

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



# International Journal of Advanced Engineering Research and Science

(IJAERS)

An Open Access Peer-Reviewed International Journal



Journal DOI: [10.22161/ijaers](https://doi.org/10.22161/ijaers)

Issue DOI: [10.22161/ijaers.98](https://doi.org/10.22161/ijaers.98)

AI PUBLICATIONS

Vol.- 9 | Issue - 8 | Aug 2022  
[editor@ijaers.com](mailto:editor@ijaers.com) | <http://www.ijaers.com/>

# International Journal of Advanced Engineering Research and Science

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

DOI: 10.22161/ijaers

Vol-9, Issue-8

August, 2022

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Publisher

*AI Publication*

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## The Black Woman Quilombola in Brazil

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Received: 29 Jun 2022,

Received in revised form: 21 Jul 2022,

Accepted: 28 July 2022,

Available online: 06 Aug 2022

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**Keywords**— *intersectionality, racial equality,  
quilombola communities, black women.*

**Abstract**— *In this work, we took the Quilombola Community Sítio de Lagoinha, from the Sertão do São Francisco Territory, as the space for this research, the only quilombola community certified by the Palmares Cultural Foundation in the municipality of Casa Nova, located in the north of the state of Bahia, 100 km from the municipality of Juazeiro and 600 kilometers from Salvador. The research is of a qualitative nature, in a necessary process and, in some aspects, of continuity of a work carried out between the years 2013 and 2020, in the communities of Juazeiro da Bahia, in the exercise of the public function in front of the Directorate of Diversity, sector of the Municipal Government of Juazeiro (BA), responsible for ethnic-racial relations, administratively linked to the Secretariat for Social Development, Women and Diversity.*

### I. INTRODUCTION

The black quilombola woman is one of the pillars of Brazil's social, economic, political and cultural history and, at the same time, is one of the subjects that suffers the most in racial relations in the country. The process that this woman undergoes is twofold: genocide and epistemicide. An intense process of oppression shaped mainly by racial and gender issues, crossed by many others, such as class and territorial issues.

Here, we take as reference the perspective of Sueli Carneiro (2005) about epistemicide as a constitutive element of a raciality/biopower device. For Carneiro (2005), epistemicide, in addition to being the disqualification and annulment of the knowledge of subjugated peoples, is a persistent process of production of cultural indigence on these peoples. This occurs,

[...] by the denial of access to education, especially of quality; by the production of intellectual inferiority; by the different mechanisms of delegitimization of the black person as a carrier and producer of knowledge and the lowering of the cognitive capacity due to material shortages and/or the impairment of self-esteem by the processes of discrimination current in the educational process. This is because it is not possible to disqualify the forms of knowledge of the dominated peoples without also disqualifying them, individually and collectively, as knowing subjects. And, in doing so, it deprives it of its reason, the condition for achieving “legitimate” or legitimized knowledge. That is why epistemicide kills the rationality of the subject or kidnaps it,

mutilates the ability to learn, etc. (CARNEIRO, 2005, p. 97).

According to the IBGE 2016, more than half of the Brazilian population is black (black and brown), 54%. Of this number, 28% are women, which denotes that the population of black women is the largest population group in Brazil, according to the 2019 Continuous PNAD. But they also share the worst rates of social inequality, illiteracy, underemployment and poor housing conditions.

In addition to being the biggest victims of violence: we can mention domestic violence, which occurs within and from family ties, as provided for in Maria da Penha Law 11,340. As well as gender violence, a type of violation affected by the social belief that feeds back that racist and patriarchal society “has the right” to dispose of the body of black women as they wish – including carrying out collective rape or harassment in their space. of work. These are just a few examples of what happens in the daily lives of most black women.

The official numbers, which are constantly published, show that Brazilian diversity is relegated to exclusion, misery and indigence processes. For a black woman, to win in a country like Brazil, it is necessary to exert excessive force to overcome many obstacles.

This context becomes more complex when referring to the Brazilian quilombola population. The next census, which would take place in 2020, and which was postponed by the Federal Government, due to the Covid 19 Pandemic, and which is scheduled to be carried out in mid-2022, being the first demographic census that will identify the population that self-declared quilombola of Brazil.

## II. HISTORICAL AND GEOGRAPHIC CONTEXTUALIZATION

According to the IBGE database, based on information from the 2010 census and the territorial base of the next census, there are already approximately 6,000 quilombola localities identified in Brazil, distributed in 1,672 municipalities. According to the Institute, the 5,972 locations are thus quantified and classified,

[...] 404 are officially recognized territories, 2,308 are called quilombola groups and 3,260 are identified as other quilombola localities. Among the groups, 709 are located within the officially delimited quilombola territories and 1,599 are outside these lands. (IBGE, 2022).

Of the regions of Brazil, the study points out that it is in the Northeast where the largest number of quilombola communities are concentrated (3,171). In sequence, the

Southeast region with 1,359 quilombos. “The other regions have the lowest numbers: North (873), South (319) and Midwest (250) (IBGE, 2022). And of the Brazilian states, Bahia is where they are most concentrated, followed by the states of Minas Gerais, with 1,021, Maranhão, with 866, and Pará, with 516 quilombola locations. (IBGE, 2022) About a population estimate, the National Coordination of Quilombola Articulation (CONAQ), pointed out that in 2017, there were more than 130 thousand Brazilian quilombola families (UN Women, 2017).

Considering this initial scenario presented by the IBGE, in relation to quilombola communities spread over much of the national territory, the fact that only in 2022 this population segment will be considered, denotes an erasure of at least three decades, considering the Federal Constitution of 1988. which in its article 68 of the Transitional Provisions recognized the existence of quilombola populations and guaranteed them the right to occupied lands. A process of indigence that reflects the realities of structural inequalities that portray most of these communities.

Thus, when we take the lives of black quilombola women into perspective, these inequalities coalesce, deepen and take root, causing developments that span entire generations, as the UN Women in Brazil states,

While men migrate to the nearest cities in search of work, they remain. There, they guarantee sustenance, based on the management of natural resources, acting for the social organization and transmission of ancestral knowledge. (...) exposed to the various forms of violence, they are the main ones impacted by territorial conflicts, development projects and the suppression of rights, which significantly compromises the social and economic development of these women. Even in this adverse scenario, these communities resist marked by female and black protagonism. (UN WOMEN, 2017).

Therefore, the path to equity is increasingly distant, because with each political coup that we experience and that further weaken the democratic process in Brazil, in addition to health crises or any other type, they directly affect the non-white Brazilian populations and mainly black women.

According to the national movement “Black Women Decide”, “the narrative dispute is urgent and black women need to be included, considering that they represent” less than 2% in the Brazilian National Congress, and in the municipalities they do not reach 5% in legislative positions (Black Women Decide, 2020, s/p).

It is against the grain of the process of indigence that this work joins many others that seek to legitimize black people and black women as producers and bearers of knowledge, knowing subjects capable not only of learning, but, above all, of teaching. Thus, inspired by Sueli Carneiro (2005), we propose the quilombola universe as a universe of life, despite the hegemonic social system in Brazil making an effort to threaten it, in particular through invisibility. In this context, the black quilombola woman emerges as a subject who has her life as a constant struggle – for survival, social and political position.

The life story of a quilombola woman is, therefore, the life story of a subject who constantly subverts and resists the relationships that subjugate and marginalize her. In this way, it is possible to affirm that every quilombola woman is synonymous with struggle and resistance.

Starting from this problem, we built this work having as a paradigm the black quilombola woman and their life stories, that is, the quilombola woman as a historical subject possessing an ancestral tradition of anti-racist resistance. Reflecting with her is, academically, an anti-epistemic exercise and reaffirms, as political subjects, that their lives make up the social frameworks, even with the effort of whiteness to erase them.

In this work, we took the Quilombola Community Sítio de Lagoinha, from the Sertão do São Francisco Territory, as the space for this research, the only quilombola community certified by the Palmares Cultural Foundation in the municipality of Casa Nova, located in the north of the state of Bahia, 100 km from the municipality of Juazeiro and 600 kilometers from Salvador. The research is of a qualitative nature, in a necessary process and, in some aspects, of continuity of a work that I carried out between the years 2013 and 2020, in the communities of Juazeiro da Bahia, in the exercise of the public function in front of the Directorate of Diversity, sector of the Municipal Government of Juazeiro (BA), responsible for ethnic-racial relations, administratively linked to the Secretariat for Social Development, Women and Diversity,

The Sertão do São Francisco Identity Territory, located in the northern region of the state of Bahia, is composed of 10 municipalities Campo Alegre de Lourdes, Casa Nova, Canudos, Curaçá, Juazeiro, Remanso, Sobradinho, Sento Sé, Pilão Arcado and Uauá. With a total population of 494,431, mostly urban, 315,797 thousand, and a rural population of 168,634 thousand, according to data from the IBGE, Census 2010 and published by the extinct Ministry of Agrarian Development (MDA). The Sertão do São Francisco Territory (TSSF) has a majority of black population (IBGE 2010) and contains six quilombola communities recognized so far by the Palmares Cultural

Foundation: Jatobá (Curaçá), Alagadiço, Rodeadouro and Barrinha da Conceição (Juazeiro), Lagoinha (New house). Traditional territories safeguarding an ancestral tradition, some date back more than 200 years (SANTOS, 2016), as is the case of the Alagadiço de Juazeiro da Bahia community. Stories like that of the Sítio de Lagoinha Community, with 111 years of resistance, which, after many generations of unpaid work, “received” from the boss, as payment, these lands, in the rural area of the municipality of Casa Nova/BA.

It is necessary to report that many researches about these communities have already been carried out, but gender issues were little problematized. Therefore, in this research, I propose a dialogue with these black quilombola women, strengthening the value of alternative histories, memories and epistemologies, such as black feminism, through intersectionality as a tool of analysis, contributing to the process of breaking the invisibility of these subjects. historically neglected by the State and even by the academy or the school system, as well as contributing to their empowerment, while I call attention to the importance of their protagonist role in the maintenance of that territory and in the struggle for access to numerous basic rights that have historically been denied to them, such as the right to land, treated water, energy,

In this process of invisibility, black quilombola women experience an even more perverse process, conditioned to their vulnerabilities, which demonstrates the need to deepen this academic framework, revealing, from the life narratives of black women from the Quilombola Communities of the Sertão do Território San Francisco, fundamental aspects in understanding the development of the Territory, such as issues of gender, identity, ancestry, life history, living conditions, resistance, rights and female protagonism.

According to Nilma Lino Gomes (2003), the paths for the construction of black identity are complex, which is neither static nor unique – “possible to be constructed by subjects who belong to this ethnic/racial group” (GOMES, 2003, p. 171). The author states that, within the multiplicity and social identities that black people construct, black identity is one of them, being a “continuous process, built by blacks in the various spaces – institutional or not – in which they circulate (.. .)” (GOMES, 2003, p. 172).

In this sense, adds the author

As social subjects, it is within the scope of culture and history that we define social identities (all of them, and not just racial identity, but also gender, sexual, nationality, class identities, etc.). These multiple and distinct identities constitute the subjects, insofar as they are challenged from different

situations, institutions or social groups (GOMES, 2003, p. 171).

Given this understanding, it is possible to perceive the complexity of the identities of black women in Sítio Lagoinha, forged within the scope of racial and gender relations, crossed by economic, social, territorial and geographic inequalities. As Rezende (2014) reflects, quilombola communities face several difficulties and obstacles to guarantee their rights – territorial, cultural, social and ancestral. In this context of struggles, the author states that political-cultural identities are created, recreated and invented, above all, as a black political subject. Therefore, the Brazilian quilombo needs to be reflected in an intersectional perspective with categories that intertwine and complement each other such as race, gender, collectivity, identity and subject.

The constitution of the quilombola identity must be understood in light of the need “to fight for the maintenance or reconquest of a material and symbolic territory” (Rezende, 2014, p. 12). In this way, the production of identity in quilombola territories can be considered as a constant, creative and anti-racist production, precisely because it starts from black subjects in a racist society, that is, operating anti-racist subversions of identity. This problem is exacerbated when we take a gender perspective, especially the issue of black women. In power relations, the black quilombola woman suffers a sociopolitical invisibility, causing vulnerability, marginalization and violence on these people. Historically, black women, especially those from or residing in rural quilombola communities, have their lives and stories relegated to oblivion. Such a group lives almost “invisible” in our society, suffering all kinds of prejudice, disrespect and distant from government public policies. Thus, the problem of this research unfolds in the question: How has the historical experience of women from the Quilombola Community of Lagoinha/BA been, based on issues related to social class, territory, gender and race?

### III. EPISTEMIC AND METHODOLOGICAL CONSIDERATIONS

As mentioned, in the exercise of the professional activities of the Diversity Board of Juazeiro da Bahia, in the applicability of the Promotion of Racial Equality, a policy that aims at ethnic-racial relations, the elaboration and execution of policies aimed at the black population of Juazeiro, among them, the traditional peoples and communities, in the last seven years of my work (2013 to 2020), I came into contact with the quilombola communities in the region.

This approach took place through the Research Project Photoethnographic Profile of Quilombola Populations of the Submédio São Francisco: identities in movement, coordinated and led by researcher Márcia Guena dos Santos, from the Department of Human Sciences III, at the State University of Bahia (UNEB), for the demands raised in carrying out the research, which resulted in the Quilombola Articulation Group, and brought together the participation of various institutional, governmental and non-governmental partners and leaders of the quilombola communities of Juazeiro (Alagadiço, Rodeadouro and Barrinha da Conceição) and the Quilombola Community Lagoinha site in Casa Nova Bahia.

The Diversity Directorate, a sector that integrates the administrative structure of the Secretary of Social Development for Women and Diversity, represented the City Hall of Juazeiro da Bahia, in the Quilombola Articulation Group of the Department of Human Sciences III, UNEB, whose main objective is to minimize the distance history, mainly of governmental organizations, in relation to the pressing demands of Quilombola Communities in the region, and, with this initiative, many public agents and non-governmental organizations reached the communities, guaranteeing some access to public policies and the construction of partnerships that carried out actions in these communities.

My first contact with the ground of these communities was acting institutionally and becoming aware of the degree of institutional oblivion to which these communities were subjected. Researcher Márcia Guena, black woman, university professor, photographer, intellectual and activist of the black movement, aware of institutional absences and the impact of racism on the lives of these people and communities, exercised two types of action: institutional and militant, when, on weekends, he called on us to organize a joint effort to clean up a disabled school in one of the communities, for example.

Working with the black population, with women, with the LGBTQIA+ population, in the Diversity Board, has given new meaning to the way I see myself and the world. In this context, the quilombola communities were fundamental in understanding both my professional performance and activism. Experiencing the construction of these intervention processes in the communities, representing only my sector, did not mean that the city hall institution as a whole was present. In addition, other communities in the Sertão do São Francisco Territory also contacted us through the Quilombola Articulation Group, as was the case of the Sítio de Lagoinha Community in Casa Nova - Bahia, the locus of this research.



The first time I was in Lagoinha was when the Community, in partnership with the Quilombola Articulation Group, held the 1st Forum for the Promotion of Racial Equality in Casa Nova/BA, an event and moment in which the municipality of the municipality entered as a supporter, in November 2018. A bold but necessary initiative, since the municipality of Casa Nova has almost no policy for the Promotion of Racial Equality (PIR), or for serving quilombola communities. From the PIR forum, we found that it was the first time that a representation of the government of Casa Nova attended this community, in which it was represented by the Education and Social Assistance secretariats, in addition to a technician from the Secretariat of Culture, the only one who had a relationship with the community. On that occasion,

After this event, contact with the community was constant and we held significant moments for the community, in the context of struggles for rights and affirmation of the quilombola identity. Some notable moments, in addition to the Forum, which we can list here, the celebration event on July 25th, the day of the Black Latin American and Caribbean-American and Caribbean Woman, in which the Quilombola Articulation Group brought together the quilombola women of the region, at a table entitled “Quilombola Women in the Resistance” to combat invisibility, a space for speech and exchange of experiences between them, which took place in the quilombola community of Barrinha da Conceição in Juazeiro, with the participation of women from Sítio de Lagoinha.

The 1st Meeting of Quilombola Communities of the TSSF, which took place in the Quilombola Community of Alagadiço, in Juazeiro and the requalification workshop of the Apiary of Sítio de Lagoinha, a project financed by the Secretariat for the Promotion of Racial Equality of the State of Bahia (SEPROMI), in which we spoke about the Buzios Revolt. In addition to experimentation as an extension worker, which also took place on a site in Lagoinha, on that occasion, together with other colleagues from the Rural Extension Master's, we carried out a survey of the socio-productive profile of the community, through the use of participatory methodologies, which resulted in the presentation of the article “Socioproductive Dynamics of the Quilombola Community Sítio de Lagoinha de Casa Nova – Bahia”, at the II International Congress of Agroecology, held by UNIVASF in 2019.

Throughout our educational and professional trajectories, we have been reflecting and discussing what most attracts our attention in the entire social and community universe, whether urban or rural, of the realities we know.

The effort to carry out this research with black quilombola women is intended to provide the field of agencies and agents of rural extension, the general public and the social movements themselves with a more comprehensive look at visibility, appreciation and recognition. political life of these subjects, emphasizing the protagonism of quilombola women. The methodology proposed for the feasibility of this research has an ethnographic approach and took place in a qualitative way, through listening to the narratives of lives, as well as participant observation, based mainly on listening to the narratives of the lives of women who occupy positions of reference in the quilombola community Sítio de Lagoinha, located in the municipality of Casa Nova Bahia, in the Territory of Identity – Sertão do São Francisco.

In this sense, semi-structured interviews were carried out, formed by questions thought as a strategy to guide the memory that would allow us to understand the reality of the performance of these women in the formation of the quilombola territory Sítio Lagoinha. Even in some questions that, at first were considered simple or mere formalities, took on another relevance in the course of the research. Like the name, which appeared in the interviewees' speeches, as an element that had an ancestral relationship. The realization of this led the research to Anas and Marias de Lagoinha, as pillars of this traditional community.

Saying the name was a moment of grace, the pride they had in saying the origins of their names are linked to strength, faith and the path taken by their elders. The intergenerationality of the universe apprehended by the research – women who were between 90 and 30 years of age – making evident the present oppressions that mark the women of Lagoinha, from generation to generation. The stories of childhood, history with education, work, the formation of the territory, the relationship with the land, with men, and the interference of racism and sexism while gender discrimination in the lives of the quilombolas of Pond.

Observing these oppressions, from an intersectional analysis (CRENSHAW, 2002), the data are indicative of inequalities of race, gender and the problem of social class, when we consider the different forms of exploitation in which it is involved, not only domestic work and the struggle for schooling, which, based on the speeches of the women of Lagoinha, became a central focus of this work, but how much, really, “black lives matter” in a country like Brazil.

According to Patricia Hill Collins (2002), intersectionality is,

A conceptualization of the problem that seeks to capture the structural and dynamic consequence of the interaction between two or more axes of subordination. It specifically addresses the way in which racism, patriarchy, class oppression, and other discriminatory systems create basic inequalities that structure the relative positions of women, races, ethnicities, classes, and others. Furthermore, intersectionality deals with the way in which specific actions and policies generate oppressions that flow along such axes, constituting dynamic or active aspects of disempowerment. (COLLINS, 2002, p. 177).

To this end, it is black feminism as an epistemology that, through its framework, subsidizes us to address aspects of black women's lives and that demonstrates as "a fundamental issue of black feminist thought [...] the analysis of women's work, black women, and especially their victimization as 'mules' in the labor market". (COLLINS, 2019, p. 99). The author mentions the "mules" in the sense that they represent "dehumanized objects [...] living machines and can be treated as an object of the landscape" (COLLINS, 2019, p. 99). The history of the quilombolas of Lagoinha allows us to demonstrate this reality.

Our experience with the quilombolas of the Lagoinha/BA Community can be thought of, in this sense, as an activist research. Mainly because of my approach with Ana Rita and José Henrique, who I can consider them as co-authors in this process.

#### IV. RESEARCH CONTRIBUTIONS

The research presents as a product the e-book "Lagoinha: Um Território Quilombola erected by Anas e Marias" in which life narratives of six women from the quilombola community Sítio Lagoinha will be presented, Ana Rita Santos Silva, 61 years old, Maria Roberta Santos Silva, 60 years old, Maria dos Anjos, 39 years old, Maria Jesuína, 83 years old, Maria da Silva Pacheco, 58 years old and Raimunda dos Santos.

In addition to her ancestors present by the orality of her descendants: the beginning of the walk by Maria Saturnina, popularly known as Maria Tô Bôa, following Ana Maria do Espírito Santo and Dona Cícera dos Santos, Lagoinha's mother, who died in 2021. By Through their trajectories, we will know more about the complexity of their fortunes and misfortunes, as well as the violence that crosses the existence of these women over time, among these, the struggle for schooling, the nuances of housework, childhood completely resignified by the hard work,

domestic violence. Relationships that are, therefore, permeated by racism and machismo, as well as the problem of classes and the exclusion of ethnic groups.

In the midst of this harsh reality, the policy of affection and belonging of the quilombo, as a safe place, with the possibility of return and affection, as well as collective and transgressive action for a process of self-definition that opposes violence. The narratives demonstrate the social and cultural relevance of the agency of quilombola women who are in the constant struggle for the existence of their territory, establishing daily survival strategies.

It is important to highlight that the editorial decision to produce the e-book was directed towards the construction of a light and very didactic product, in which we used only part of the material from the narrative interviews, the parts in which the characters presented themselves. It manifests a wealth of possibilities, among so many, learning from the history of these women and the Quilombo Sítio Lagoinha.

