under the action of dynamic loads. The formulations are based on classical multilayer shell theory taking into account geometric nonlinearity. With the numerical survey results on the problem classes with the change of many parameters, it is the basis for the selection of reasonable parameters for the 3-phase composite cylindrical shell structure subjected to dynamic loads.

REFERENCES

[1] Budiansky B., and Roth R.S., (1962). Axisymmetric dynamic buckling of clamped shallow spherical shells in Collected papers on instability of shell structures. Technical Note NASA TN D-1510, Langley Research Center, Langley Station, VA.

[2] Vanin G.A., (1985). Micro-Mechanics of composite materials. "Nauka dumka", Kiev. Rusian.

[3] Jonghwi Lee and Albert F. Yee (2001). Fracture Behavior of Glass Bead Filled Epoxies: Cleaning Process of Glass Beads. © 2000 John Wiley & Sons, Inc. J Appl Polym Sci 79: 1371–1383, 2001.

[4] Randall M. German (2016). Particulate Composites Fundamentals and Applications. Springer International Publishing Switzerland. EBook ISBN 978-3-319-29917-4, DOI 10.1007/978-3-319-29917-4.

[5] Roger N. Rothon (2003). Particulate-Filled Polymer Composites. Rapra Technology Limited Shawbury, Shrewsbury, Shropshire, SY4 4NR, UK. ISBN: 1-85957-382-7.

[6] Rothon, R . Particulate-filled Polymer Composites; Longman Scientific & Technical: Essex, U.K., 1995.

[7] Vanin, G. A., and N. D. Duc (1996a). The theory of spherofibrous composite.1: The input relations, hypothesis and models. Mechanics of Composite Materials, 32(3), pp. 291-305.

[8] Vanin, G. A. and N. D. Duc (1996b). The theory of spherofibrous composite.2: The fundamental equations. Mechanics of Composite Materials, 32 (3), pp. 306-316.

OJS Editorial and Publishing Process

Author

Editor and Section Editor

Journal Manager, Reviewer, Copyeditor, Layout Editor, and Proofreader

Submission
Author uploads file to journal Web site, and enters metadata for OAI indexing

1. Submission Queue
Editor assigns submission to Section Editor to see through the editorial process

Journal Management
Setup and configure journal; enroll editors, reviewers, copyeditors, proofreaders.

2. Submission Review
a) Check submission
b) Conduct peer review
c) Reach editorial decision

Submission Review
Author can track process, see files, reviews, revise and resubmit, at editor's request

Select Reviewers
Editor invites reviewers from database with interests, load

Review Conducted
Reviewer submits review and recommendation (which may be rated by editor)

3. Submission Editing
a) Copyedit submission
b) Layout of formatted galleys
c) Proofread galleys

Submission Editing
Authors reviews copyedits and proofreads galleys

Copyediting

Layout
Layout Editor prepares galleys in HTML.PDF. PS. etc.

4. Issue Management
a) Create issues
b) Schedule submissions
c) Organize Table of Contents

Proofreading

Key

Journal Manager	
Editor	
Section Editor	
Reviewer	
Copyeditor	
Layout Editor	
Proofreader	
Author	
Reader	

Open Journal Systems is an open source development of the Public Knowledge Project.

http://pkp.sfu.ca

5. Publication
Offering immediate open access or delayed open access, with subscriptions

Submission Archive
Complete records kept of submission process for published and declined items

Current Issue
Items appear with Reading Tools linking to related internal and external resources

Journal Archive
Browsing issues, with indexing by OAI search engines, as well as Google, etc.

~IJAERS Workflow~

Important links:

Paper Submission Link:

https://ijaers.com/submit-paper/

Editorial Team:

https://ijaers.com/editorial-board/

Peer Review Process:

https://ijaers.com/peer-review-process/

Publication Ethics:

https://ijaers.com/publication-ethics-and-publication-malpractice-statement/

Author Guidelines:

https://ijaers.com/instruction-to-author/

Reviewer Guidelines:

https://ijaers.com/review-guidelines/

Journal Indexed and Abstracted in:

- Qualis-CAPES (A2)-Brazil
- Normatiza (Under Review-Ref.020191511)
- NAAS Score: 3.18
- Bielefeld Academic Search Engine(BASE)
- Aalborg University Library (Denmark)
- WorldCat: The World's Largest Library Catalog
- Semantic Scholar
- J-Gate
- Open J-Gate
- CORE-The world's largest collection of open access research papers
- JURN
- Microsoft Academic Search
- Google Scholar
- Kopernio - powered by Web of Science
- Pol-Index
- PBN(Polish Scholarly Bibliography) Nauka Polaska
- Scilit, MDPI AG (Basel, Switzerland)
- Tyndale University College & Seminary
- Indiana Library WorldCat
- CrossRef DOI-10.22161/ijaers

- Neliti - Indonesia's Research Repository
- Journal TOC
- WIKI-CFP
- Scinapse- Academic Search Engine
- Mendeley-Reference Management Software & Researcher Network
- Dimensions.ai: Re-imagining discovery and access to research
- Index Copernicus Value(ICV): 81.49
- Citeseerx
- Massachusetts Institute of Technology (USA)
- Simpson University (USA)
- University of Louisville (USA)
- Biola University (USA)
- IE Library (Spain)
- Mount Saint Vincent University Library (Halifax, Nova Scotia Canada)
- University Of Arizona (USA)
- INDIANA UNIVERSITY-PURDUE UNIVERSITY INDIANAPOLIS (USA)
- Roderic Bowen Library and Archives (United Kingdom)

- University Library of Skövde (Sweden)
- Indiana University East (campuslibrary (USA))
- Tilburg University (The Netherlands)
- Williams College (USA)
- University of Connecticut (USA)
- Brandeis University (USA)
- Tufts University (USA)
- Boston University (USA)
- McGill University (Canada)
- Northeastern University (USA)
- BibSonomy-The blue social bookmark and publication sharing system
- Slide Share
- Academia
- Archive
- Scribd
- ISRJIF
- Cite Factor
- SJIF-InnoSpace
- ISSUU
- Research Bib
- infobaseindex
- I2OR
- DRJI journal-repository

AI Publication

International Journal of Advanced Engineering Research and Science (IJAERS)

104/108, Sector-10, Pratap Nagar, Jaipur, India