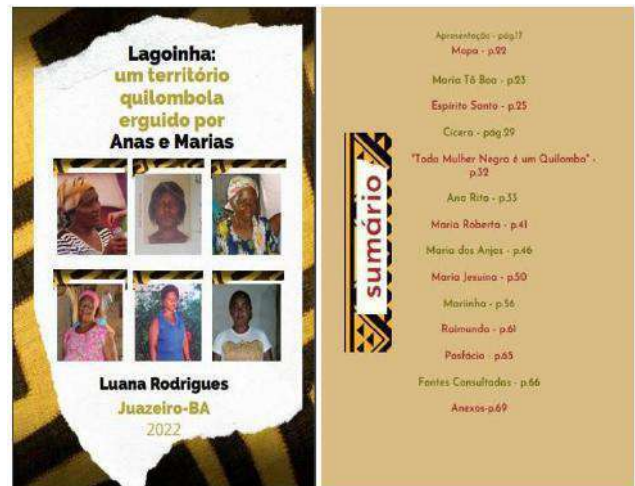


Fig.1 - Cover and summary of the e-book

Source: RODRIGUES, et al 2022.

The book has 85 pages and has as co-authors the quilombola women of Lagoinha. In addition, there is the preface written by the activist of the national black women's movement, Céres Santos, professor at the Department of Human Sciences - III at the State University of Bahia.

Thus, as an afterword written by the professor at the Federal University of Vale do São Francisco, Nilton de Almeida, activist of the Black Movement in the São Francisco region and supervisor of this research. The images are from the photographic collection of the characters themselves, from the Quilombola Association of Lagoinha/BA, as well as photographs from the collection of the researcher and photographer, Márcia Guena dos Santos.

The graphic project proposal was elaborated and carried out by a militant woman of the social movements in the

region, Carmem Costa, who used as a reference images from the Bogo Já Festival, in which 429 women illustrated their homes with mineral paintings, held in the village of Siby in Mali. , from the year 2021, published on the Instagram page of the Brazilian artist, Jhon Bermond. According to the Bermonds, the illustrations made by the women in their homes bring ancestral symbolism to their homes.”

Thus, in addition to the photographs, voices and ancestry of quilombola women, the African prints, intertwined, compose the aesthetics and message of the e-book “Lagoinha, a territory erected by Anas and Marias”.

A result like this is configured as an important instrument, of notes of a historical, economic, social and political reality of this ethnic group, from the point of view of the women of Lagoinha/BA.

In order to point out the reality, and also to emerge in the face of it, the deepening of the demands and the signaling for the elaboration of public policies that can contribute to the strengthening of the community, consequently, of the women and their families. In addition to expanding the range for academic performance, through teaching, research and extension, which also seek to act in this sense.

According to Ângela Tadei (2009), “to narrate is, above all, to fight against forgetting the traditions that shape us, the identities we invest in, the projects for the future that we cherish” and occurs in “all times in multiple” genres (2009). TADEI, 2008, p. 03). In this way, “narrate has been a recurring human activity” (TADEI, 2009, p. 03), even more so for traditional peoples and communities that preserve their oral history, perceived in everyday life as a transmission of knowledge and ancestral ways of life. .

According to Antônio Bispo dos Santos (Nego Bispo), contrary to what happens in capitalist society, which transforms knowledge into merchandise, in quilombola communities what happens is its sharing, because when knowledge is shared, the person who receives the knowing, has the possibility to add to that knowledge and want to know a little more (NEGO BISPO, 2020). This desire is shared by the women who built the research. Thus, the e-book was published and made available on the website of the Master's Program in Rural Extension, as well as the Nucleus of Ethnic and Afro-Brazilian Studies Abdias do Nascimento e Ruth de Souza (NEAFRRAR) of Univasf, on the blog Quilombos e Sertões and others. platforms they wish to disseminate widely.

## V. FINAL CONSIDERATIONS

Throughout this work we present the definitions about the modern quilombo in Brazil, as well as we seek to understand the state of the question of the research carried out in the Bahian context. This contextualization adds to the history of the Quilombo de Lagoinha, the first wanderings of the community's ancestors, as well as the construction of the quilombola kinship along the São Francisco River, culminating in the current community.

It marks the awakening of the academy to the reality of the region's ethnic groups, more especially the Sertão do São Francisco Territory (TSSF). The importance of this problematization, not only for the academy, can subsidize social movements, which, from this, join forces with traditional communities and the black people of the region in the search for guaranteeing the rights of historically marginalized populations. As well as understanding historical concepts of the formation of quilombos and the paradigms that explain the materialization of a contemporary quilombo, a concept in which it contemplates the formation of TSSF quilombos, within these, the community of Lagoinha.

For the historical context of the formation of this territory, we analyze the protagonist action of black women in the formation of a quilombola territory. In this way, we go back to the black history of a community in the Sertão do São Francisco Territory, from the point of view of black women.

The emergence of this quilombola territory is the result of a process of migration from a northeastern municipality to another, from Afrânio - PE to Juazeiro- BA, due to the lack of resources and the drought of the northeastern hinterland, which for centuries, the lack of investments in technology and incentives for coexistence with the semi-arid region has shaped the lives and destinies of a number of the inhabitants of the Brazilian semi-arid region.

In this way, it is essential to highlight that this reality has been modified by the agency of community-based movements that have long been putting pressure on the State to implement policies of coexistence with the semi-arid region. Faced with this context of water scarcity, the São Francisco River was configured in the river of hope that symbolized opportunity, at a time when Juazeiro was considered one of the main centers of river commerce. Over the generations, while male labor is exploited by the boss, female labor is used for both: production on the boss's land and the subsistence of the "next wave", the children who would grow up and provide more. a generation of unpaid work, just by “luck”.

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## Quilombo Communities: Historical and Legal Aspects

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Received: 28 Jun 2022,

Received in revised form: 20 Jul 2022,

Accepted: 27 July 2022,

Available online: 06 Aug 2022

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**Keywords—** *Traditional Communities, Legal  
Aspects, Gender and Race.*

**Abstract—** *Faced with the numerous social and political struggles that take place in the Brazilian scenario, the recognition and guarantee of the rights of quilombola communities emerges as one of these necessary guidelines for the country. The present work therefore discusses legal and political aspects of these struggles, based on the interdisciplinary work of postgraduate programs in the São Francisco Valley. In the development of the research, in the bibliographic review process, it is possible to find significant scientific production, in research carried out in communities of the Sertão do São Francisco Territory (TSSF), where the concepts and realities that subsidize us to understand the quilombo in the territorial context were worked. .*

### I. INTRODUCTION

The quilombola communities in Brazil live a constant struggle for basic rights and for the maintenance of their territories. According to bulletin n° 3 Omission of the Brazilian State and Conflicts by Territory of the National Coordination of Quilombola Articulation (CONAQ, 2021), “the absence of a speedy process of recognition of Quilombola property causes serious consequences”, resulting in thousands of victims all over the world. over the years between indigenous people and quilombolas in conflicts over land.

The marks of this absence of the State, the struggles for land and other social rights are characteristic of the rural black communities of the Território Sertão do São Francisco (TSSF). Above all, due to non-compliance with Brazilian laws and international frameworks for the protection of traditional peoples and communities, the State ends up producing and reproducing various forms of inequity.

CONAQ concludes its bulletin n°3, stating that what is happening is a process of trivializing the life of the black quilombola population, who have been murdered and that this genocide has lasted for more than 400 years by the ruling classes, urging the need for this reality change.

CONAQ is the result of the mobilization of social movements, especially the black movement and the mobilization of quilombola communities started in the 1990s. In 1995, in the presence of more than 400 communities, due to the “I National Meeting of Black Communities Quilombola Rural Communities”, during the Zumbi dos Palmares March, the Provisional National Commission of Black Quilombola Rural Communities was created.

But it was in 1996, in the process of evaluating the national meeting that took place in Bom Jesus da Lapa, that the National Coordination of Quilombola Articulation (CONAQ) was born. Today the entity is present in twenty-

four states, representing “a universe of more than three thousand five hundred communities in all regions of the country”. (CONAQ, 2021). The entity's objectives are:

[...] fight for the guarantee of collective use of the territory, for the implementation of sustainable development projects, for the implementation of public policies taking into account the organization of quilombo communities; for quality education that is consistent with the way of life in the quilombos; the protagonism and autonomy of quilombola women; for the permanence of the young person in the quilombo and above all for the common use of the Territory, natural resources and in harmony with the environment (CONAQ, 2021).

With all the implosive attacks that the Palmares Cultural Foundation (FCP) has been suffering since the beginning of the Bolsonaro government, it is mainly in the field of symbolic violence the violation of cultural, social and ethnic rights conquered by the Brazilian people, represented mostly by the social movements.

Serving the interests of a racist and sexist extreme right, the attacks range from the attempt to change the name of Fundação Cultural Palmares to Fundação Princesa Isabel (Carta Capital, 2022) to the threat of exclusion from the FCP collection, with the argument that most of the books contained “inappropriate” content, related to the “sexual revolution, sexualization of children and banditry”. But such an initiative was prevented by a popular civil action that resulted in an injunction issued by the federal judge, which established a fine of 500 reais for each item donated or damaged (Carta Capital, 2021). However, these losses are not limited to the FCP, nor have they started now, but in the course of the political coup against which resulted in the impeachment of President Dilma.

Before her departure, the president was pressured by the National Congress and its “traditional” extremist benches to demote the National Secretariat for Policies for the Promotion of Racial Equality (SEPPPIR) and the National Secretariat for Policies for Women – both had ministry status and were diluted –, today there is an emptying of all policies promoting racial equality, women and human rights, such as the “pillow up” of the Brazil Quilombola Program or the dismantling of the National Institute for Colonization and Agrarian Reform (Incra).

Incra, the body responsible for the definitive titling of the lands of quilombola communities, came from the Brazil Quilombola program since 2003, gaining strength in Brazil, from the prism of 4 axes development - Access to Land, Infrastructure and Quality of Life, Productive Inclusion and

Development Place and Rights and Citizenship – which aimed to ensure, through inter-ministerial actions, greater effectiveness of policies in quilombola territories. However, currently, all policies at the national level are compromised and, in the face of this absence, it is the organized social movement that has acted decisively.

## II. UNDERSTANDING THE HISTORICAL CONTEXT OF QUILOMBOLAS COMMUNITIES

In the case of quilombola communities, it has been CONAQ, at the national level, in addition to entities at the local and state level, which have sought to guarantee the rights of quilombola communities. In the Sertão do São Francisco Territory, it is the Quilombola Articulation group that has been active in the search and struggle of these communities, which was created in the midst of the Fotoethnographic Profile research, given the perception of the difficult reality of the black quilombola communities in the region, due to the researcher, Prof. Dr. Márcia Guena dos Santos.

Created in 2011, the group, which is currently a Quilombola Articulation Extension project, works mainly in surveying demands presented by quilombola communities in the region. In addition to articulating with partner institutions for their resolution and carrying out training actions aimed at the quilombola public.

The Quilombola Articulation project is linked to the Department of Human Sciences III of the University of the State of Bahia (UNEB) and has the collaboration of several partners, such as UNIVASF, Municipality of Juazeiro da Bahia, through the Municipal Secretariats, the Municipal Council for the Promotion of Racial Equality in Juazeiro da Bahia (COMPIR), the recently created Frente Negra do Velho Chico, which has a very important collective action in the region with the demands of the black population.

The Quilombola Articulation is a fundamental initiative that has a radius of territorial articulation and that has brought governmental and non-governmental institutions closer to the quilombola communities, seeking to minimize the effects of the inequalities faced by these populations and, mainly, has representations of the quilombola communities present in the Territory. , such as the communities of Juazeiro (Alagadiço, Rodeadouro, Barrinha da Conceição, the community of Cural Novo), the municipality of Curaçá, the quilombola community Jatobá, the first to be certified by the TSSF, and the Comunidade Sítio de Lagoinha in Casa Nova – BA, research space, territory of this work.

The impacts of institutional racism are stamped, without the need for sophisticated equipment, or for long contact with these communities to verify them. Problems in garbage collection, lack of treated water in the taps, basic sanitation, quilombola education, lack of infrastructure in accesses, land grabbing, lack of identification are problems shared by quilombola communities in the Sertão do São Francisco Territory.

These are examples found from my work in the quilombola communities of the territory. There are few traces of public policies. formal school? Only in neighboring communities. School transport, problematic garbage collection, cisterns, energy?

In most communities, water tanks without a water pump for taps and without adequate treatment for consumption. Recently, communities that were awarded the Bahia Productive Public Notice, from the Bahia State Government, are starting to have access to Rural Technical Assistance. In this context, the Quilombola Articulation Group has functioned as a space to enhance the quilombola communities, as well as ensure greater visibility of their problems, so that they can be resolved by Organs competent bodies and other partnerships.

### III. THE STRUGGLES FOR THE LEGAL GUARANTEES OF THE QUILOMBOLAS COMMUNITIES

Based on the Quilombola Articulation group, the Quilombola Community of Lagoinha held the 1st Forum for the Promotion of Racial Equality in the municipality of Casa Nova, with the participation of the local municipality. As a result, the Law on the Council for the Promotion of Racial Equality was approved, but the government of Casa Nova never swore in the council, creating several obstacles.

To combat racism, by which the structures are formulated, it is urgent to resume the process of institutionalization of policies for the Promotion of Racial Equality and policies to guarantee the rights of traditional peoples and communities, as recommended by the Federal Constitution in its articles 68. and 216, and in the Convention on Indigenous and Tribal Peoples 169 of 1889 of the International Labor Organization (ILO) and ratified in Brazil through decree n° 143 of June 20, 2002.

CONAQ was created based on the realization that, in different parts of the world, these peoples are not able to “enjoy fundamental human rights to the same degree as the rest of the population of the States where they live and that their laws, values, customs and perspectives have suffered”. erosion frequently”, as well as the “particular contribution of indigenous and tribal peoples to cultural diversity, the

social and ecological harmony of humanity and international cooperation and understanding;” (Brazil, 2002, s/n).

In this way, reparation policies are essential for the subsistence of these territories. However, the history of Lagoinha and the rural black communities of the TSSF demonstrate a total historical abandonment. What happens to transform this scenario is the result of collective action and especially the agency of communities.

According to Júlio Rocha (2013, p. 264-265), it was for the purpose of regulating the convention and provisions of the 1988 Constitution, in a discussion about who would be the subjects of rights of Convention 169, that Brazil published Decree 6040 /2007, which instituted the National Policy for Sustainable Development of Traditional Peoples and Communities - PNPCT, and defined PCT and its territories, as

[...] culturally differentiated groups that recognize themselves as such, that have their own forms of social organization, that occupy and use territories and natural resources as a condition for their cultural, social, religious, ancestral and economic reproduction, using knowledge, innovations and practices generated and transmitted by tradition; II - Traditional Territories: the spaces necessary for the cultural, social and economic reproduction of traditional peoples and communities, whether used permanently or temporarily, observing, with regard to indigenous peoples and quilombolas, respectively, as provided for in arts. 231 of the Constitution and 68 of the Transitional Constitutional Provisions Act. (Decree 6040, of February 7, 2007, art. 3 I and II). (Brazil, 2007).

Despite the importance of these legal frameworks, these laws are constantly disrespected, seriously compromised in the country by the 2016 coup and deepened by the far-right guidelines underway in the country. What can harm the transformations through which the quilombola communities have been experiencing, according to the author José Maurício Arruti: “those borders, (...) change in consistency, that the political arrangement internal to the communities undergoes transformations in the sense of a greater formalization and that the relationship with memory and with “traditions” also undergoes profound transformations.” (ARRUTI, 2008, p. 27).

It is in article 68 of the transitional provisions of the Federal Constitution of 1988 (ADCT/CF) that the rights of Quilombola Communities are inaugurated. However, Arruti

(2008) warns of the context of incorporation of article 68 (ADCT/CF 1988),

[...] incorporated into the Magna Carta “at the end of the day”, in an “amputated” formulation, in an improvised way, without a clear original proposal. There was a clear agreement around the idea that “article 68” should have a sense of reparation for the damages brought by the slavery process and by an abolition that was not accompanied by any form of compensation, such as access to land, but from then on, everything was under discussion (ARRUTI, 2008, p.08).

Indeed, within the correlation of forces in which article 68 was inserted, and in the face of the challenge that would be the regulation of the transitional provisions of the Constitution, several mobilizations took place in different sectors, social and scientific, as there was a need to define the urgency the existence of the numerous rural black communities that existed throughout the country.

In this sense, neither the quilombo as a target of repression, thus identified in the colonial period, nor the quilombo only as “remaining”, could handle the complexity, both with regard to the formation of these territories and the existence of these ethnic groups spread throughout the whole world. national territory, as these “do not refer to waste, are not isolated, do not always originate in rebellious movements, are not defined by the number of members, do not make an individual appropriation of the land” (ARRUTI, 2008, p. 02) ).

It was in this emerging context that the concept of contemporary quilombo was forged. The contemporary quilombo that begins to be disputed conceptually, in the process of resemanticization carried out by entities of social movements, of the black movement, coordinated by the Brazilian Association of Anthropology (ABA) in the 1990s, a historical moment in which the understanding of quilombolas gains projection as “subjects who are in a permanent relationship with other cultures and are not stationary in time”.

Therefore, the concept of quilombo is “dynamic and contemporary and is not linked only to reminiscences” (ABA, 1994, s/p).

The result of a joint work carried out by the Working Group on Black Rural Communities of the ABA, it had the mission of contributing to the recognition of all this heterogeneity that comprises quilombola communities, an approach different from that presented in the context of the constituent in 1988, seeking to remove the quilombo from the field of mere historical remnants, in the recognition of the remnants, to understand them as ethnic groups: “an

organizational type that confers belonging through norms and means used to indicate affiliation or exclusion”. (ABA, 1994, s/p).

For ABA (1994), the quilombola identity is independent of the number of its members, being explained through their collective experiences throughout life. “It is, therefore, a common historical reference, built from shared experiences and values.” (ibdem) For Arruti (2008), the processes of resemanticization are not only in the field of understanding the term, “but of successive symbolic assemblages of the quilombo, capable of explaining the basis on which the constitutional article was conceived and that justifies its formulation. vague and uninformed.” (ARRUTI, 2008, p. 03).

To understand the contemporary quilombo, Arruti points out three paradigms in which this concept is implied. The first paradigm is the attribution of the term “remainings” introduced in art. 68 of the Transitional Provisions of the Federal Constitution (ADTCF/1988), in which it presents very complex scenarios for the realization of the rights of rural black groups.

For the author, even though the term “remnants” was introduced in the constitution in a context similar to the indigenist discussion, its value was inverted by a racist, limited reading that does not understand contemporary complexities. The author states that in the midst of complexity, the term “remaining”, after re-semanticization, attributed important changes to the “quilombo”, in relation to the one presented in the 1988 Constitution.

In it, what is at stake are no longer the “reminiscences” of former quilombos (documents, remains of slave quarters, emblematic places such as Serra da Barriga, etc.) (...). Finally, in the same way that it occurs among indigenous remnants, such assumptions implied in the term place at the core of the definition of those groups a historicity that always refers to the pair memory-rights: when it comes to remnants, what is at stake is the recognition of a historical process of disrespect (ARRUTI, 2008, p. 14).

The second paradigm presented by Arruti (2008) is the term “Common Use Lands”, whose concept is supported by studies on rural black communities in the country. In these communities, “the use and control over the land would be a more collective than an individual function, its limits would be tributary to social, symbolic and environmental ties and uses, rather than the possession of documents (abstract and formal property relationship). [...]” (ARRUTI, 2008, p.15).



For the author, what allowed us to speak of a “land of common use” is the notion of community implicit in this “common”. Thus, in view of this territoriality, whose main characteristic is “common use”, there are definitions based on the different forms of “self-representation and self-denomination of peasant segments”, among these: “Terras de Santo, Terras de Índios, Terras de Relativas, Lands of Brotherhood, Lands of Heritage, and finally Lands of Black.”

They are also diverse, with regard to the recognition of the formation of these territories, ranging from the

[...] concessions made by the State in return for the provision of warrior services; the situations in which the direct descendants of large landowners, without their former power of coercion, allowed the permanence of the families of former slaves (and the forms and rules of common use) through tenures of symbolic value, as a way of not opening hand of their formal property right over them; or even in former quilombos (ARRUTI, 2008, p.16)

Thus, the author states that this “sociological reduction” promoted important links on the process of resemantization of the quilombo when it allows its materialization not only in a sense of opposing the “repressive character that marked its colonial and imperial use”, but also also the “existence of a “peasant right”, subordinated to the national legal system, whose recognition, in itself, would be capable of translating the existence of a wide variety of forms of possession.”

Likewise, it would be necessary to recognize that the denial of belonging to these “prohibited social forms” is a result of the criminalization process by the State, “which would now require a resemantization of the local self-denominations themselves”.

Thus, for the author, the contemporary category of quilombos becomes associated with the sociological reduction of local denominations under the analytical category of “common use lands” (ARRUTI, 2008). For Selma dos Santos Dealdina (2020), quilombola leader of the Argelim III community, in Espírito Santo and advisor to the state CONAQ, the paradigm “of common land use” presented by Arruti was a great milestone for the practical struggle of quilombola communities.

According to this author (2020), the identification of quilombos having territoriality and the collective use of land as structural elements, ancestrally occupied by generations and generations, was an important normative advance. In this sense, the author refers to Decree 4,887 of 2003, published by the government of President Luiz Inácio Lula

da Silva, which regulated article 68 of the 1988 DCT/CF, more specifically article 2, which defined the remnants of quilombo communities as “ ethnic-racial groups, according to criteria of self-attribution, with their own historical trajectory, endowed with specific territorial relations, with presumption of black ancestry related to resistance to the historical oppression suffered.” (BRAZIL, 2003, s/p).

In her considerations, Dealdina (2020) ponders that this same decree was the target of several coup attempts against the rights of communities. In addition to counting that for 14 years the quilombola communities lived the threat of loss of their rights, due to the unconstitutionality action of the aforementioned decree, which was filed by the Liberal Front Party (PFL), currently Democrats (DEM).

For Selma Silva, the victory in the Federal Supreme Court by the Brazilian quilombola communities, on February 8, 2018, when the Federal Supreme Court took a stand for the constitutionality of Decree 4,887, was a great victory, “a milestone in the struggle for land in Brazil and in the affirmation of the right to territory by rural black communities”.

However, he concludes, “legal victory is not enough if there are no resources committed by the executive power to ensure that the titling of territories takes place.” (DEALDINA, 2020). When it comes to ethnicity, the third paradigm presented by Arruti (2008) highlights the important role of the black movement for the regulation of article 68 of the CF/1988, reverberating in the field of legislation, and the human sciences, by definition.

The author points out that the discussion was inserted from the studies developed in the 1970s, when there was, which points to a subtle change, an inversion in the studies whose object was the rural communities that were black to the black communities that were rural.

According to Bandeira (1997 apud Arruti, 2008, p.15), it is the category of ethnicity that explains the social mechanisms of maintenance of the so-called “black territories”: they would be defined based on ethnic limits, developed “in the face of situation of alterity proposed by whites”. According to the author, when dealing with an ethnic group to designate black rural communities “historically linked to quilombos (or other forms that have corresponded to it) it should not lead to the search for “small Africas”, which could refer to an idea of resistance whose counterpart would be conservation and/or return to the past.” (ARRUTI, 1997, p. 20).

The author points out that, through the lens of ethnicity, it was proposed to replace the search for “self-evidence intrinsic to the slave ideology and the legal precepts emanating from it” (2008, p. 18) by the process of “self-attribution of a social movement that , in his public demand

for the reversal of stigma, resorts to this “more than symbolic way of denying the slave system”. Such a change in conception was the result of dynamics in several rural black communities, no longer seen only as remnants, but also emerging (ARRUTI, 1997) across the country.

Still for the author, the contemporary concept of quilombo points to social groups produced as a result of localized and dated land conflicts, linked to the dissolution of the forms of organization of the slave system (Arruti, 2008, p. 02).

It is the current process of attributing “rights” to the “remaining” quilombo communities that operates a similar type of transformation among black rural communities, also giving rise to processes of ethnogenesis. The ethnogenesis to which the author refers is an affirmative and confrontational process against ethnocide that systematically exterminates lifestyles.

#### IV. FINAL CONSIDERATIONS

Throughout history, the Brazilian quilombo, in its dynamism and heterogeneity, was built as an anti-racist and subversion institution to the slavery structure.

In essence, an Afro-Brazilian territory. It is, therefore, a territory that constantly seeks to disrupt from the point of view of white supremacy and segregating oppression. Far from being a simplistic institution, it is complex, multiple and transgressive.

In an undeniably racist country like Brazil, the quilombo has been a problem for the hegemonic power system for centuries. Regarding the recovery and affirmation of an ancestral black memory, in the last decade, in the Sertão do São Francisco Territory (TSSF), it is possible to identify advances from the process of self-declaration of quilombola communities and the increasing participation of professionals and/or nuclei. of the academy, through teaching, research and extension, contributing to the rescue, registration, legitimation and recognition of the value of traditional knowledge of these black communities present especially in rural areas.

As pointed out throughout the work, the following stand out in the territory: the Project “Photoethnographic Profile of Quilombola Populations of the Lower Middle São Francisco: Identities in Movement”; the Postgraduate Program in Human Ecology and Social and Environmental Management (PPGEcoH); the Graduate Program in Education, Culture and Semi-arid Territories of the State University of Bahia - (UNEB); the Professional Master's Degree of the Graduate Program in Rural Extension (PPGExR) and the Nucleus of Ethnic and Afro-Brazilian Studies Abdias do Nascimento - Ruth de Souza

(NEAFRRAR), both from the Federal University of Vale do São Francisco, in their academic performance, are part of a broader enterprise of construction and repercussion of knowledge in the territory. This work is developed from the meeting of social movements, notably the quilombola movements,

In the development of the research, in the bibliographic review process, it is possible to find significant scientific production, in research carried out in communities of the Sertão do São Francisco Territory (TSSF), where the concepts and realities that subsidize us to understand the quilombo in the territorial context were worked. .

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# Central Nervous System Infection by SARS-CoV-2 and Neuropsychiatric Consequences Related to Disease Caused by the Virus: A Review

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Received: 01 Jul 2022,

Received in revised form: 26 Jul 2022,

Accepted: 30 July 2022,

Available online: 06 Aug 2022

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**Keywords—** Central Nervous System, Citokynes, SARS-CoV-2, Infection,

**Abstract—** The COVID-19 virus infects the body, preferably by inhalation, reaching the Central Nervous System through the olfactory pathways, characterizing a primary infection. The Central Nervous System (CNS) can also be affected when the virus spreads hematogenously and crosses the blood-brain barrier. The brain tissue damage caused by the pathogen can occur directly, with the injury caused by the direct contact of the virus with neuronal cells, or indirectly, through the activation of inflammatory and thrombotic pathways due to the entry of the pathogen into the body. Endothelial dysfunction is potential for brain complications and can have neuropsychiatric consequences, both during the course of the disease and after its remission. The objective of the present literature review was to associate Central Nervous System Infection by SARS-CoV-2 with possible neuropsychiatric consequences caused by the pathological process caused by the virus. In addition to the organic factor involved, such consequences may also be related to psychosomatic processes, involving post-traumatic stress, fear and grief of individuals when facing these issues during the pandemic.

## I. INTRODUCTION

The SARS-CoV-2 presented itself in 2019 as an infection that caused mild and intermediate symptoms, such as flu and gastrointestinal symptoms, in most patients with a higher incidence in elderly patients or patients with comorbidities. In addition to these symptoms, some can also be presented by the Central Nervous System – CNS (BRITO & SILVA, 2020). Clinically, a strong feature of SARS-CoV-2 infection is the disturbance of smell (BUCHAIM *et al.*, 2020). In the literature, 86% of patients

showed signs of hyposmia or years of symptoms, even before symptoms of some symptoms (DOUAUD *et al.*, 2022).

In April 2020, in a sample of 214 patients infected with the new coronavirus, neurological symptoms in a percentage of 36.4% were already noticed, being more common in severe cases of infection (MAO *et al.*, 2020).

With the advance of the COVID-19 pandemic, the protests alert continued to grow. ELLUL *et al.* (2020) cites cases of 901 individuals, whose organic hypotheses

revolved around direct viral effects on the nervous system (attack on nervous tissue and vasculature), immune-mediated disease during and after infection, as well as systemic effects leading to neurological complications. In this retrospective study of cases in Wuhan, cerebrovascular manifestations were reported in 6% of 221 patients and as the virus spreads, evidence increases for an association with cerebrovascular disease, as well as other forms of vascular disease. In this retrospective study of cases in Wuhan, cerebrovascular manifestations were reported in 6% of 221 patients and as the virus spreads, as an association of vascular disease increases, as well as with other forms of vascular disease.

In addition, turning attention to fear, even the patient, should influence the mental health of patients, anxiety and/or post-traumatic stress, anxiety and/or more rare depression (DE OLIVEIRA *et al.*, 2021). It is known that during a pandemic, the development of symptoms and quarantine led to fear and increased stress, leveraging different psychiatric disorders. It is also known that some viral syndromes harm the CNS, as they have neuropsychiatric and consequent effects on the affective, behavioral and perception domains. Dealing with the pandemic situation is a significant stressor state, as it substantially influences all areas of life, community organizations, socially and economically (MOREIRA *et al.*, 2021).

Recognizing an evolving or asymptomatic neurologic neurological disease to the joint SARS-CoV-2 may be more difficult, even the infection-neurological disease ratio tends to remain minimal. However, when they do not occur, neurological sequelae may only be present as they are severe. However, considering the suffering associated with the pandemic and the pathological process that causes the virus, the effects on the CNS are still known and complementary therapies are being poorly studied, aiming at a functional and psychological recovery of the affected animals (BUCHAIM *et al.*, 2007; ROSSO *et al.*, 2020; DE MATOS *et al.*, 2021).

## II. MATERIALS AN METHODS

This literature review was initially prepared by searching for information in the SCIELO, PubMed/MEDLINE and MedRxiv databases, during the month of May 2022, on events associated with SARS-CoV-2 infection with an effect on the Central Nervous System. The Google Scholar website was also used to search for articles with the theme discussed, in the selected period between 2020 and 2022. The following descriptors were used: "COVID-19 and Central Nervous System", "SARS-CoV-2", "Covid long" and "cytokine storm".

Initially, 21 articles were selected that provided information about the damage caused by the virus in the body, and among these, 10 were excluded because they addressed neurological repercussions superficially or because they had little data on the topic to be discussed in this study.

## III. RESULTS AND DISCUSSION

According to MOREIRA *et al.* (2021), it is known that SARS-CoV-2 binds to the cell to enter it through the angiotensin 2-converting enzyme receptor as well as smooth muscle cells. In addition, an in vitro experiment showed virus replication in neuronal cells. To reach the CNS, the entry of SARS-CoV-2 occurs through the ascent of the virus through the olfactory pathways (through the olfactory bulb), precisely because it is part of the CNS not protected by the dura mater. Another form of CNS infection would be through the blood-brain barrier (BBB) crossing, hematogenous route, by contaminated leukocytes or viremia.

In a study of animal models, it was observed that SARS-CoV-2 makes use of the trans-synaptic neuronal pathway, through olfactory nerves (BUCHAIM *et al.*, 2020), reaching other brain structures such as the trunk, thalamus, basal ganglia, in addition to others, this being main or additional road. This fact explains the symptoms of decreased or loss of smell in some cases. Central nervous tissue damage can be caused directly or indirectly by the infection. Directly by the virus is a possibility, but the data found do not suggest that it is highly neurovirulent - as with neurotropic viruses. The main issue would be restricted to the way in which the pathogen enters the organism (ELLUL *et al.*, 2020). Even so, the neurotropism of the coronavirus can still lead to inflammation by activating glial cells (BRITO & SILVA, 2020)

An autopsy was performed on a patient who, weeks after infection with COVID-19, developed encephalopathy, identifying edema, neuronal necrosis and glial hyperplasia. In evaluating the injured tissue using immunohistochemistry, it was noted that the virus was associated with the expression of cytokines, chemokines and infiltration of defense cells. Such findings are consistent with the hypothesis that the coronavirus, upon entering the CNS, triggers immune-mediated inflammatory processes, promoting tissue damage (ELLUL *et al.*, 2020). The term "cytokine storm" is used for the exaggerated immune response, which accompanies intense release of inflammatory cytokines, in which, when linked to infectious diseases, it is strongly associated with viral causes, being a hot topic after the beginning of the pandemic of COVID-19 (ALCOCK & MASTERS, 2021).

Studies show that this “cytokine storm” can break the integrity of the BBB, reaching the CNS, leading to neuroinflammation. The basis of encephalopathy caused by a toxic effect on tissue is supported by evidence of cerebral edema, as well as neuronal degeneration in patients with COVID-19 who were autopsied (BRITO & SILVA, 2020).

TAQUET *et al.* (2021) reports that cross-sectional studies formed by electronic health records covering 62,354 cases of COVID-19 were used, evaluating bidirectional associations between the aforementioned condition and psychiatric disorders. Among the sample of patients with no prior history of psychiatric disorder, illness caused by the coronavirus was associated with an increased incidence of psychiatric diagnoses within the three-month period after infection, with a 95% confidence interval and risk rate of 2.1 (1.8-2.5). Anxiety disorders increased the most, followed by depression, insomnia and dementia. Another point observed was the increased risk for COVID-19 in patients with a previous psychiatric diagnosis.

Thus, among the factors involved that explain these repercussions, when correlated with SARS-CoV-2 infection, we can mention the immune response to the virus, as discussed above, as well as psychosocial factors, such as fear related to the disease, individual and family, bereavement, and social isolation. A large part of the people who survived the disease had some type of psychiatric disorder, namely: anxiety (40%), depression (31%) and post-traumatic stress disorder (28%). In addition, disease processes have been described at the cerebrovascular level with micro ischemia caused by the virus, being related to depression (MACEDO *et al.*, 2021).

DOUAUD *et al.* (2022) describes an investigation of brain alterations using the UK Biobank database, in which 785 participants were evaluated, aged between 51 and 81 years. Therefore, brain magnetic resonance imaging (MRI) was performed at two moments, in which 401 analyzed, with a positive test for COVID-19, in the corresponding period between the two exams, had proficient images. Among these, for 351 individuals who had a diagnosis date based on antigen tests and medical records, they had an average of 141 days between diagnosis and obtaining the second image. The importance of having pre-infection imaging data available reduces the possibility of previously existing risk factors. That said, the significant effects found between the two imaging groups studied, in positive cases for COVID-19, were: gray matter reduced in thickness; contrasted orbitofrontal cortex and parahippocampal gyrus; areas with functions linked to the primary olfactory cortex (Piriformis cortex), with changes

in tissue damage markers; brain with reduction in its overall size.

In view of this, in addition to the changes in the images, on average, infected individuals also evolved with greater cognitive decline in this period. When comparing a control group with SARS-CoV-2 positive participants, the differences between both were explored, based on cognitive tasks, addressing scores of patients outside the sample more susceptible to cognitive impairment and, after correction of the discovery rate false, a significant increase in the time required to perform such tasks was found (DOUAUD *et al.*, 2022).

#### IV. CONCLUSION

In view of the above, based on the extractions of articles presented, it is concluded that the SARS-CoV-2 virus has, albeit little, neurotropism. Even so, it is a potential cause of injury to the CNS, directly or indirectly, due to its pathogenicity, inflammation and exacerbated immune response of the infected organism. It is noted that the lesions can also lead to morphological and functional changes in the brain parenchyma, which can lead to neurological disorders. Nevertheless, with regard to the increase in diagnoses of psychiatric diseases, it is important to emphasize not only the organic cause, but also psychosocial aspects related to the entire pandemic context.

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# Culture and Regionality in Sergipe: Views on the Creative Economy and Architecture

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Received: 25 Jun 2022,

Received in revised form: 19 Jul 2022,

Accepted: 25 July 2022,

Available online: 06 Aug 2022

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**Keywords**— *Creative economy; Regional  
Economy; Culture.*

**Abstract**— *The present work discusses the mountable architecture, as it can also be called, is conceived with the purpose of contemplating the temporary needs of people or social groups, although it can also leave its mark on the environment in which it is contextualized. In this sense, we make a historical contextualization about this process, as well as evaluate the benefits of using it currently in architecture.*

## I. INTRODUCTION

Inherent to the human condition, creativity, in all its facets, is the raw material of what is called the creative economy or economy of culture. Combined with technical knowledge, it generates an infinite network of goods and services capable of generating meanings, values and desires.

A relatively recent term, the expression creative industry is a product of the third industrial revolution, directly related to the paradigm of “the production of contemporary society based on the post-industrial, post-Fordist era of knowledge, information and learning” (MIGUEZ, 2007).

According to PIRES; ALBAGLI, (2012) apud ALMEIDA et al. (2014), analyzing this economy in a more comprehensive way, it is called creative economy as a set of companies that have their production process and final product, simultaneously, fully explained about everyday life, the pulsating living knowledge, creativity, art, the way of doing things from different perspectives, culture in its facets, in general.

Working on the immaterial, a society adapted to a knowledge-based economy in which “cognitive and communicational skills, that is, immaterial resources,

emerge as new factors of production and impose a review of business strategies, organizational dynamics and business models until then in force.”

They configure a new field of study in the solidification phase, but several scholars have already put the creative economy as a scenario to be guided. But, according to Cohen (2008), there is a long trajectory written in this area, in which, in 1970, there is a process of deindustrialization of large cities and the search for substitute activities to the “normal”.

Later on, in the 1990s, a deeper analysis began on the impact of the cultural industry and the creative class on the regional economy. (COSTA, 2011, p. 2). But Howkings (2001) was the author who shaped this economy by showing it as a way for people to actually turn their ideas into money by making the suit more popular.

In numbers, taking as an example a large metropolis like Buenos Aires, the creative economy chain corresponded to 9% of the generated product, 9.5% of the jobs and the addition of US\$ 4.3 billion to the city, between 2003-2007. (UNESCO, 2010, p.54).

In Brazil, the recognition of the importance of creativity as a production input has begun in recent decades, as well as its transformative and strategic role in the productive system and economic scenario of the country.

## II. SCENARIO OF THE CREATIVE ECONOMY IN SERGIPE

As highlighted by CHAGAS (2010), Sergipe is a state blessed by five large river huts, which together with sugar cane were the engines of Sergipe's economy for decades.

Allied to this, he mentions the availability of mineral resources, as well as the presence of a center of commerce and services in the capital and countryside, which, in turn, have enormous cultural wealth, which is necessary as a contextualization here in this work. "After all, our approach involves the understanding that cultural production forms space and, as such, its mapping is also a social construction (MARTINELLI, 1991).

Table 1, presented below, lists some traditional and contemporary manifestations.

Table 1: Cultural Manifestations

Traditional Manifestations	Contemporary Manifestations
<p><i>Religious traditions: predominance of the Catholic matrix with processions and festivities of the patron saints of the cities. One can cite: Penitents, Queima de Judas, Cosimo and Damião.</i></p>	<p>Parties and events: forrós and micaretas</p>
<p><i>Crafts: embroidery, wood, ceramics and leather, straw and vine.</i></p>	<p>Civic celebrations: September 7 and political emancipation of the municipalities.</p>
<p><i>Shows and dances: June cycle and Christmas cycle.</i></p>	<p>Horseback riding and horseback riding</p>
<p><i>Popular Literature: Cordel.</i></p>	<p>Other events: Festa do Mastro, Cabacinha, Rock Sertão, Laranjeiras Cultural Meeting, Feirinha da Gambiarra.</p>
<p><i>Revelries of war, struggle and liberation: Capoeira, Maculelê, Chegança, Lambe Dirty and Caboclinhos, Cavalhadas.</i></p>	<p>Theater and Music: Grupo Imbuauça, Mamulengo de Cheiroso, The Baggios.</p>

According to an analysis carried out by the Federation of Industries of the State of Rio de Janeiro (FIRJAN) in 2015, it appears that Sergipe has the best average remuneration (Figure 1) in the entire northeast for professionals in the creative area. The FIRJAN system is the representative of all industries in the state of Rio de Janeiro with five organizations - SESI, SENAI, IEL, FIRJAN AND CIRJ acting in areas such as business competitiveness, education and quality of life for workers with the objective of guaranteeing the industrial growth in the country.

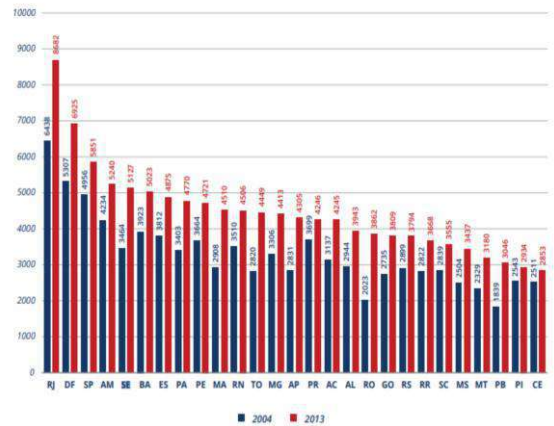


Fig.1 - Average remuneration graph

Source: FIRJAN (2016)

Positioning itself in 5th place across the country, the state is behind Rio de Janeiro (R\$8,682.00), Distrito Federal (R\$6,925.00), São Paulo (R\$5,851.00) and Amazonas (R\$5,240.00 ). Based on the analysis carried out in 2004, the average remuneration of professionals in Sergipe was R\$3,464.00, rising to R\$5,127.00 in 2013, very close to the national average of R\$5,422.00.

Another relevant information is to know the number of creative professionals by activity, which in 2013 had 4,947 creative professionals in Sergipe divided into: Architecture (836), Performing Arts (70), Biotechnology (358), Design (352), Expressions Cultural (190), Fashion (94), Music (127), Research and Development (928), Advertising (463), Audiovisual (499), Editorial (383), Heritage and Arts (83) and Information and Communication Technology ( 564). There is also a quantitative emphasis on professionals in Research and Development and Architecture. (BIRTH, 2015).

It can be seen that the creative areas are based on a chain that is supported by pillars such as: academic training (federal and private universities), free courses in



educational institutions (public and private), actions created by the public authorities - government and city hall, as well as as actions created by civil society professionals.

In the cultural economy scenario in Sergipe, the projects of the Institute for Research in Technology and Innovation (IPTI), based in the municipality of Santa Luzia do Itanh (SE), surrounded by Atlantic forest and mangroves, the institute works in partnership with various bodies, competes for public notices and combines these funds with the objective of changing the reality of the community with projects that have as their essence stimulus to entrepreneurship, art and technology.

According to Saulo Barreto, co-founder of IPTI:

We started in São Paulo, in 2003. Six years later, we moved to a municipality of extreme poverty in the south of Sergipe because we wanted to develop a model of how art, science and technology could promote human development (Interview on the Brazil website Foudation, 2014: <https://brazilfoundation.org/arte-ciencia-e-tecnologia-como-ferramentas-para-o-desenvolvimento-humano/?lang=pt-br>).

In this and other aspects, the creative economy is understood at the institute as the best way to generate income, as it is based on the characteristics of creativity and cultural heritage of that region. Models are developed that are reapplied within the community itself, by the residents themselves, who become acting agents inside and outside the municipality. Among the projects, brands such as Felícia, the name of one of the artisans, appear combining contemporary design and traditional handicraft techniques with the use of palm and grass with associations that already exist in the municipality.



Fig.2 - Illustration of the Naturalist Art project, from IPTI

Source: Mangrove Life Cycle - IPTI, year 2015.

Naturalist Art (Figure 2) is another project of the institute that selected young talents from the region who

were trained through Art History classes and illustration techniques such as pointillism and watercolor. Today they become multipliers by teaching in public schools, signing collections for big brands on the national scene such as Morena Rosa and Osklen, in addition to creating their own brand of t-shirts, Casa do Cacete.

At the same time, actions by the State Department of Culture - SECULT are shown to be of paramount importance in the scenario, with the launch of public notices that financially encourage projects in the areas of performing arts and visual arts, encourage the participation of the population in the management of the State Plan for Culture, which is directly linked to the National System of Culture, as well as involving society in units it manages: Teatro Atheneu, Teatro Tobias Barreto, Teatro Lourival Baptista, Public Library Epifânio Dórea, Children's Library Aglaé Fontes, Cento de Criatividade, Complexo Cultural Gonzagão, J. Inácio Gallery, João Ribeiro House of Culture, Afro-Brazilian Museum of Sergipe, Historical Museum of Sergipe and Public Archive of Sergipe, as well as the coordination of the Sergipe Symphony Orchestra – ORSSE.

Responsible for various actions in the cultural and artistic area of the city of Aracaju, FUNCAJU5 – Fundação Cultural da Cidade de Aracaju, was born in 2013 and strengthens the city's cultural scene through public notices that foster the local artistic scene, as well as through its units : Aracaju Cultural Center, Digital Production Center, Clodomir Silva Municipal Library, Mário Cabral Municipal Library, Public Archive of the City of Aracaju, Ivone de Menezes Vieira Municipal Library, Álvaro Santos Art Gallery and Valdice Teles School of Arts.

Still in this scenario, a new business model moves the creative sector scene and gives space for the emergence and professionalization of new entrepreneurs. Coworkings, that is, spaces used as shared offices and/or virtual offices (for address registration and other services) and, in the city of Aracaju, there are more than 10 spaces in this format, among them:

Prime Offices, located at Av. Jorge Amado, 1565, in the Jardins district;

CEC – Virtual office and coworking, located at Av. Pedro Paes Azevedo, 488, room 02, Salgado Filho neighborhood;

Grupo Rede+, located at Praça Getúlio Vargas, 63, São José neighborhood.

Neoworking – Shared office, located at Av. Jorge Amado, 382, São José neighborhood.

Base – shared office and coworking – Rua Santa Luzia, 590, São José;

Job Connect – Rua Rosalina, 305, Farolândia neighborhood.

In general, it is observed that Sergipe has a pulsating scenario with a long history of construction from different facets, whether traditional or contemporary.

However, it is clear that it is a scenario that still needs to be implemented and strengthened in the sense of professionalizing the creative sectors - and valuing them - and concrete initiatives that work as "springboards" for these creative entrepreneurs to trace their businesses. thinking about a local-global connection.

### III. STRUCTURES THAT WALK: CONTEXTUALIZING ITINERANT ARCHITECTURE

In order to understand what this work proposes, it is necessary to return to antiquity, placing what is understood as itinerant architecture in a historical context and the development of man in space. This, in turn, can be understood from the way of life of man in prehistoric times.

The ancient peoples moved through the territories in search of food and utensils for daily use in gathering, hunting or fishing, characterizing nomadism (FREITAS, 2011).

The development of this ability to move from territory to territory was an essential factor in the survival of these early men. For them, as well as their tools, weapons and clothing, shelters demonstrated qualities in maintaining their lives.

[...] man created migration routes to seek food, adapt to climatic conditions, trade goods, look for community protection and uncover the unknown, making it essential to use light and flexible structures that collaborate to build their shelters. In this way, portable architecture emerged as a survival solution and origin for current construction techniques. The examples of this prehistoric architecture are basically formed by tents that differ in structure and covering membrane. The materials used varied according to the region in which the tribe was located. The Tipi, Black Tent and Yurth, some of the models of the period, were basically made of animal skins and wooden frames (JOTA; PORTO, 2004).

Over the years, several societies have maintained the nomadic culture for reasons that hover between some specific need and/or option. Even though they roam a defined territory, the nomadic people do not have a

permanent geographic base, which clarifies the line of thought from the perspective of association between specific parts of their territory with certain periods of the year. This is due to numerous reasons such as trade in goods, search for community protection, migratory sources of food, adaptations to climate change and even the search for the unknown.

This process of nomadism leads us to reflect on the concept of territoriality that can be observed, according to Brandão (2008, p. 63) “[...] is not only the arrangement of the sphere of activities of an individual, a couple or a group, but also of the organization of the relationship with others – the animal or the people of the other territory”.

Immediately, the walk of man in search of meeting his demands provokes a series of elements that compose him and establish his territory, his body and the relationship between these two points.

This process leads us to believe in space as a preexisting, neutral component and receiver of such needs that come to it. “It means arriving somewhere with your stuff, observing it, checking its possibilities and, having decided that it serves, planting a flag, founding territory, applying the multidimensional organization in that space” (BRANDÃO, 2008, p. 63).

All this continuous sketch that is drawn in space builds the man and the spaces he travels, leaving traces and making us believe in the concept of home not as what is built – bedroom, living room, bathroom, kitchen – but for what we live. there.

[...] territory is an expressive signature that makes rhythms emerge as their own qualities that, not being indications of an identity, guarantee the formation of a certain domain. The functions and directions of conduits cannot account for the formation of the territory. The expressive signature is incarnated in conduits, and cannot, however, be explained by it. (PASSOS; ALVAREZ., 2015, p. 133).

The spatial configuration of this territory does not define it, but the use made of it.

Through the study of body movements and gestures (body patterns of action) we could decipher their bodygraphs and, from these, the urban experience that resulted in them. In this sense, the understanding of corpographies can serve for reflection on urbanism, through the development of other forms, corporeal or incorporated, of apprehending the urban space and, later,

proposing other forms of intervention in cities. The corpographic study can be interesting to understand the bodily pre-existences resulting from the experience of space, to apprehend the spatial pre-existences registered in the body itself through urban experiences. This type of experience, of the ordinary and everyday body, can be stimulated by a practice we call wandering. The urban experience that mobilizes more complex bodily perceptions could be stimulated by a practice of wandering around the city, which, in turn, would result in equivalently more complex urban corpographies. (BERENSTEIN, 2004, p.3).

As an essentially urban activity, commerce and the actors that are part of its action produce the spatial configuration of the city, creating relationships that allow us to understand the history of a community from the analysis of the history of commerce (PINTO, 2015).

According to Pinto (2009, p. 25), “[...] Humanist Geography seeks to consider aspects of man and his symbolisms, thus, the consumer starts to play an important role and his behavior is understood as a process intersubjective and collective.

This process of spatial displacement in the search for adaptation to the diverse needs of man does not remain stationary in a prehistoric context. It is clear that today's man is increasingly configured as a nomad. The latter, in turn, moves in space in an incessant search for their professional and personal needs associated with technology and globalization. Thus, in many situations, housing no longer needs to be eternalized in the same place, it always needs to be stable and flexible (BÓGEA, 2009).

This inevitable comparison between the time of nomadism in the past and in contemporary times brings to light an observation guided by Zygmunt Bauman that deals with the speed of how space can be traversed, making the difference between what is far and near can be a point relative and space no longer defines limits to action (DIAS, 2011).

In this perspective, it is possible to think of the debate between the body and the city not only as a meeting of common perceptions, but as a process of building a zone of understanding for solutions for the city and, consequently, for the wandering bodies that in it act.

This body-space rhythm leads us to observe the situation of homeless people with an existential experience that inevitably derives from nomadism (MAGNI, 2006).

This almost daily mobility brings to light points such as the ephemerality of relationships built daily, simplicity in its various aspects, material detachment and creativity in adapting to the most diverse adaptation situations which are imposed.

#### IV. FINAL CONSIDERATIONS

Faced with the numerous emergencies that characterized the 20th century, objects that are not made to last, or rather, temporary objects with different purposes appear in a context of buildings and spaces that needed to be relocated.

The remountable architecture, as it can also be called, is conceived with the purpose of contemplating the temporary needs of people or social groups, although it can also leave its mark on the environment in which it is contextualized.

In this way, it is understood a scenario composed of different types of itinerant architecture among: structures for camping, emergency shelter or military purpose, as will be analyzed in the next point.

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# The Social Role of Flexible Architecture

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Received: 30 Jun 2022,

Received in revised form: 23 Jul 2022,

Accepted: 29 July 2022,

Available online: 06 Aug 2022

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**Keywords**— *Social Role, shelters, UPIK.*

**Abstract**—*The present work focused on case studies about flexible architecture. As case studies, trailers and ephemeral structures of different profiles and applications were analyzed. Throughout the study, it is demonstrated that flexible structures can be solutions that are inserted as alternatives to the reality of homeless people and, thus, flexible architecture can have as a focus on shelter, whether for people in a state of vulnerability on the streets or to care for the homeless after natural disasters, which are increasingly frequent in different parts of the world, including Brazil.*

## I. INTRODUCTION

Temporary shelters, mostly in community places, are generally proposed as an alternative to the loss of homes due to natural disasters, which are in a public context, without the minimum privacy and guarantee of individuality, and the collective begins to live.

In addition to the families facing the pain of losing their home, the feeling of insecurity of living in the temporary shelter, there is the doubt of when there will be a home again as a private and inviolable space.

It is also important to think that temporary shelters are given, summarily, in spaces of the public sphere and, therefore, they end up affecting the mental health of those who live there, as they create obstacles for the singularities of the subjects who live in the place (VALENCIO, 2012).

The disparity of a community life is perceived, the lack of a particularized space is a block in a search for the subject's identity and a prediction of a better future.

In this context, flexible structures can be solutions that are inserted as alternatives to such a reality, which focuses on shelter, whether for people in a state of vulnerability on the streets or to care for the homeless after natural disasters, increasingly frequent in different parts of the world, including Brazil.

To this end, we raised some existing proposals to make a case study of each of the proposals presented hereinafter.

## II. UPIK – A TRAVELING OFFICE OF ARCHITECTURE

The architecture firm UPIK (Figure 1), created in São Paulo, adapted a trailer structure with the central objective of democratizing access to the Architecture service, considered elitist, creating consultancies with little time at affordable prices, parking at several strategic points in the city that reach their target audience such as contemporary fairs and streets close to stores in the decoration and furniture sector.



Fig.1 - Refurbished UPIK trailer

Source: Folha Uol (2015)

According to Márcia Monteiro (2018) in an interview with the author of this research via email, the co-founder of the trailer reports that the logistics of everyday work have

never been simple. Initially there was a need to change your car for a 4x4 model that adapts to load the trailer structure, which weighs more than 1,000 kg.

Bought in a bad state of repair, it was completely renovated in a specialized store in the city of Itu, also in the interior of São Paulo, and the architect managed to adapt the 10m<sup>2</sup> to receive the office with a basic structure to accommodate three people working and a bathroom.

Among the positive aspects, Márcia Monteiro points out that the daily interaction with several different people on the streets where the trailer was parked generated very important connections for her business, which is currently undergoing a reformulation in the operating model with online service only due to the large flow in this niche.



*Fig.2 - UPIK trailer internally*

Source: Hometeka website (2016)

From the analysis of the UPIK case, it can be seen that itinerant architecture plays an important role in disseminating the object it proposes, in this case: to popularize the architectural service, generally considered noble and costly, restricting architectural activity, whether small or large size to the middle and high income classes.

We consider here the difficulties of the project that leaves the comfort line of common architecture offices, placing as negative points: the high investment in renovation of the trailer and the difficulty of locomotion due to the weight (another investment, a car that could support).

In this sense, the UPIK is believed to be an example of flexible architecture as a bridge for the dissemination of an idea, reaching a much larger number of people, in a shorter time, compared to an idea that is dependent on a series of factors such as: plastered space or displacement of people. It is the strengthening of a chain from an element that transits until reaching its objective, as it clearly happened with the São Paulo office.

### III. L'AUVENT – EDUARD BÖHTLINGK

To compete in the Temporary Living competition in 1985, Dutch architect Eduard Böhlingk designed “L’Auvent”, a flexible trailer measuring 2x4.50m in its ordinary state that unfolds into a temporary accommodation with at least triple its original size.

The work, a temporary holiday home to adapt to different places, won the Audience Award at the Design Rotterdam Prize in 1966 and was made by the company specializing in awnings De Markies.



*Fig.3 - Trailer designed by Böhlingk with sides being mounted*

Source: Gadgetsin website (2016)

Böhlingk developed the idea from a question: “How do you define living space in today's mobile world?”<sup>9</sup>. Following the concept, the architect designed a structure of side awnings that unfold like the bellows of an accordion, creating two new compartments, estimated to accommodate up to six people comfortably.



*Fig.4 - Trailer mounted being used in camping*

Source: Gadgetsin website (2016)

The space, divided into three distinct parts, consists of a plywood and steel structure, with a kitchen, bathroom, living room with terrace and bedrooms.

The side awnings have different functions, one of them has the clear objective of providing a direct connection with nature, bringing direct lighting through the transparency of the material, while the other extreme seeks privacy.

#### IV. 3-IN-1 FOLDABLE SHELTER DEPLOYMENT – SHARKCAGE

Following the goal of easy mobility, both in cities and on roads, the development of the 3-in-1 Foldable Shelter Deployment was based on studies of cargo shelters manufactured with a focus on military use for communications headquarters, medical triage and disaster aid.

These shelters are built from expandable containers that triple their mobile size, so, despite being heavy, they are reasonably sized to be moved on roads and meet the expectation of space when stopped at the desired point, with the space tripled.



Fig.5 - Foldable structure being assembled

Source: Print Screen saved by the author from the video on Youtube (2011)



Fig.6 – 3-in-1 Fordable in phase of assembly from one side

Source: Print Screen saved by the author from the video on Youtube (2011)

One of these models, the 3-IN-1 Foldable Shelter Deployment (figure 8) was developed by Sharkcage10, a brand specializing in military logistics equipment working

in direct collaboration with the United States Armed Forces and the North Atlantic Treaty Organization - NATO since 1998

The company, in turn, argues that the products are developed to interface between storage, transport and operation, giving those who use them the necessary flexibility to reduce loading time.

However, it is still noted that the time of assembly and expansion of the container in the chosen location is not as satisfactory as the company sells, as well as the material weight ratio for the assembly speed.

In the search, the exact value of the product is not found on its website or catalogues. As a positive point, the internal dimension of the expanded container is quite satisfactory for its purpose.



Fig.7 – Fully assembled Foldable frame with both sides open

Source: Uniteam website (2018)

The model brings to the study in question the contribution of understanding that the same itinerant structure can bring the necessary flexibility for its use, even with a structure in extremely heavy material which, in this case, perfectly meets what is proposed as a structure for military use.

#### V. CARDBORIGAMI - PAPER HOUSE

With a flexible architecture focused on shelter for people in situations of social vulnerability, Cardborigami<sup>12</sup> was designed by architect Tina Hovsepian as an alternative structure to minimize the vulnerability of these people who live on the margins.

The structure can be assembled by anyone in a maximum of 30 seconds, serving as protection against the weather.

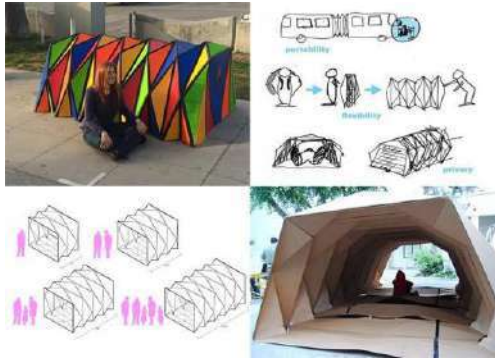


Fig.8: Sketches, perspective design and assembled structure of Cardborigami

Source: Gazeta do Povo website (2015)



Fig.9 – Professionals closing Cardborigami

Source: Cardborigami official website

With recycled paper material, the structure can easily be reused after the end of its useful life and, created as a portable and temporary shelter, the action aims to include these citizens in housing and social reintegration programs, in addition to creating jobs from of manufacturing the products, which are sold online and at fairs in the area.

In addition, the mission of the NGO that leads the movement, namesake to the product, is to provide the step-by-step process for the manufacture of the shelter for the greatest number of people around the world.

**RD-SHELTER - PAUL GRAY**

Developed by the Scottish design agency Suisse: the RD-Shelter follows the humanitarian line of the previous one, but with a specific focus on sheltering people displaced by war or natural disasters.

Natural disasters kill thousands of people a year. Usually the biggest killer is not the event itself, but the hours after the event. It is often the lack of adequate shelter – a basic human need for survival combined with the destruction of infrastructure and services and

the lack of provisions, that make the 48 hours post-disaster a critical zone for victims; a determining factor between survival or death. (FULCHER, Merlin, 2017).

The prototype was created by Paul Gray, director of the agency, who defends the shelter as the most basic item in the face of a tragedy, as essential “as air, water and food”, believing that the shelter brings safety and minimal comfort to those who use it ( TUCKER, 2016).

With that in mind, it was designed with the intention of, as its name says in literal translation - Shelter - shelter people after a natural disaster or other occurrence that has the need to provide a minimum comfort structure.



Fig.10 - Perspective drawing - rd-Shelter

Source: Dezeen website (2016).

In the model developed and named as a quick-deployment shelter, corrugated polycarbonate, a material also known as corrugated plastic, is used, creating a small opaque structure that is windproof, waterproof and capable of housing at least two adults and a child, considering an ordinary small family.

In addition, the prototype has the ability to store basic items at the base of the structure, such as food and medicine.



Fig.11 – Paul Gray Creative Pool Prototype Presentation

Source: Creative Pool Website (2016).

The material used, the polywave plastic, also known as Coroplast, which was given the same name as one of the brands that develops it, a fact that is widespread especially

in Latin America where it has been gradually implemented, brings to the project several positive points such as: lightness – it has hollow structure, waterproof, good corrosion resistance, long life and, from an aesthetic point of view, a wide variety of colors.

It is worth mentioning that the Coroplast company started its activities in 1973, in Montreal and inaugurated its factory in Granby, Quebec, in 1975 and began its activities by supplying plastic widely to the signage market, as was the example of the Olympic Games in Montreal, in 1976. In 1985, the factory opened in Dallas, Texas, and in 2014 Coroplast became part of the Intoplast Group, one of North America's leading plastic manufacturers. Today it is the leading manufacturer of corrugated plastic sheets for the North American signage, packaging and industrial markets.



Fig.12 - rd-Shelter Prototype

Source: The Architectural Review website (2017).

Corrugated plastic is obtained by extrusion of polypropylene and appears in the 70s as a new option for various purposes such as packaging and construction. A sheet with a honeycomb structure, polywave plastic does not allow the formation of mold or other foreign bodies and has an alternative for recycling (MURARO et al., 2006).

It is noted that Paul Gray's project has a lot of relevance for application in countries with frequent natural disasters to care for people in need of basic care through the shelter. It is apparently easy to transport and reasonably easy to assemble/disassemble.

Bringing it to the Brazilian reality, it could also be shared with the same use after natural disasters, as well as for use, in a palliative way as an alternative for temporary shelter to the reality of homeless people who are in a state of social vulnerability. Allied to this, after meeting their basic needs for shelter from the elements and basic comfort, it is necessary to provide health care and forward actions

that take them out of the risky situation that is living on the street with multidisciplinary teams.

The use of polywave plastic explains the importance of a light, resistant material that is an alternative to other materials, commonly used for temporary shelters such as canvas or plastics in general, as well as in civil construction, showing a good option for various uses such as facades and closures.

## VI. FINAL CONSIDERATIONS

The study of the cases demonstrated throughout the present work presented the proposal of some of the flexible architectural structures that can meet urgent demands.

It is valid to consider that adjustments are necessary for its implementation in Brazil, considering the country's reality and the urgent demands it has, such as the current housing deficit, as well as the natural disasters it suffers.

In this sense, flexible architecture presents itself as an important way to think about more urgent situations that require practical and immediate responses.

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# Traveling Architecture as a Bridge to Creative Entrepreneurship: The Gambiarra Case

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Received: 01 Jul 2022,

Received in revised form: 22 Jul 2022,

Accepted: 26 July 2022,

Available online: 06 Aug 2022

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**Keywords**— *itinerant architecture, changes, Gambiarra.*

**Abstract**— *This work aims to provoke the reader to reflect on itinerant architecture as a bridge to entrepreneurship from the dialogue between body and architecture, this body, in turn, as an agent of innovation and itself, an agent provoking other bodies. Therefore, connection between body-space that generates new ideas, new businesses.*

## I. INTRODUCTION

Constant changes in the last decades have marked the job market and the way entrepreneurs face the creative processes, a movement concomitant with the whole crisis that affects the world economy. Faced with the chaos in which the Brazilian scenario finds itself, in particular, it is necessary to mobilize collective intelligence as a way of solving the basic problems of these aforementioned processes.

In this way, it is possible to find abundance in the surplus capacity, that is, all the accumulated experience that is not shared. For this reason, this project seeks to become an open platform to this excess capacity by engaging people from different areas, as creators uniting passion, inventiveness and customized local applications to create flexible systems with real solutions for cities and for their own businesses through the exchange and meeting of information.

As we connect with more people and with their knowledge, this new possibility of finding the right expert has led to increasingly valuable results [...] all over the world, large trucks run empty around 30% of the time. time! Exposing and making this excess

capacity available makes it possible to send and receive cargo at reduced prices for those willing to accept more flexible terms (CHASE, 2015, p.91 and 102).

It is this connection as a generator of new businesses and ideas that the house proposes as an object and a means for this: to become a physical space that welcomes several entrepreneurs in the area of Creative Economy, aspirants in the area and the curious who seek study or exchange of experiences. .

It aims to create the ideal scenario for these professionals to work in a shared environment, better known as coworking, as well as the place to be conducive to study through the library composed of books in the area, as well as courses and debates, eventually taking place in the same space.

In the early 2000s, several North American coffee shops became “offices” for many workers. Flexibility in relation to work and communicative mobility allowed these people the incredible ease of working together, even being in separate places. The main difficulty of these workers was to find

an ideal place to develop their activities, since they could do it wherever they wanted. This is how the first hubs and coworking offices appeared in the North American country. [...] The business model proposed by these environments is based on the sharing of the same space, by different people, who share the experience of working together, even if their activities are not related. [...] The central idea of a coworking office is the sharing of space, experiences and knowledge among the consumers who use it. (HECKLER, Henrique, 2012)

This “multi” feature shows the need to build a highly flexible space that can become either a classroom or a coworking space in a short space of time, focusing on the development of furniture that is easy to assemble-dismantle, as well as easy storage for thinking about a compact space.

In the current scenario of the test site for the trailer, flexible structures that resemble this proposal were not registered in research, but important places were found to be registered here as a way of contextualizing the current scenario of spaces that serve these actors. in study.

Being designed in a general area of 9.48 m<sup>2</sup>, O Gambi has a detachable box profile and seeks to insert itself in the Inácio Barbosa forest, respecting the surroundings and making itself sensitive to the relationship of the residents with the neighborhood. For this first proposal for the insertion of the itinerant structure, a land was delimited within the Otávio de Melo Dantas Park located in front of Tiradentes Square, bordering the river and Av. Cecília Meireles, close to houses and Pizzeria Manjeriçã, a restaurant opposite the aforementioned square.

Having as an aesthetic and conceptual reference the Google offices developed by different architecture offices around the world, but always following the same concept, the space seeks to stimulate the exchange of experiences in the workplace and study through characteristics such as: of ideas during the working day with spaces/furniture layout that directly stimulate this practice, create a fun environment with games for occasional breaks in the daily work and tools that encourage the longest possible stay in the place.

## II. GAMBIARRA: EVENT SPACE

The case was designed to be a point of convergence for the itinerant creative economy, reaching as many professionals as possible, with the main function of becoming a meeting point for creative entrepreneurs as a

favorable scenario for this, generating networking and new connections, as a result. , new business.

Aiming at strengthening the creative chain, initially at the level of Aracaju, it assumes the role of flexible architecture and aims to meet the demands of: education, entertainment and work, as can be seen in the organization chart of Figure 1. The three points are interconnected and show how the space needs to be flexible to meet different demands, including a musical show open to the public, a debate between professionals in the area and even a workplace in the form of a shared office (coworking).

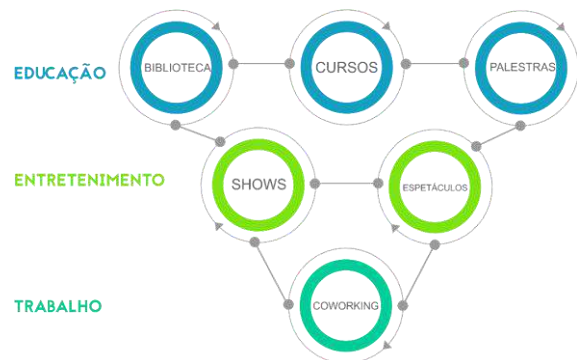


Fig.1 - Organizational chart of Casa Gambiarra's areas of activity

SOURCE: RIBEIRO, 2022.

Assuming the role of an itinerant structure, Gambiarra intends to reach as many people as possible, inside and outside the state, so, after several studies, the project develops from the study of existing structures, such as snack or tour trailers. , widespread in the country and even in Aracaju.



Fig.2 – 1st edition of the Feirinha da Gambiarra, in the São José neighborhood, in Aracaju

SOURCE: Mota Collection, 2012.

This project originates from the Feirinha da Gambiarra, the first creative street fair in Sergipe that emerged in 2012 (Figure 2), in the São José neighborhood, bringing together on a Sunday, in the same scenario, 12 exhibitors from different creative sectors with small stalls selling their own

products and small shows with bands from Sergipe. This, in turn, had its last two editions in a new location: the Bosque do Inácio Barbosa.

The Feirinha has been consolidating itself in the cultural scene of the city as an environment of exchange and movement of creative areas such as traditional and contemporary crafts, clothing, decoration, gastronomy, music, among others, in addition to provoking the feeling of belonging to the city through the choice of places such as streets, squares and cultural facilities, such as the Epifânio Dórea Public Library, as can be seen in Figure 3.



Fig.3 – 6th edition of the Feirinha da Gambiarra, in the São José neighborhood, in Aracaju

SOURCE: ALLEN, 2015.

It is from the need to disseminate, professionalize and consolidate these creative sectors in the state that the idea of creating Gambiarra arises, bearing the same name as the event as a way of facilitating the link with the public and other stakeholders, in addition to strengthening it. A multipurpose and flexible space that welcomes creative entrepreneurs with their different needs and desires through free courses, space for debates, library, meetings, space for work and exchange of ideas, designing an experience space with the itinerant profile that the fast pace that the term that debate requires.

The choice of the Inácio Barbosa neighborhood to host the idea is due to the positive response from the local community, the exhibitors involved and the general public with the last edition of the Feirinha da Gambiarra, which took place for the first time in this place occupying the forest with music, gastronomy and creativity. It, in turn, is inserted in the space respecting the notorious sensitivity of the residents towards the square, with an architectural project that respects the organicity of the existing space and causes the local movement of people who have as a principle respect and reciprocity towards the urban space.

For the insertion of the structure in the proposed land, the positive response from the residents of the neighborhood was taken into account with the experience of two editions

of the Feirinha da Gambiarra event that took place in December 2017 and May 2018 and field interviews. It was also found, with field research, good acceptance of exhibitors, who sell their products at the event on stalls and carts of creative sectors ranging from Gastronomy to Clothing.

Popularly known as Bosque do Inácio by local residents, Parque Otávio de Melo Dantas borders the river and has mangrove vegetation, being heavily wooded with almond trees (*Terminalia catappa* or beach almond) and other species. On this point, seedlings were recently planted by groups of volunteers formed by residents of the neighborhood itself. Large trees, such as the species mentioned above, create a microclimate for the square, bringing thermal comfort to those who use it with excellent shading and protection from the weather.

The roads have an average flow of cars caused by the profile of the surroundings, which is essentially residential, having commercial points such as restaurants - such as Sr. Inácio, Brejas Bar, Pizzaria Manjeriçã and Confraria do Cajueiro - and small businesses such as bakeries and neighborhood "sales", usually attached to the houses of the residents. There is also a record of public transport flow, with a bus stop at Praça Tiradentes, in front of the land chosen for the project. The pedestrian flow is reasonable and there is an important record of residents who walk their dogs daily in the place, as well as children accompanied by parents and grandparents, making the environment familiar and always alive.

The street parallel to the Bosque has a two-way street, speed bumps, but does not have a proportional parking lane, with some spaces at 45° in part of the forest. In this case, on days with a greater flow of people, such as during events (such as the Feirinha da Gambiarra) or even on days with a greater flow of people in the bars and restaurants in the area on weekends, it is observed that the cars park in an irregular on parallel streets.



Fig.4 - Inácio Barbosa Bosque Record

SOURCE: Author's personal collection, 2018.

The sidewalks are not adapted to the guidelines of the Free Sidewalk booklet, and there is no record of signaling lanes for people with special needs, neither directional throughout the flow, nor warning signs for equipment such as poles or ramps. The sidewalks are in good condition, but with improvements to be made, with small parts damaged.

It is important to note that intervention actions are already taking place on the part of the residents of the neighborhood itself, as reported in an interview (Appendix C) by young Melício Britto Araujo, who has lived in Inácio Barbosa for 26 years and is at the forefront of actions such as the urban garden.

According to him, the planting activities began in 2016 and today they harvest the fruits, literally, cultivating papaya, corn, beet, among others.



Fig.5 - Inácio Barbosa Bosque Record

SOURCE: Melício Britto's personal collection, 2018.

About this reality, Britto's report, provided during the research, is fundamental for understanding the project and the context in which it is inserted.

In this history of a few years, it is necessary to consider the participation of so many other people from different neighborhoods of the city, the state and even foreign tourists who passed through here and shared with our activities, however, as long as there is common sense of those who want to interact with us, respect this place we live so that we can work together. After all, there are annual events here that are not well accepted by the mostly elderly and elderly residents. I believe that any mobilization with a proposal similar to Feira da Gambiarra is welcome in any urban space that today cries out for novelty and always needs a culture that renews the environments. The benefits of interventions

such as those that embrace the family circle, economy, health and environment are remarkable.

In addition to the existing vegetable garden, cultivated and maintained by the community itself, Cine Mangureira is a cinema with films and documentaries with the support of the Secretary of the Environment, but it does not have the same community engagement regarding the aforementioned vegetable garden. Another activity is the Community Garden, which transforms organic waste from residents' homes into fertilizer for planting local trees.

### III. GAMBIARRA ACTORS

Gambiarra's target audience is made up of entrepreneurs from different sectors of the creative economy, including photographers, dancers, visual artists, architects, among others, who see in that space a way to directly or indirectly meet their professional needs.

Wherever the ancient city still functions satisfactorily... it's a complex order. Its essence is the complexity of the use of sidewalks, which brings with it a constant succession of eyes. This order is made up of movement and change, and while it is life and not art, we can imaginatively call it an urban art form and compare it to dance. Not a synchronized precision dance with everyone lifting their feet in the air at the same time, twirling in unison and bowing in harmony, but an intricate ballet in which each individual dancer and group play distinct roles that, miraculously, reinforce each other. others and compose an ordered whole. The ballet of the good urban sidewalk is never repeated elsewhere and everywhere is always full of new improvisations (JACOBS, 2013).

The project also stands as a point of convergence for students and aspiring creative entrepreneurship as a way of further valuing the creative area and strengthening the scenario of this economic niche. This same function is placed in front of the community of the Inácio Barbosa neighborhood, placing itself as an open space for those who want to understand the creative universe, create their own business or study.

From a questionnaire applied, the profile of the creative entrepreneur and their real desires and needs were traced. Among them we can point out: Young – between 21 and 39 years old; Predominantly female; They live in the neighborhoods: Aeroporto, Aruana and Inácio Barbosa; Work from home: *home office* or studio; They feel alone,

they want to share ideas with other entrepreneurs; have difficulty in discipline yourself Working in House, managing household chores with everyday life.

Immersed in this context of economy/business, a pause is necessary, a literal pause in time from the rhythm in which these entrepreneurs walk. Creative work – which does not necessarily have to be linked to the creative sectors – requires a break. Pause for what is to come, pause to be inspired, feel new looks, create other means from what seems simple. It is here that the inevitability of time for leisure is perceived and here the role of architecture as a way to build playful paths that provide this hiatus.

If we compare the flâneur, the urban explorer, the bohemian, the dreamer or that cultured person who has time to walk around the city with the thousands of people who travel every day from home to work with the pressure of converting that time into a productive space, we notice that the in-between time is missing, transformed into a space for production (LABIRINTO do tempo, Revista AU, São Paulo, year 28, nº 230, 2013, p.51)

Here, space must bend to give space to time, revering all its nuances and giving value to each sign of those who use it. Here the project contextualizes its intervention proposal bringing a knot, a setback with playfulness, inspired by the children who pass in the woods, the dogs that walk daily with their owners in the Inácio Barbosa neighborhood and proposes a small complex of temporary and flexible elements that provoke the actor to its various uses.

#### IV. FINAL CONSIDERATIONS

It is undeniable that the connection between space and actor is important in the creative process, in all its moments and scenes, even in the non-creative actor as a professional. The understanding that creativity is inherent to the human being makes us reflect on the urgent need to take the creative sectors to a level of prominence and attention in civil society.

This reach, in turn, is one of the key points of this proposal: Aracaju as an incubator for an object of practice and strengthening of the creative scenario that expands, not only in its form, but in its itinerancy to reach the largest possible number of people .

It is moving together and knowing that several nodes can be created, in a space that promotes exchange, a firm scenario that integrates the various sectors and, especially, aware of their role in society.

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## A Look at Endomarketing and the Relationship with Motivational Factors

## Um Olhar Sobre o Endomarketing e a Relação Com os Fatores Motivacionais

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Received: 02 Jul 2022,

Received in revised form: 27 Jul 2022,

Accepted: 03 Aug 2022,

Available online: 08 Aug 2022

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**Keywords—** *Endomarketing. People  
management. Internal Communication.  
Motivation.*

**Palavras-chave—** *Endomarketing, Gestão de  
pessoas, Comunicação Interna, Motivação.*

**Abstract—** *In order to promote an internal harmony in the relationships work that govern the enterprises, The Endomarketing search to promoting employees, setting them as internal clientes and alinging with stocks and internal communication and motivation, factores of great importance to company success. On that aspect, this research brought as general goal, the look about the Endomarketing and the relationship with the motivational factores governing this relationship. For the support of it, the specifics objectives were raised: expose the Endomarketing concept as a marketing strategy, discuss the actions linked to the Endomarketing motivation and internal communication and report Endomarketing results from an internal experience report. For this purpose, it was used the search method, a basic character, descriptive nature, classified as qualitative for resonating with bibliographic sources. As a conception of their employees, wich communication well-aligned is able to promote motivation, and this is nothing more than the Endomarketing focused on people, what about this aspect are be able to produce more and better, after all, the asset that cannot measured within the organization is its your human capital.*

**Resumo—** *Com o intuito de promover a harmonia interna nas relações de trabalho que regem as empresas, o Endomarketing busca promover os colaboradores, definindo-os como clientes internos e alinhando com ações a comunicação interna e a motivação, fatores de grande relevância para o sucesso da organização. Sob esse aspecto, o estudo trouxe como objetivo geral o olhar sobre o Endomarketing e a relação com os fatores motivacionais que regem essa relação. Para sustentação do mesmo, levantou-se os seguintes objetivos específicos: expor o conceito de Endomarketing como ferramenta estratégica, discorrer as ações ligadas ao Endomarketing na motivação e comunicação interna e relatar resultados do Endomarketing a partir de um relato de experiência interna. Para tal, utilizou-se a metodologia da pesquisa, de caráter básico, com natureza*

*descritiva, classificada como qualitativa por alicerçar-se de fontes bibliográficas. Como resultado, constatou-se que nos últimos anos as empresas estão mudando sua concepção sobre seus colaboradores, que uma comunicação bem alinhada é capaz promover motivação e isto nada mais é que o Endomarketing focado nas pessoas, que sob esse aspecto são capazes de produzir mais e melhor, afinal o ativo que não pode ser mensurado dentro da organização é o seu capital humano.*

## I. INTRODUÇÃO

Desde a ideia até concepção de uma empresa, tem-se como meta o desenvolvimento e crescimento sempre ascendente, no entanto para que isso ocorra, decisões estratégicas precisam ser tomadas ao longo do tempo. Essas decisões - quando pensadas e acertadas a médio e longo prazo - serão um diferencial para a empresa.

Entretanto, para que se possa alcançar o sucesso, faz-se necessário a atuação efetiva do capital humano. Nesse sentido, para que a organização alcance de modo efetivo seus clientes externos, faz-se necessário primeiro encantar, cativar e zelar seus colaboradores, os primeiros clientes da organização.

Neste contexto, o endomarketing busca focar nos colaboradores internos para culminar nos resultados idealizados pela organização, interagindo no envolvimento de todos junto a empresa, já que os processos internos são realizados pelos mesmos.

Portanto, destaca-se a importância do tema em enfatizar como forma estratégica, quando a empresa investe em endomarketing, objetivando o comprometimento dos seus colaboradores, buscando com isso, que os processos internos evoluam na qualidade e êxito dos produtos ou serviços ofertados.

O pressuposto levantado nesta pesquisa parte da visão sobre o endomarketing e a relação com os fatores motivacionais, no contexto de que desenvolver ações que motivem os colaboradores contribui para a obtenção dos resultados almejados pela organização.

Tem como objetivos específicos: (i) Expor o conceito de endomarketing como ferramenta estratégica na gestão de pessoas; (ii) Discorrer as ações ligadas ao endomarketing na motivação e comunicação interna; (iii) Relatar resultados do endomarketing a partir de um relato de experiência interna.

O estudo refere-se a uma pesquisa de natureza básica que busca contestar perguntas para amplificar a base dos nossos conhecimentos. Gil (2022), frisa que o objetivo da pesquisa básica é ocupar os espaços desiguais que o conhecimento oferece. A pesquisa é caracterizada como descritiva pois a mesma visa apresentar características sendo indispensável a participação do

pesquisador. Andrade (2012, p. 112), afirma que “Nesse tipo de pesquisa, os fatos são observados, registrados, analisados, classificados e interpretados, sem que o pesquisador interfira neles.” Segundo o seu propósito.

O estudo é de teor qualitativo, por ser um estudo que procura esclarecer determinados comportamentos. Sampieri, Collado e Lucio (2013), falam que o ponto central da pesquisa qualitativa é conseguir entender e se aprofundar nos fatos e assim se tenha uma melhor perspectiva de tudo que acontece no ambiente natural e o que gira em torno de seu contexto. O relativo trabalho se embasou em fontes bibliográficas que inclui livros, monografias e artigos encontrados tanto expresso como em plataformas digitais. Gil (2022, p. 44) salienta que a vantagem de se utilizar da pesquisa bibliográfica “está no fato de permitir ao investigador a cobertura de uma gama de fenômenos muito mais ampla do que aquela que poderia pesquisar diretamente.”

## II. GESTÃO DE PESSOAS

A concepção de sucesso de uma empresa em um mercado globalizado, em que se caracteriza como época da informação e do labor intelectual, a gestão de pessoas tem se tornado fator determinante para as organizações na obtenção deste objetivo. Sob essa afirmativa, Gil (2016), reforça isso quando assegura que o sucesso das organizações são as pessoas e que a gestão de pessoas passou a ganhar destaque por possuir papel fundamental para que se possa alcançar os objetivos almejados de todos os setores da organização.

Desta forma, gestão de pessoas são as diretrizes políticas e conjunto de práticas que permitem o alinhamento de entendimento e expectativas entre a organização e seus colaboradores para que juntos possam concretizá-las ao longo do tempo (DUTRA; DUTRA & DUTRA, 2017).

Inserido dentro desse contexto, Sentanin (2004), expõem que é de suma importância que a organização trabalhe a compreensão dos colaboradores sobre o trabalho em equipe, alcançando mudança de cultura de todos os envolvidos, como também os gestores. Importante destacar que ter flexibilidade, rápida adaptação



às constantes as mudanças do mercado e granjear a lealdade dos colaboradores, desponta como fator contundente nos tempos atuais para as empresas.

Para Silva e Pinho (2021), é notório que a inserção entre a gestão de pessoas e os objetivos da organização não é um processo simplificado e explícito de atingir, antes é abstruso, diligente e participativo e está estreitamente ligado aos vínculos e pecúlios de todos que tenham interesse pela organização, principalmente os próprios colaboradores. Portanto, torna-se imprescindível a construção de vínculos de confiança, constituído através de ações sólidas e estruturadas envolvendo todos os departamentos da organização.

Seguindo o mesmo entendimento, Dutra, Dutra e Dutra (2017) contextualiza que a união entre a política e a prática de ações, que permitam harmonizar os interesses entre a organização e os colaboradores isso no decorrer do tempo, é o que caracteriza a gestão de pessoas, pois não importa o tamanho da empresa, o capital humano assume fator determinante para o seu sucesso.

Sob essa afirmativa, Ribeiro (2017) corrobora ao dizer que quando a organização consegue enxergar seus funcionários como cooperadores deixando de ser somente um recurso, estes deixam de ser passivos e assumem papel ativo, gerando decisões e ações inovadoras dentro da organização.

Dentro dessa visão, Silva e Pinho (2021) asseguram que a construção de uma administração eficiente de colaboradores, visando alcançar competitividade para a organização, tem como ponto de partida a prerrogativa de que as políticas e as práticas de ações andem juntas com as diretivas estratégicas da própria organização.

Essa visão é assegurada por Oliveira e Oliveira (2011), ao mencionar que, os membros quando estimulados e dispostos com as diretrizes organizacionais, tornam-se ativos mais vultuosos para a organização no cenário atual de mercado. Sob essa perspectiva, as políticas e as práticas de gestão de pessoas tornaram-se um diferencial competitivo, tornando-se um investimento para a empresa.

Tendo como diferencial competitivo nas organizações, a gestão de pessoas muda o conceito obsoleto e restrito de que as pessoas são apenas números assimilados com setores como financeiro ou materiais. Para Gil (2016), essa concepção muda dentro do contexto atual e as pessoas passam a ser parceiras, colaboradores, fomentando a organização com seu capital intelectual, destacando suas habilidades, saberes e entendimento.

Dada a importância das pessoas dentro das organizações, a gestão de pessoas consiste num sistema aberto e comunicativo, no sentido de integralizar várias atividades, com o objetivo em resultados comuns, tanto para a empresa quanto para seus colaboradores. É o que afirma Demo (2012), expressando que a gestão de pessoas e sua gestão, alinhado com as práticas de gestão de pessoas produzem resultados importantes, assumindo assim papel estratégico nas organizações.

A gestão estratégica de pessoas, torna-se relevante para a sobrevivência da organização, pois concede a mesma um norte para o desenvolvimento de um protótipo de aptidões, a fim de prever mudanças e abordar dúvidas futuras pela identificação de processos com o objetivo de alcançar os objetivos da organização.

Dentro desse contexto, a concepção de que reter tecnologia e informação não é mais decisivo para o sucesso da empresa, se faz necessário que a mesma leve em consideração seus ativos impalpáveis, neste caso o intelecto e habilidades individuais e profissionais de cada colaborador (MARRAS, 2016).

Seguindo essa premissa, a gestão estratégica de pessoas pode aprimorar o planejamento, organização, desenvolvimento, coordenação e controle de métodos para que se possa elevar o dinamismo dos colaboradores como vantagem competitiva (CARVALHO; SILVA, 2017).

Assim a gestão estratégica de pessoas dentro das organizações, assume o papel de prover táticas organizacionais, sempre com o objetivo de promover o capital intelectual, nivelando com os interesses econômicos da empresa, contribuindo com isso a consolidação da empresa no mercado global e conseguindo, ao mesmo tempo, equiparar os interesses dos colaboradores com os da organização.

### III. ENDOMARKETING

Com a acirrada competitividade no cenário atual de mercado, é notório que as organizações busquem meios alternativos para que possam se diferenciar umas das outras ganhando destaque e conseqüentemente rentabilidade.

Como definição do termo endomarketing, Almeida & Avanzi (2019) expõem que são ações e meios utilizados pelo marketing tradicional, mas agora direcionados exclusivamente para os colaboradores internos, a fim de promover a consolidação da marca no sentido reverso - de dentro para fora.

Neste contexto, o Endomarketing enfatiza que, tão importante quanto o cliente externo, é o cliente interno e é imprescindível que este também seja alcançado e

valorizado pela organização. França (2013, p. 133), explica que:

O Endomarketing gera melhoria da produtividade, da relação interpessoal, do que precisa acontecer em todos os setores, da saúde física e mental das pessoas envolvidas, fato consequente à saúde da empresa. Por essa razão, o fluxo de informação deve ser constante e transparente.

Dando prosseguimento, quando a organização entende as necessidades do seu colaborador - cliente interno - vislumbra o objetivo do marketing - fidelização do seu cliente - mas, no caso internamente. De forma simples e objetiva, o endomarketing é vender a imagem da organização - identidade e propósito - aos seus clientes internos (ROSA; RIBAS; ALVES, 2008). Se as crenças forem bem recebidas internamente, terá reflexo direto no público externo.

Nesta visão, o objetivo do endomarketing é que, através de seus colaboradores a empresa possa representar suas crenças aos clientes externos. Brum (2017), fala que o endomarketing tem por objetivo: gerar um entendimento organizacional para as estratégias de sua cultura organizacional dentro da própria organização e também tem o objetivo de promover como facilitador o próprio colaborador, para que assim personalize a imagem de uma empresa consolidada e com valor de mercado.

Sobre as características do endomarketing, Minadeo (2008), destaca:

- a) Acessibilidade e coerência a comunicação interna;
- b) Tornar cientes a todos os objetivos da empresa;
- c) Granjear, cativar, capacitar e reter novos talentos reduzindo assim os índices de turnover dentro da organização;
- d) Propagar um ambiente favorável para exposição de ideias pelos colaboradores;
- e) Promover melhoria de qualidade nos produtos e serviços disponibilizados através do acréscimo da operosidade dos colaboradores e melhoria dos processos, sob a conscientização da importância do termo “cliente” dentro da organização.

É conveniente salientar que, o endomarketing deve alcançar desde o nível operacional, passando pelo

tático e culminando no estratégico da empresa, pois o objetivo do endomarketing é apresentar a todos os colaboradores - dentro de todos os níveis hierárquicos - o entendimento dos valores desempenhados através do trabalho em equipe (BEKIN, 2003).

Essa ideia é reforçada por Silva e Bastos (2021), quando afirma que a visão do endomarketing é despertar nos gestores a busca por meios técnicos para a integralização de seus colaboradores nos processos de gestão da empresa. O endomarketing busca dar ouvidos aos colaboradores, contribuindo assim para condições sólidas de trabalho e transparência de gestão, consolidando uma relação de confiança e autenticidade dos cooperadores com a organização.

Partindo dessa premissa, o endomarketing é uma simbiose entre a organização e os colaboradores, com enfoque no fortalecimento e apoio da comunicação interna tornando-a eficaz e eficiente, alcançando assim o mercado externo.

#### IV. COMUNICAÇÃO INTERNA E A RELAÇÃO COM O ENDOMARKETING

A Comunicação torna-se algo relevante para se chegar à eficiência, quando a organização toma para si essa responsabilidade, alinhando com isso confiabilidade ao seu canal de comunicação. Quando bem alinhada e quando os propósitos e os valores organizacionais são compartilhados, o grau de motivação e satisfação dos colaboradores internos se eleva, refletindo diretamente na maneira como seus clientes externos são tratados.

A comunicação interna tem a função de administrar o fluxo das informações, com o intuito de alcançar os objetivos da organização (BRUM, 2017). Assim, toda ação que seja direcionada para atingir os objetivos idealizados pela organização, expressa o significado de comunicação interna.

Ainda citando, Silva e Bastos (2021) enfatiza que nos processos de tomada de decisões, a comunicação auxilia como instrumento facilitador, tratando diretamente no modo de agir dos colaboradores, deixando claro como deve ser feito, avaliando como está a conduta do mesmo e, principalmente tornando todos ciente do que deve ser feito para melhorar.

Segundo Tavares (2009), o diálogo e o estímulo são duas perspectivas do endomarketing - marketing interno voltado para o cliente mais próximo da organização: o seu colaborador. Ele continua dizendo que os processos de comunicação e motivação devem ser contínuos e planejados, com ações que sejam integradas ao

longo de todo o ano operacional da organização e não apenas de forma circunstancial.

Sob essa perspectiva em relação com a comunicação interna nas organizações, esta contribui para a idealização e consolidação da mesma - sua identidade como empresa - contribui para o bom relacionamento dos diferentes níveis hierárquicos e promove harmonização dentro do ambiente de trabalho, isto claro, quando contínua e planejada (POLLI, 2015).

Visando alcançar os objetivos da organização, a comunicação interna é um norte, que tem como objetivo mostrar como gerir o fluxo da informação dentro da empresa, assim define (Brum, 2017). O endomarketing estabelece essa comunicação interna de forma visível e palpável através de cores, formas e frases, tornando-se assim extremamente relevante para a empresa.

Portanto, se a comunicação interna for bem feita e bem sucedida, torna-se um fator de máxima importância para aperfeiçoar a informação, tornando-a linguagem universal na organização, unificando e promovendo a inclusão dos colaboradores, contribuindo de forma direta para a solidificação da imagem da organização.

## V. A CONTRIBUIÇÃO DO ENDOMARKETING PARA A MOTIVAÇÃO DOS COLABORADORES

As ações envolvendo práticas de Endomarketing nas organizações tem total relevância como ferramenta estratégica, pois agem diretamente como fator motivacional para os colaboradores, promovendo bem estar e encantando os clientes externos.

Quando as expectativas dos colaboradores são correspondidas pela organização dentro do ambiente de trabalho, gera motivação e está diretamente ligado ao endomarketing, pois promove a sensação de felicidade pelo trabalho desenvolvido. Ainda citando Brum (2017), assegura que o sentimento de felicidade reflete diretamente na produtividade dos colaboradores, que em suma é o fundamento do endomarketing.

A concepção de uma organização não se resume apenas a mensuração de valores financeiros, a real existência deve preceder antes de tudo resultados humanos e socioeconômicos dentro da sociedade em que está inserida. Costa (2018), salienta que o endomarketing tem como um dos objetivos a motivação, indo além como meio para se atingir melhores resultados.

Em síntese, colaboradores motivados é o início para o sucesso da organização. Como consequência é a garantia de que toda decisão, seja ela de qualquer grau de complexibilidade, tenha a menor margem de erro possível

e conduza aos interesses distintos da organização (COSTA, 2018).

Sob essa ótica, Feitosa; Santos e Almeida (2016) enfatizam que as políticas de endomarketing devem ser de cunho estratégico da organização, que possam oferecer aos seus colaboradores benefícios que os motivem, despertando o sentimento de que ocupam um papel importante para o sucesso da organização.

Portanto, atuando como fator motivacional para os colaboradores, o endomarketing assume papel importante como ferramenta estratégica dentro da organização, possibilitando o contentamento e satisfação dos clientes internos e externos.

## VI. CONSIDERAÇÕES FINAIS

É importante frisar que a concepção das empresas com os seus colaboradores tem mudado ultimamente, no cenário atual as organizações mudam a visão e passam a refletir melhor sobre os colaboradores desenvolvendo o sentido de preocupação - diga-se assim - com as pessoas. O endomarketing usado como ferramenta estratégica age no sentido de integrar os valores, modificando toda a cultura organizacional da empresa. Com isso, o primeiro passo para se chegar ao êxito, inicia-se quando a organização passa a acreditar que o seu primeiro cliente é o seu colaborador.

Partindo da estrutura aplicada, o endomarketing atua diretamente como ferramenta auxiliar na administração da empresa, objetivando sempre a integração de todo o capital humano com os princípios e valores que norteiam a mesma, despertando nos seus colaboradores o sentimento de empenho, convicção, instigação e cognição, com o intuito de alcançar resultados mensuráveis, consolidando valor econômico e social a marca.

Dentro desse contexto, enfatiza-se que o endomarketing alinhado com a comunicação interna e a motivação atuam - em perfeita simbiose - como ferramentas estratégicas dentro da organização, no sentido de fortalecimento das crenças internas garantindo assim sua sobrevivência. A junção dessas três ferramentas norteia, no sentido de tornar notório o que necessita ser feito para que as pessoas que compõem a mesma se sintam realmente participantes do processo.

Sob a afirmativa, para que a empresa alcance os clientes externos, precisa-se primeiro alcançar os internos - seus colaboradores - afinal são eles que diariamente, vão oferecer os produtos e serviços disponibilizados pela empresa. Clima organizacional melhor, colaboradores motivados proporcionando um ambiente de trabalho

tranquilo, aumento na produtividade e, conseqüentemente qualidade dos produtos e serviços ofertados, são alguns dos resultados obtidos quando a empresa investe no seu cliente interno.

Na elaboração do projeto, fica nítido a percepção que o endomarketing quando usado como ferramenta estratégica na gestão de pessoas, contribui diretamente na comunicação e motivação interna dos colaboradores, pois tem como objetivo primordial priorizar, dando oportunidade de voz e vez dentro da organização, fortalecendo com isso os laços entre empresa e colaborador, fazendo com que partilhem a visão e se empenhem em alcançar os objetivos e metas da organização, ganhando com isso projeção dentro do mercado de trabalho.

Discursando sobre a questão problema que aborda a relação do endomarketing com os fatores motivacionais, constatou-se uma ferramenta primordial na gestão e que pode contribuir, e muito, no desenvolvimento de qualquer organização, pois busca sempre o fortalecimento da relação empresa-colaborador, promovendo o sentimento de pertencimento. Ressalta-se que como toda ação sempre tem uma reação, destaca-se que para que o endomarketing produza motivação, este precisa ser bem planejado, se faz necessário que a organização busque entender, mensurar os pontos fortes e fracos, para que possa planejar ações assertivas com resultados satisfatórios.

Conclui-se que diante do exposto pela pesquisa, a mesma abordou com êxito o tema e almeja-se que novas pesquisas sejam realizadas, para que se possa cada vez mais aprofunda-se e com isso promover entendimentos mais abrangente sobre o endomarketing, assunto hoje de extrema relevância para as empresas que buscam se destacar no mercado.

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## Impact of seawater and canopy cover on the phyllosphere bacterial community of *Rhizophora mucronata* leaves

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Received: 01 Jul 2022,

Received in revised form: 26 Jul 2022,

Accepted: 30 July 2022,

Available online: 09 Aug 2022

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**Keywords—** Leaves phyllosphere, Mangroves, Leaf-wax, Seawater, Canopy cover, Bacterial composition

**Abstract—** The plant-microorganism interaction is a well-studied topic in the world of science due to the sustainable management of the ecosystems. The phyllosphere remains the habitat of some microorganisms where several interactions take place. In order to assess whether the mangrove leaves can harbor a bacterial population and analyze the abundance in these leaves microbiotas, leaf samples of mangroves species (*Rhizophora mucronata*) were collected in the mangroves of Ouroveni in East-Mbandjini, Grande-Comoros. Through the 16S rRNA genes sequencing, the results showed that in the different experimental group, 105303, 110873, 124703, 146954 and 112225 OTUs were identified respectively, where the canopy was open (C1), semi-open (C2), completely closed (C3), and where the plants are submerged (S) and non-submerged (NS) in seawater. The identified OTUs was positively correlated with leaves-wax ( $p < 0.05$ ,  $r^2 = 0.91$ ), nitrogen ( $r^2 = 0.72$ ), phosphorus content ( $r^2 = 0.62$ ) and the factor "seawater" ( $r^2 = 0.93$ ). It was however highly and negatively correlated with the canopy cover ( $r^2 = 0.93$ ). Considering the factor "seawater", the relative abundance of bacteria in the submerged leaves was significantly higher compared to that from the non-submerged plants. By taking into account the factor "canopy cover", it was revealed that more the canopy cover was open, the less was the relative abundance of bacteria. Thus, the finding of this present study affirm that the leaves of mangroves can be a major habitat to host a large population of bacteria that can be influenced by local abiotic factor.

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## I. INTRODUCTION

The symbiotic relationship between plants and microorganisms is an interesting studied subject in the world of science. They can cohabit together in such a way that each of these two hetero-specific organisms benefit from this association. Until these several years, the research were mainly focused on microorganisms and their relationships with their host plants (Fatima and Senthil-Kumar 2015; Fester et al. 2014). However, several reports showed that different parts zone of plant host can harbor microorganisms which can be used for different scientific need. We distinguished therefore, phyllosphere, the endosphere and the rhizosphere which are considered as a habitat for microorganisms. The phyllosphere is the aerial part of plants mainly the leaf surface, which is an environment largely inhabited by microorganisms (Koskella 2020), while the rhizosphere is the part of the soil penetrated by plant roots and associated microorganisms (Liu et al. 2020). Studies by the rhizosphere are much more advanced compared to that of the phyllosphere. However, quite a large number of the phyllosphere reports are reported recently due to the massive production of data resulting from the use of omics and related technique. This enhanced a significant advance in the understanding of microbial dynamics in the aerial organs of plants, mainly in the leaves.

The community of microorganisms living both on the surfaces of plant organs (phylloplane) or inside plant tissues (endosphere), is composed by bacteria, viruses, fungi, algae, archaea and rarely by protozoa and nematodes (Vacher et al. 2016). The phyllosphere designates the community of microorganisms that live in a symbiotic relationship with plants, in particular on leaves, stems, buds and flowers. It is a complex and relatively unknown world of microbes interacting with each other and with host plants, especially with aerial organs. Nowadays, scientific studies are looking at this new world for a better understanding of this new subject (Lindow and Brandl 2003) and for other interests such as phylloremediation (Wei et al. 2017), pest control (Tripathi et al. 2020), invasion of pathogenic microorganisms on plants in general and leaves in particular (Wang et al. 2019), services for agriculture (Zhang et al. 2019), forestry, etc.

The microbiota of the phyllosphere can be translated to the overall microbial habitat potentially influencing the fitness and functions of their host; which would have an impact on plant biogeography and ecosystem functioning (Yuan et al. 2018). Following this consensus, the microbiota phyllosphere of several plant species, including economically important crop plants, has been explored for

their agro alimentary functions. It is now well documented that phyllosphere microbial consortia regulate many plants that have a vital role in plant health as well as plant production (Yuan et al. 2018). Due to their agricultural potential, the phyllosphere microbiota serves as an imperative alternative to chemical fertilizers, which not only facilitate crops to thrive in poor-resource and stressful environments, but also provide resistance to combat dangerous pathogens without disrupt the essential ecosystem balance (Weyens et al. 2015).

Recent advanced development in molecular tools, high-throughput screening procedures and fusion of omics techniques has greatly improved the understanding of bacterial communities associated with phyllosphere including their structural, functional and ecological properties. Among the phyllosphere microorganisms living on the leaf surface, bacteria is far outnumber other epiphyte groups, both in cell numbers and in diversity of taxonomic groups (Zada et al. 2021). After the soil, the phyllosphere ranks second as the habitat containing the greatest concentration of microorganisms on earth. Indeed, the leaf area of terrestrial plants is estimated at more than  $6.4 \times 10^8 \text{ Km}^2$  (Izuno et al. 2016). Given that the bacterial density on the leaf surface reaches  $10^6$ - $10^7$  cells per  $\text{cm}^2$  (Zhang et al. 2019), the phyllosphere remains an indisputable habitat for different types of microorganisms.

Our present study joins recent efforts to highlight the beneficial plant-microbe interaction in nature with particular reference to phyllosphere microbiota which can be used in the agricultural, or ecotoxicological sector to respectively boost global food security in conjunction with maintaining environmental sustainability. However, most studies on the microbe-plant relationship focus on terrestrial plants and little research is carried out on the marine domain and more particularly on mangroves. Given their particular ecology and the variable environmental conditions faced by these plants of the intertidal zone, it is obvious that these plants could constitute an exceptional habitat for phyllosphere microorganisms and bacteria in particular. This study aims to (i) highlight that the leaves of mangroves (*Rhizophora mucronata*) can host a large population of bacteria, (ii) analyze the abundance of bacteria in the leaves of *Rhizophora mucronata* taking into account different factors such as canopy cover and the seawater and (iii) express a correlation between leaf nutrients and the relative abundance of the bacterial population present on the leaves of *R. mucronate*.

## II. MATERIALS AND METHOD

### 1- Design and collection of samples

The leaves of the mangrove species (*Rizophora mucronata*) were collected in the intertidal zone of Ouroveni in East-Mbandjini, Grande-Comoros (longitude: 11°54'45 S, latitude: 43°41'08 E and altitude: 0 m). Leaves samples were collected by considering the canopy cover state and seawater as separate factors. Considering the canopy factor, three sampling zones were established: zone 1 corresponding to the canopy fully open (0-10%) and denoted C1; zone 2 corresponding to the semi open/close of the canopy (50-70%) and denoted C2 and zone 3 corresponding to the canopy fully close (100%) denoted C3. The percentage of the canopy was estimated by using a densiometer at a fixed point and rotating through the four cardinal points. The canopy percentage was then calculated according to occupied small square, as was described in (Elyamine 2012). In each branch where leaves were collected, we considered three levels which were basal denoted Ci-1, medium (Ci-2) and apical denoted Ci-3 where i can be 1, 2 or 3 accordingly. In addition to the canopy factor, plants submerged and not submerged in seawater were also considered. Leaves were collected with sterilized scissors with 70% ethanol on site. Twenty seven healthy green and mature leaves were collected for each mangrove zone at 1.5-2 m height. They were then sealed in a sterile 500 mL PVC bags and brought to the laboratory. After collect, leaves samples were divided into two groups; the first one was used for bacterial experimental purposes and the second one for the determination of leaves characteristics. An empty bag without leaves was considered as control denoted CR.

### 2- Determination of leaves characteristics

A party of mangroves species leaves were used to determine leaves surface area. Graph paper was used to draw the outer shape of leaf and calculate the surface area in square meters as was reported in (Pandey and Singh 2011). Others characteristics were determined in the laboratory of environmental microbiology at Shantou University, Guangdong, China. Leaves water and wax contents were expressed as the percentage of fresh weight and determined as was described in (Waight et al. 2007). Briefly, to determine leaf water content, the leaves samples were weighed (4 g) and dried for 24 h at 105°C in an oven. Thereafter, the dried sample was cooled in a desiccator and weighed. The percentage of leaf water content was calculated by using the following equation (1). The same weight of sample (4 g) was weighted and used to extract wax content with 20 mL hexane in a microwave extractor. The GF/C filter was used to filter the extract into a round bottom drying flask. The total was pre-weighed before

drying by rotary evaporator. After drying, the round-bottomed flask was reweighed and the percentage of wax was calculated by using the following equation (2). Nitrogen (N) and phosphorus (P) contents were analyzed by using respectively, Kjeldahl method and double digestion with H<sub>2</sub>SO<sub>4</sub> and perchloric acid method.

$$\text{Leaf water content (\%)} = \frac{\text{fresh weight} - \text{dried weight}}{\text{sample weight}} * 100 \text{ eq (1)}$$

$$\text{Leaf - wax (\%)} = \frac{\text{reweight flask} - \text{preweight flash}}{\text{sample weight}} * 100 \text{ eq (2)}$$

### 3- Leaves phyllosphere bacteria extraction

In laboratory, the samples were used to extract phyllosphere bacteria in the leaves surfaces. Leaves were transferred in sterile 500 mL Erlenmeyer where was already added autoclaved water, to suspend the leaves phyllosphere bacteria extract. The sample was alternately manually shaken, four times in total. The leaves were then removed and the solution was used as the phyllosphere bacteria extract.

### 4- DNA Extraction and amplification

Total genomic DNA of the different sample was extracted using an Ultra-Clean Microbial DNA Isolation Kit (MoBio Laboratories, Carlsbad, CA, USA). Polymerase Chain Reaction (PCR) amplification of the 16S rRNA genes from the V3-V4 region of each sample was conducted by using the universal primers, 338F (5'-ACTCCTACGGGAGGCAGCAG-3') and 806R (5'-GGACTACHVGGGTWTCTAAT-3') as was described in (Huang et al. 2014). The extracted DNA was sent to Sangon Biotec Institute (SBI) platform at Shanghai, China, to be sequenced. DNA concentrations and purity were measured using a NanoDrop 2000 spectrophotometer (Thermo Fisher Scientific, USA).

### 5- Computational analysis

The de-duplication and filter-qualification of the raw fastq files, sequences classification, annotation and beta diversity distance calculation were performed by using Quantitative Insights Into Microbial Ecology (QIIME Version 1.9). UPARSE software (version 7.0.1001) was used to group the filtered sequences OTUs clustered with a 97% similarity cutoff. At 97% of confidence threshold, the taxonomy of each 16S rRNA gene sequence was analyzed using 16S rRNA database and the RDP Classifier (version 2.11). Different functional genes composition of bacterial community was determined by using PICRUST.

### 6- Statistical Analysis

Data were subjected to statistical analysis of variance (ANOVA) in SPSS (20) software. Differences between



means and multiples stepwise were performed using the appropriate post-hoc with a 95% confidence level. ANOSIM was used to evaluate similarities among different experimental group. The Shannon index was calculated to describe  $\alpha$  diversity and the richness of microbiota. Different graphs were performed by using SigmaPlot and Origin pro.

### III. RESULTS

#### 1- Leaves characteristics

Leaf area, water content, leaf wax content and nutrients such as nitrogen and phosphorus were determined in leaves of *R. mucronata* species and plotted on the Table 1. Statistical results of leaf area in different collection areas show no significant difference. However, although no difference was observed, the leaves collected from the plants submerged in seawater (S1, S2 and S3) had a slightly reduced surface area.

The leaves water content of this mangrove species was also measured. It was observed that the water content in the leaves of submerged plants (S1, S2 and S3) was significantly higher compared to that in the leaves of non-submerged plants (NS1, NS2 and NS3).

The leaves of the plants collected from the different plants showed a significant difference in wax content. Leaf-wax content in non-submerged plants (NS1, NS2, and NS3) was higher compared to that in leaves of plants from submerged ones. Therefore, the order of leaf-wax content was arranged as follows: Ci<S<NS.

The nitrogen content in the green leaves of different mangrove plants was also determined. The leaf N content of non-submerged plants (NS1, NS2, and NS3) was significantly higher than that of submerged plants (S1, S2, and S3). Additionally, considering the canopy cover, the leaves collected in the zone where the canopy was totally closed (C3), the N content was more considerable compared to that in the leaves in the other two zones (C1 and C2).

The phosphorus content of the leaves of the plants collected in the different zones was also measured. The P content in leaves of non-submerged mangrove plants (NS1, NS2, and NS3) was slightly higher than that of submerged plants. The order of P content in the leaves of different mangrove plants was as follows: Ci<S<NS.

Table.1: leaves characteristics including the surface, water, wax, nitrogen and phosphorus content

Group experimental	Leaves Surface (cm <sup>2</sup> )	Water content (%)	Wax contents (%)	Nitrogen (mg/Kg)	Phosphorus (mg/Kg)
C1	24.76 ± 9.5	26.85 ± 3.8	17.36 ± 4.3	0.95 ± 0.3	0.08 ± 0.2
C2	28.04 ± 7.6	29.67 ± 2.4	14.75 ± 7.2	0.99 ± 1.2	0.07 ± 0.6
C3	29.54 ± 5.3	28.68 ± 2.7	16.45 ± 6.6	1.05 ± 1.2	0.05 ± 1.4
S1	27.66 ± 4.5	39.65 ± 4.2	17.56 ± 4.4	1.86 ± 0.4	0.11 ± 1.1
S2	25.25 ± 8.2	41.85 ± 7.2	15.65 ± 7.2	1.67 ± 2.6	0.10 ± 0.3
S3	24.77 ± 6.5	43.12 ± 7.4	16.46 ± 4.1	1.98 ± 1.5	0.13 ± 1.7
NS1	28.98 ± 6.4	27.76 ± 4.1	22.87 ± 5.6	2.98 ± 0.3	0.29 ± 0.6
NS2	27.46 ± 8.9	27.78 ± 8.5	22.98 ± 4.3	2.65 ± 0.3	0.19 ± 0.7
NS3	27.23 ± 8.7	26.75 ± 4.4	21.98 ± 4.5	2.34 ± 2.2	0.29 ± 0.7

Data are the mean of three replicate ± SD and were compared by Duncan's multiple range tests at  $p < 0.05$ .

#### 2- Bacterial community in the leaves of the species *R. mucronata*

After sequencing the 16S rRNA genes, the number of OTUs identified in the different leaves of mangrove plants was significantly higher compared to those identified in the control (CR1 and CR2). In the different experimental groups, 105303, 110873, 124703, 146954 and 112225 OTUs were identified respectively in the leaves where the canopy was fully open (C1), semi-open/closed (C2), totally

closed (C3), where the plants were submerged in seawater (S) and where the plants were out of the water (NS) (Table 2). The OTUs identified were different in the three different areas, taking into account the canopy cover. The results show that the more the canopy is closed, the more the number of OTU increases. On the other hand, considering seawater as a factor, the number of OTUs identified on the leaves of submerged plants was significantly higher than that identified in non-submerged plants. These results suggest that the number of OTUs in

the phyllosphere depends not only on water availability, but also on canopy cover. The richness estimated by the Shannon and Chao indices showed a slight difference in favor of the presence of seawater (S) and also at canopy

closure (C3). However, no significant difference was noted when comparing the results from the leaves of submerged and non-submerged plants.

Table 2: Different bacterial OTUs and estimated bacterial abundance and diversity alpha indexes in different mangroves species leaves.

Experimental Group	Code bar	Seq_Num	Num- OTUs	Shannon index	Chao index
CR1	TCCGAC	45372	68563	2.06 ± 0.23	356.28 ± 36.33
CR2	AGCTAG	42387	59564	2.02 ± 0.24	346.14 ± 41.33
C1	CTGACG	61408	105303	2.18 ± 0.23	376.18 ± 46.33
C2	CACGAT	78803	110873	3.39 ± 0.67	411.14 ± 30.87
C3	CGCATA	89494	124703	3.48 ± 0.22	445.11 ± 28.42
S1	CGCCAT	91882	148373	4.39 ± 0.24	478.17 ± 32.86
S2	TCTATT	91075	147330	4.34 ± 0.26	467.16 ± 30.59
S3	AGGCGG	91930	145160	4.53 ± 0.45	483.15 ± 34.61
NS1	ATTGTG	73480	111830	3.13 ± 0.47	444.15 ± 37.38
NS2	TATCGA	74961	112982	3.62 ± 0.55	456.13 ± 41.18
NS3	GCCGCT	73712	111863	3.35 ± 0.74	444.15 ± 31.18

Data are the mean of three replicate ± SD and were compared by Duncan's multiple range tests at  $p < 0.05$ . Seq\_Num is the quality number of samples reads and Num-OTUs is the 16S rRNA sequences OTUs obtained by sample clustering and normalized.

### 3- Correlation between different identified OTUs and different factors

Correlation test was performed to assess the possible relationship between different leaves characteristics (leaves surface area, leaves water content, leaf-wax, nitrogen and phosphorus content) and local abiotic environmental factor (canopy cover and seawater) with the abundance of bacteria in the different mangroves leaves (Figure 1). It was revealed that bacterial abundance moderately correlated to plant leaves surface area (Fig 1A,  $r^2 = 0.053$ ). However it showed no correlation with plant leaves water content (Fig 1B,  $r^2 = 0.1795$ ). The identified OTUs in all different mangroves leaves was found to positively correlated with leaf-wax, nitrogen and phosphorus content and the factor seawater (Fig 1C,  $r^2 = 0.904$ , Fig 1D,  $r^2 = 0.72$ , Fig 1E,  $r^2 = 0.62$  and Fig 1F,  $r^2 = 0.93$ ) respectively. On the other hand, the abundance of identified OTUs was negatively correlated with the factor canopy cover (Fig 3G,  $r^2 = 0.93$ ).

## IV. BACTERIAL COMPOSITION ON THE *R. MUCRONATA* LEAVES

### 4.1 Based on class level

The bacterial relative abundance of *R. mucronata* leaves was assessed at the class level (Figure 2). It was shown that in the three experimental groups (Ci, Si and NSi), Gammaproteobacteria was the most dominated class with more than 50% on average of the total bacteria identified. Betaproteobacteria and Bacilli are the next with 23% and 19% respectively. The relative abundance of Proteobacteria in general including Gamma, Alpha and Betaproteobacteria is far the highest with more than 78%. Compared to the control, apart from individuals belonging to the class of Gammaproteobacteria, most of the bacteria identified presented less than 1%.

### 4.2 Based on family level

The relative abundance of bacteria in *R. mucronata* leaves was further assessed at the family level (Figure 3). Enterobacteraceae were the most dominant bacterial family in the leaves of all the collected mangrove plants, whether they were in where the canopy was open (C1), semi-open (C2) or fully closed (C3), or where plants are submerged or not (Si or NSi). Rhodocyclaceae is the

second family identified on the leaves of the species *R. mucronata* with 21%.

**4.3 Based on genus level**

The relative abundance of bacteria in the leaves of *R. mucronata* was finally assessed at the genus level (Figure 4). The genus *Pantoea* was the most abundant in C3-3, S-1, S-3, N-S1, and NS-3 with more than 60% on average and less abundant or even almost absent in CR1, C1-1, C1-2

and C3-1. On the other hand, the genus *Metthyloversalitis* was rather more dominant in CR2, C1-1, C2-2, C3-1 and C3-2. In the experimental groups C1-3, C2-1 and C2-3, more than half of the bacteria belonging to the Enterobacteriaceae family are unclassified.

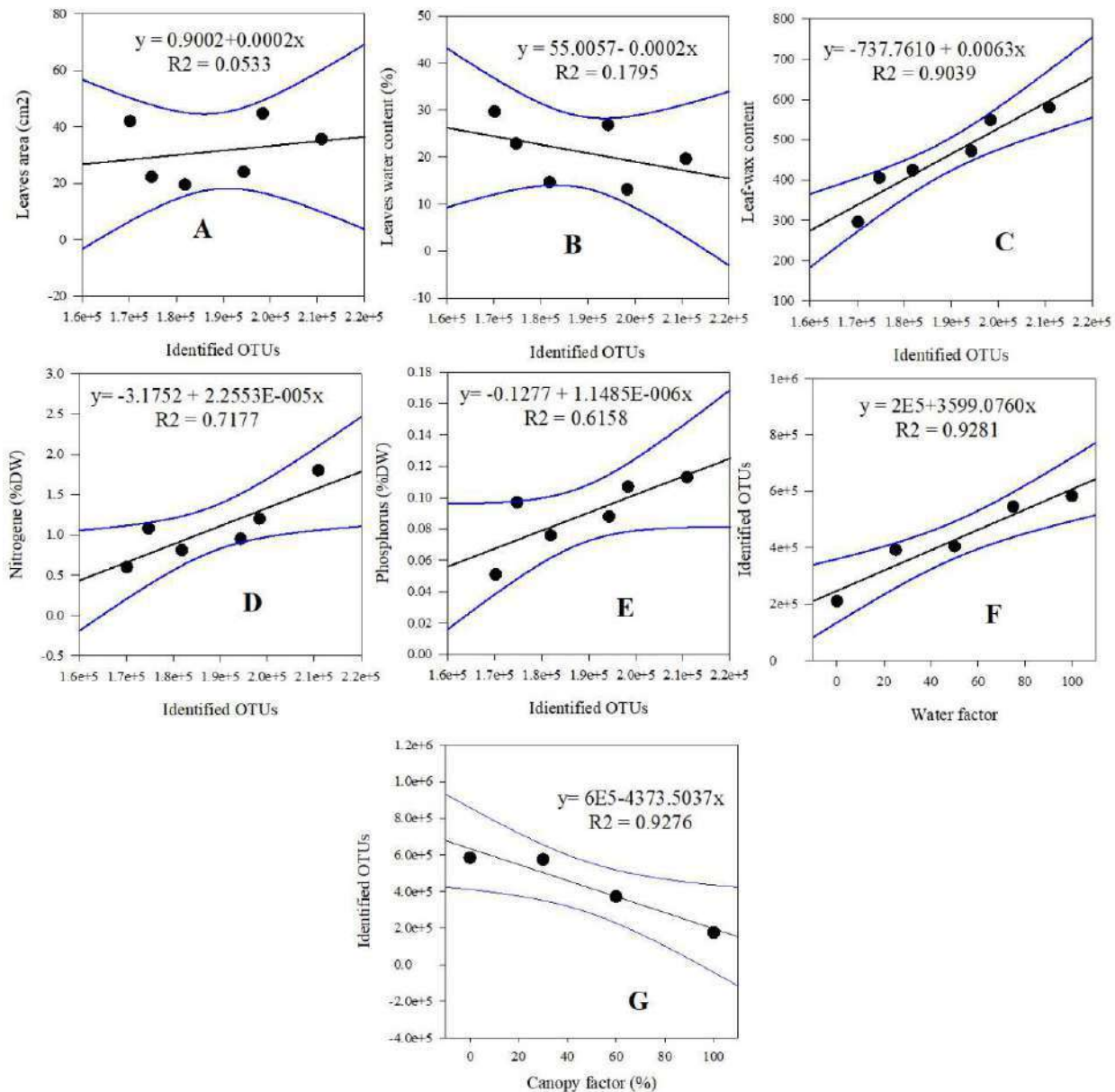


Fig.1 : Correlation between leaves areas (A), leaves water content (B), leaves wax (C), leaves nitrogen (D), phosphorus (E) and local abiotic factors (F and G) with bacterial identified OTUs. Bacterial identified OTUs moderately correlated to plant leaves surface area ( $r^2 = 0.053$ ), showed no correlation with plant leaves water content ( $r^2 = 0.1795$ ), positively correlated with leaf-wax, nitrogen and phosphorus content and the factor seawater ( $r^2 = 0.904$ ,  $r^2 = 0.72$ ,  $r^2 = 0.62$  and  $r^2 = 0.93$ ) respectively and negatively ( $p < 0.05$ ,  $r^2 = 0.93$ ) with the canopy cover factor.

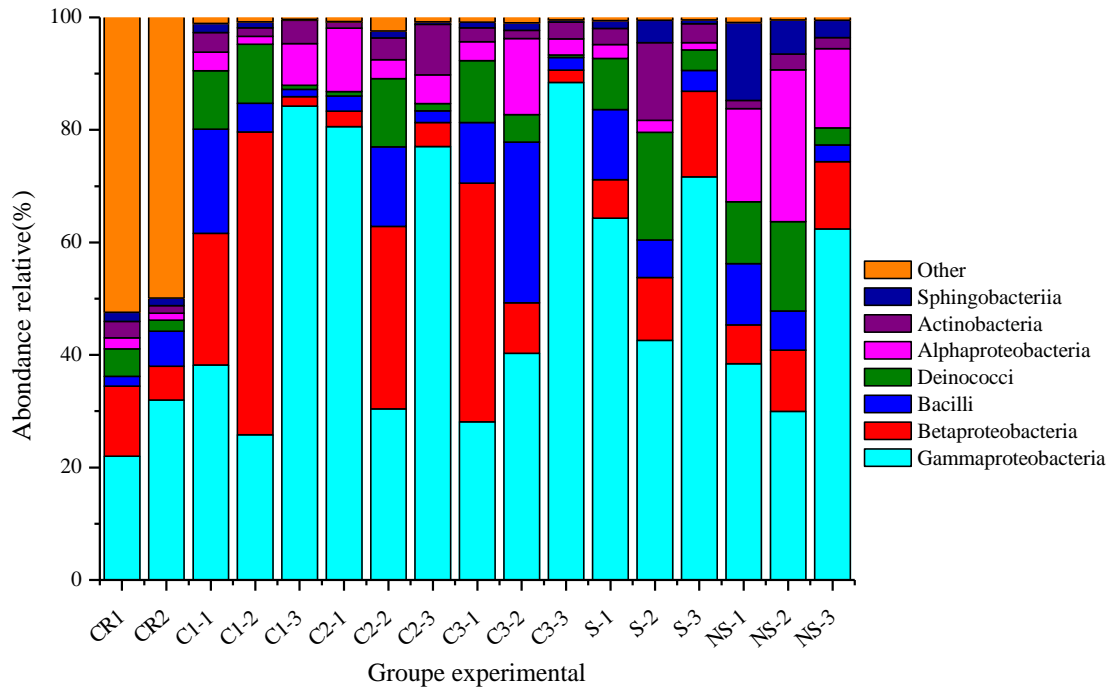


Fig.2 : Bacterial relative abundance at the class level. The horizontal and vertical axis represent respectively the name of each sample and the abundance ratio in three replications. Each color corresponds to the name of the class and at the same time indicates the abundance of the different classes

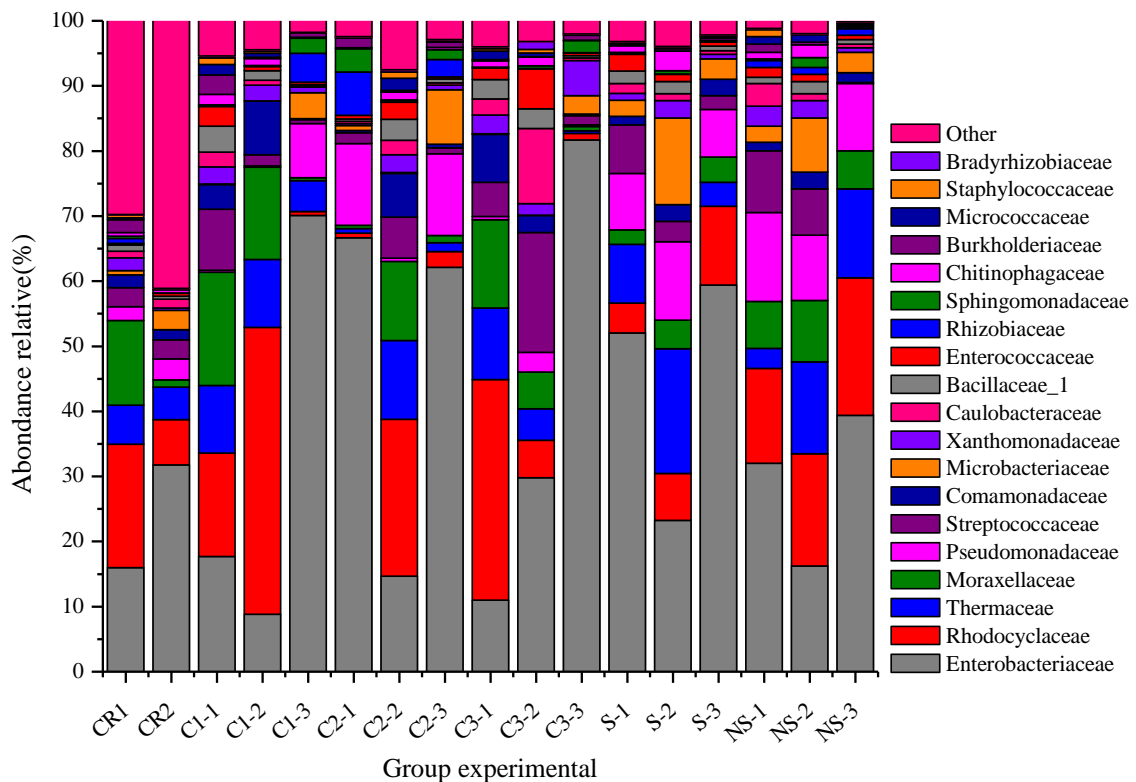


Fig.3: Bacterial relative abundance at the family level. The horizontal and vertical axis represent respectively the name of each sample and the abundance ratio in three replications. Each color corresponds to the name of the class and at the same time indicates the abundance of the different classes.

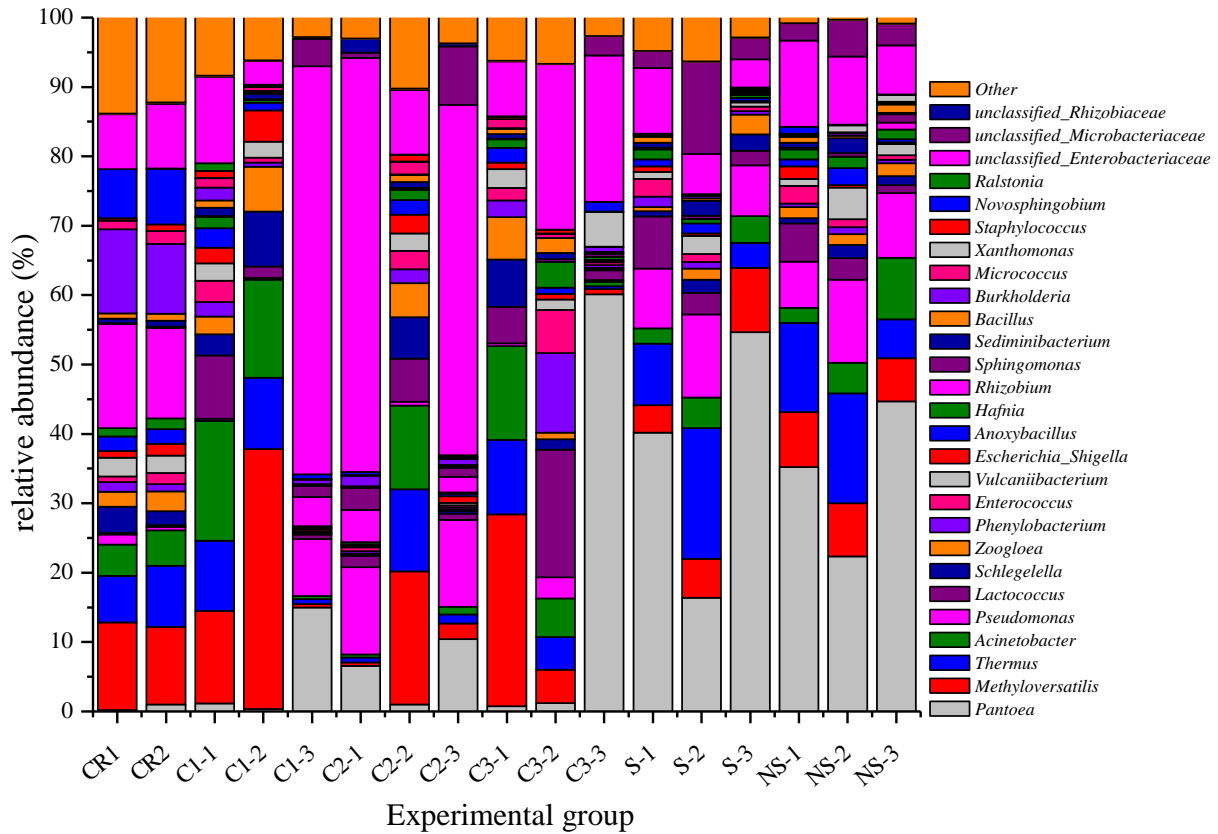


Fig.4 : Bacterial relative abundance at the genus level. The horizontal and vertical axis represent respectively the name of each sample and the abundance ratio in three replications. Each color corresponds to the name of the class and at the same time indicates the abundance of the different classes.

**V. IMPACT OF LOCAL ABIOTIC FACTOR ON R. MUCRONATA LEAVES BACTERIA**

**5.1. Influence of canopy cover**

The relative abundance of bacteria present on *R. mucronata* leaves was assessed at the family level, by considering the factor “canopy cover” (Figure 5). Among the different identified families, it was noted that the more the canopy cover was open, the lower was the relative abundance of bacteria. Enterobacteriaceae are the most dominant with more than 67% of all the identified bacteria in zone C. On the other hand, in comparison with the control, the relative abundance of bacteria in zone C1-1, C2-1 and C3-1 was lower. This supports the results that the relative abundance of bacteria is dependent on the state of the canopy cover.

**5.2. Influence of seawater**

The relative abundance of bacteria present on *R. mucronata* leaves was further evaluated at the family level by considering the factor “seawater” (Figure 6). In general, the results obtained in the different experimental groups (Si and NSi) are important compared to those found in the control. However, the variation in relative abundance of the different bacteria correlated with the factor seawater. The relative abundance of bacteria in leaves collected from submerged plants was significantly higher compared to that in the leaves collected from non-submerged plants. This again supports the fact that the relative abundance of bacteria was dependent on the water factor.

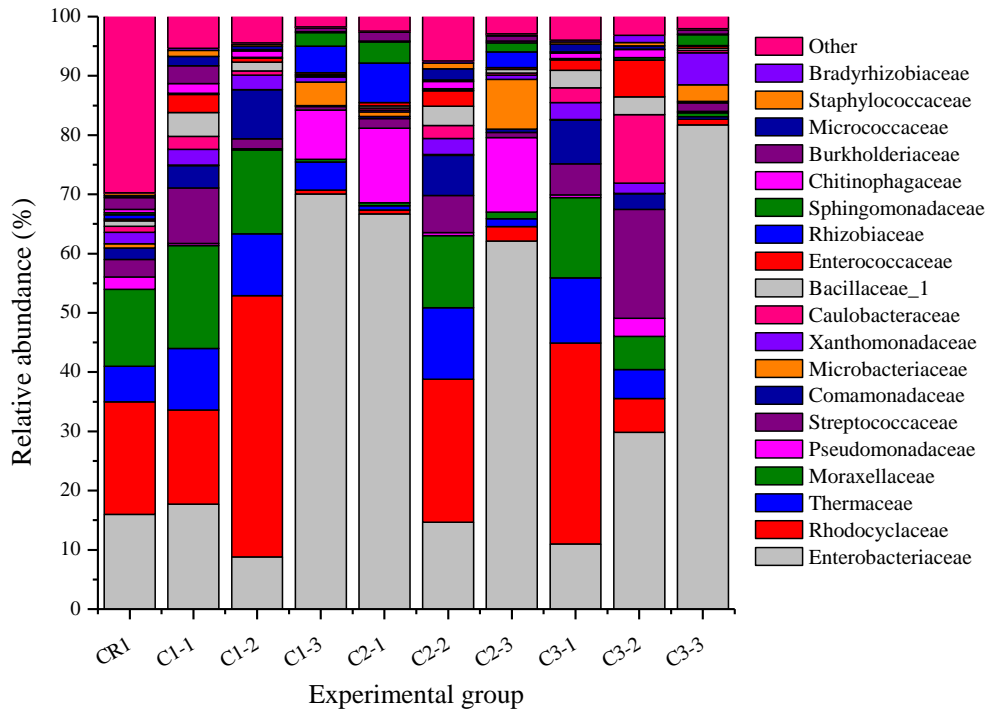


Fig.5: Relative bacterial abundance at the family level taking into account the factor canopy. The horizontal and vertical axis represent respectively the name of each sample and the abundance ratio in three repanditions. Each color corresponds to the name of the class and at the same time indicates the abundance of the different families.

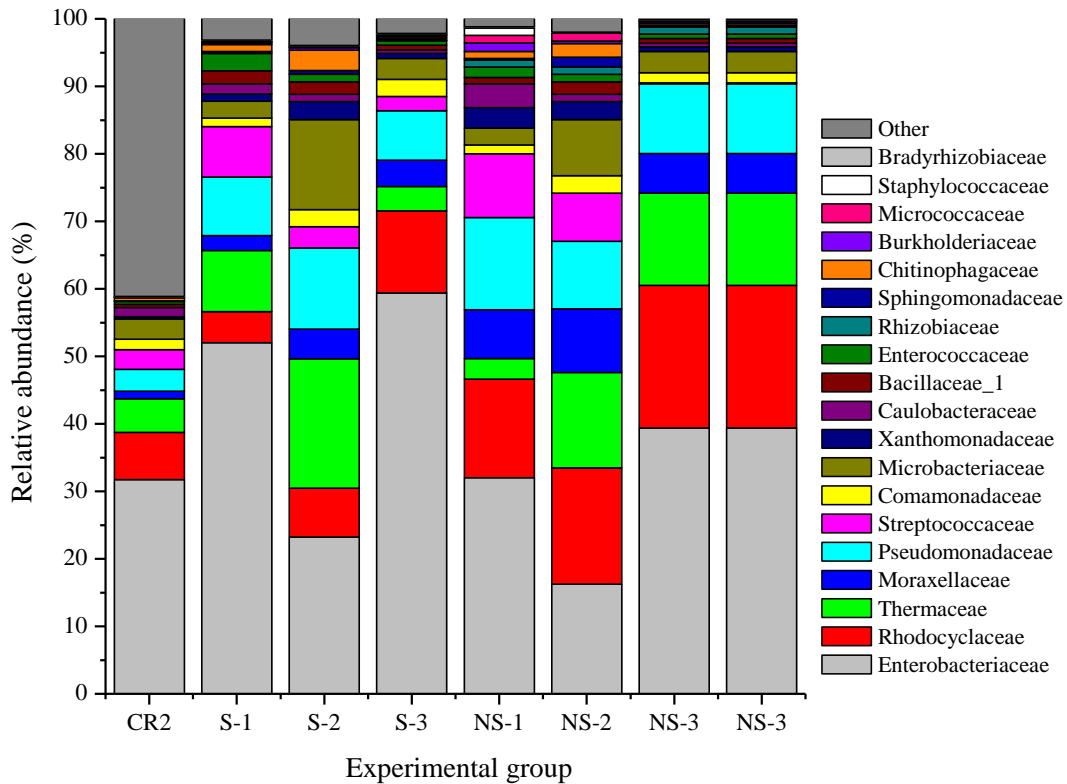


Fig.6: Bacterial relative abundance at the family level taking into account the seawater factor. The horizontal and vertical axis represent respectively the name of each sample and the abundance ratio in three repetitions. Each color corresponds to the name of the class and at the same time indicates the abundance of the different families.

## VI. DISCUSSION

The wax content of the leaves has proven to be a critical parameter not only for the water conservation of the leaves, but also for the dynamism of the bacterial community phyllosphere of plant leaves. Studies have shown that, unlike the presence of trichomes (Reisberg et al. 2012), the composition of the cuticular wax influences the composition of bacterial communities in the phyllosphere (Reisberg et al. 2013; Bodenhausen et al. 2014). The leaf wax content in the different leaves of the species *R. mucronata* was different (Table 1). This result was consistent with that found by (Wang et al. 2008) which reported that the leaf wax content in *Rhizophora stylosa* was important. Leaf wax content was found to be positively correlated with OTUs identified. The leaves of plants, as organs is constantly exposed to pressures environmental, and exhibit several adaptive characteristics, such as the production of varieties of primary and secondary metabolites, among which are the constituents of the epicuticular wax that lines the leaf surface (Barthlott et al. 1998). These complex compounds consisting of long-chain aliphatic and cyclic components, including hydrocarbons, alcohols, aldehydes, flavonoids, etc., coat the outer surface of the epidermis of all the leaves of higher plants (Medina et al. 2006; Kunst and Samuels 2009) and plays an important role in the restriction of cuticular transpiration.

Water is an incontestable living factor for all organisms (animals, plants and microorganism). Its absence could not only impact plant viability, but also affect the microbial community on plant leaves. Naturally, plants exposed to permanent water conditions exhibit low quantity of epicuticular wax than those in drought conditions (Oliveira et al. 2003; Cordeiro et al. 2011). This could explain the difference in the results observed among submerged and non-submerged mangrove species. The amount and distribution of water on the leaf is another highly dynamics of the foliar microclimate which greatly influences the development of micro organizations (Morris 2001). (Yadav et al. 2005) showed that leaf water content is the main factor in the abundance of phyllosphere bacteria in trees and shrubs Mediterranean, followed by leaf phosphorus content. The water content of the leaves of submerged mangroves was significantly higher than that of non-submerged mangroves (Table 1). Naturally, water in the leaves favors chemical reactions between the compounds dissolved in rain or dew water and those that escape from leaf. These reactions in turn have an effect on the microorganisms of the phyllosphere by altering water pH and nutrient availability (Morris 2001).

The results of the nitrogen and phosphorus content of the leaves were in agreement with that found by (Kembel and Mueller 2014) which reported that nutrients such as N and P influence bacterial community structure in tropical trees. Besides the nutrients on the mangroves leaves, it was found that the canopy cover was negatively correlated with the identified OTUs. Indeed, the greater was open the canopy cover, the lower the relative abundance of the identified bacteria was. Studies have shown that the environmental factors can alter the size and structure of communities in the phyllosphere in several ways, including environmental events such as rain (Vorholt 2012), the host plants and canopy cover (Khondoker et al. 2020). Studies by (Truchado et al. 2019; Aydogan et al. 2018) have shown as environmental factors such as temperature and solar radiation (prevent or promote canopy cover) have been implicated in the modification of the microbial community.

The correlation test revealed that the abundance of identified OTUs was not correlated with the surface of plant leaves. As a reminder, mangroves are halophilic plants i.e. that resist and thrive in saline conditions. The leaves of the mangroves are therefore known to secrete salt through salt glands located at their base. Studies on mangroves have shown a high accumulation of salt on their leaves, linked to the ability of the plant to resist salinity (Dias et al. 2012; Clough 1984). Although we know nothing about the effects of salt accumulation in the leaves on the microbial communities of the phyllosphere, due to salt exudation, it can be easily to imagine an impact negative on the whole microbial community. However, the non-correlation of the abundance of OTUs identified with leaf area suggested that the relationship between microorganisms and mangrove leaves could have another factor besides saline exudation and the adhesion surface which are considered to be contributors to the survival of the phyllosphere, as a means of dispersal (Grinberg et al. 2019).

## VII. CONCLUSION

The present study showed that the leaves of the mangroves (*Rhizophora mucronata*) constitute a special environment capable of hosting a diverse bacterial community. The analysis of bacteria abundance and composition revealed that factors which influenced diversity and abundance of the different microbial taxa included the local abiotic environment to which the plant and its leaves are exposed, the nutrients and characteristics of the leaves. However, although much information has been obtained from individual studies on the plant microbiome, the present study suggest that meta-analyses controlling and others different methodologies are needed

to better understand the leaf-microbe associations of mangroves and whether they are suitable for particular beneficial effects.

### ACKNOWLEDGMENTS

The authors gratefully acknowledge the laboratory of environmental microbiology of Shantou University for their remarkable support.

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# Polycyclic Aromatic Hydrocarbons Effect on the phyllosphere bacterial community of *Gliricidia sepium* leaves

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Received: 02 Jul 2022,

Received in revised form: 25 Jul 2022,

Accepted: 31 July 2022,

Available online: 09 Aug 2022

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**Keywords—** *Phyllosphere bacteria, Road Traffic, Polycyclic Aromatic Hydrocarbon, Gliricidia sepium leaves, Bacterial taxa.*

**Abstract—** *Plants and microorganisms can coexist in such a way that each of these two heterospecific organisms benefit from this association. In the environment of plants there are several habitats of bacteria among them the phyllosphere which is the aerial part of the plant. The phyllosphere can be influenced by several factors including hydrocarbons. Thus, polycyclic aromatic hydrocarbons (PAHs) have been used to assess their influence on the phyllosphere microorganisms of the leaves of *Gliricidia sepium*. The results showed that the atmospheric concentrations of PAHs are rather high in rural areas. The spatial patterns of atmospheric concentrations of PAHs showed higher concentrations of naphthalene in the two experimental group due to the high road traffic. In the different experimental groups, 93626 and 96954 OTUs were identified in the leaves collected on the road (SR) and out of the road (SH), respectively. In this present study, the leaves harvested on the road which are more exposed to PAHs present a strongly elevated relative abundance of Actinobacteria and Bacilli. It can therefore easily deduce that these bacteria could have developed a kind of resistance to these road PAHs. On the other hand, bacteria belonging to the Alphaproteobacteria class are significantly less represented in this rural area.*

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## I. INTRODUCTION

Plant-microorganism interaction is a very interesting and well-studied subject in the world of science. Plants and microorganisms can cohabit in such a way that each of these two heterospecific organisms benefit from this association. It can be encountered in the environment of plants, several microorganisms such as bacteria, fungi, archaea and protozoa that can live inside, outside the plants or close to the plants roots. Therefore it can be distinguished the rhizosphere which is the zone of the soil close to the plants roots where the microorganisms are concentrated. This region is characterized by its microbial diversity, and in particular its bacterial richness and microscopic fungi (Asemoloye et al. 2017). This zone is the privileged place for exchanges between these microorganisms and plants. The endosphere however, is an internal tissue of any plant occupied by certain microbiomes, while the phyllosphere is the aerial part of plants, constituting an environment largely inhabited by bacteria (Fatima and Senthil-Kumar 2015; Fester et al. 2014). The phyllosphere can be subdivided into caulosphere (stems), phylloplane (leaves), anthosphere (flowers) and carposphere (fruits) (Morris 2001), thus designating the community of microorganisms living in a symbiotic relationship with plants. The phyllosphere is a complex and relatively unknown world of microbes interacting with each other and with host plants. Studies of the rhizosphere are much more advanced than those of the phyllosphere. However, quite a large number of the phyllosphere reports are reported recently due to the massive production of data resulting from the use of omics and related technique. This has enhanced a significant advance in the understanding of microbial dynamics in the aerial organs of plants, mainly in the leaves. Although the nutrient content on the phyllosphere is poor, plants release an adequate concentration to support large microbial communities (Lindow and Brandl 2003), and microbial communities develop mechanisms to acquire other nutrients (Abdullah et al. 2020). The microorganisms benefit from the plant's carbon intake and play a protective role for this plant.

Recent scientific discoveries and numerous studies nowadays focus on different microorganisms for various scientific uses ranging from phylloremediation and biodegradation of organic pollutants such as polycyclic aromatic hydrocarbons (PAHs) (Wei et al. 2017), pest control (Tripathi et al. 2020), the invasion of pathogenic microorganisms on plants in general and leaves in particular (Wang et al. 2019), services for agriculture (Zhang et al. 2019b) and forestry, etc. Thus, after the soil, the phyllosphere ranks second as the habitat containing the greatest concentration of microorganisms on earth. Indeed,

the leaf area of terrestrial plants is estimated at more than  $6.4 \times 10^8 \text{ Km}^2$  (Izuno et al. 2016). Given that the bacterial density on the leaf surface reaches  $10^6$ - $10^7$  cells per  $\text{cm}^2$  (Zhang et al. 2019b), the phyllosphere remains an indisputable habitat for different types of microorganisms.

Among the most prevalent and persistent contaminants, PAHs have attracted increasing attention following their carcinogenic effects on humans (Cabrerizo et al. 2011). PAHs are a ubiquitous group of organic pollutants, composed of two or more single or fused aromatic rings. They arise from both biological processes and by-products of incomplete combustion from natural combustion sources or caused by man-made sources (Kweon et al. 2014; Primost et al. 2018; Cristaldi et al. 2017). PAHs are therefore classified into 3 types: (1) Pyrogenic PAHs, formed by organic substances exposed to high temperature under conditions of low oxygen or no oxygen. (2) petrogenic PAHs formed during the maturation of crude oils and similar processes and (3) biological PAHs formed by biological processes (Keir et al. 2020). The biological approach, based on the capabilities of microorganisms with the necessary assets to degrade and/or detoxify/or biotransform organic contaminants, has proven to be the most recommended technology, due to the advantages without secondary pollution, their versatility and their environmentally friendly treatment (Morillo and Villaverde 2017). However, the adverse effects of PAHs are not only observed on humans but even microorganisms in the air and soil are not spared.

Our present study joins recent efforts to assess the impact of PAHs on leaf phyllosphere bacteria. The aim of our study is to (i) identify the major different PAHs released following road traffic in Moroni, (ii) analyze the phyllosphere bacterial population of the leaves of *Gliricidia sepium* and (iii) establish a correlation between the abundance of the bacteria phyllosphere with the PAHs identified in the study area. To do this, samples of the leaves of the *Gliricidia sepium* plant were collected on the road and off the road to identify the different PAHs and the bacterial community found there.

. Cependant, les effets néfastes des HAP ne sont pas seulement observés sur les humains mais même les macros et microorganismes de l'air et du sol ne sont pas épargnés.

## II. MATERIALS ET METHODS

### 1- Design and collection of samples

The leaves of *Gliricidia sepium* were collected on the Corniche road, Moroni, Comoros (longitude:

11°41'33'S, latitude: 43°15'08'E and altitude: 0m). The leaves sample were collected along the road (1 m from the road) and away from the road in the same area designated as SR and SH respectively. In each branch where the leaves were collected, we considered three levels which were: basal, noted Ni-1, middle (Ni-2) and apical noted Ni-3 where i can be 1, 2 or 3 depending on the case and N can be SH or SR. The leaves were collected with scissors sterilized with 70% ethanol on the spot. Sixty healthy and mature green leaves were collected at 1.5-2 m height. They were then sealed in 500 ml plastic tubes and brought to the laboratory. After collection, the leaf samples were divided into two groups; the first was used for bacterial experimentation and the second for the determination of PAHs. Two empty tubes without leaves were considered as control and marked CR1 and CR2.

## 2- Determination of the different PAHs on the leaves

To assess the concentration of different PAHs present on the leaves of *Gliricidia sepium*, the leaves of the plant were treated with dichloromethane as an extract and analyzed in high performance liquid chromatography (HPLC) as described in (Wang et al. 2016).

## 3- Extraction of bacteria from the leaves

At the Laboratory of Animal Biology, Faculty of Science and Technology, University of Comoros, leaves collected from the field were used to extract the bacterial phyllosphere content on the leaf surfaces of *G. sepium*. The leaves were transferred to 500 ml bottles containing sterile water (autoclaved), to suspend the bacteria from the leaf phyllosphere. The sample was alternately manually shaken for ten minutes four times. The leaves were then removed and the solution was used as an extract of phyllosphere bacteria and transferred to small tubes.

## 4- DNA extraction and amplification

Total genomic DNA from the different samples was extracted using an Ultra-Clean Microbial DNA Isolation Kit (Morio Laboratories, Carlsbad, CA, USA). Polymerase chain reaction (PCR) and amplification of 16S rRNA genes from the V3-V4 region of each sample was performed as described in (Huang et al. 2014), using the universal primers 338F (5' -

ACTCCTACGGGAGGCAGCAG-3') and 806R (5'GGACTACHVGGGTWTCTAAT3'). The extracted DNA was sent to Sangon Biotech Institute (SBI) in Shanghai, China, for sequencing. DNA concentrations and purity were measured using a Nano Drop 2000 spectrophotometer (Thermo Fisher Scientific, USA).

## 5- Bioinformatics analysis

Deduplication and filter quantification of raw fastq files, sequence classification, annotation, and calculation of beta-diversity distance were performed using Quantitative Insights Into Microbial Ecology (QIIME Version 1.9.). The UPARSE software (version 7.0.1001) was then used to group the filtered sequences of the Operational Taxonomic Units (OTU) with a similarity threshold of 97%. At 97% confidence level, the taxonomy of each 16S RNA gene sequence was analyzed using the 16S rRNA Database and RDP Classifier (version 2.12). The distance matrix and similarity or difference in sample community composition was performed using UniFrac in QIIME Version 1.9.01.

## 6- Statistical analyzes

Physical and chemical data were subjected to statistical analysis of variance (ANOVA) in SPSS software (20). Differences between the means of multiple samples were made using the Duncan post-hoc with a confidence level of 95%. The Shannon index was calculated to describe the diversity and richness of the microbiota present. Various graphs were performed by using Origin pro software.

## III. RESULTS

### 1- The different PAHs identified on the leaves of *G. sepium*

Table 1 below contains the concentrations of PAHs recording to the two experimental groups (SR and SH). 20 hydrocarbons were detected, and their concentrations vary depending on where the leaves were collected. Among the 20 PAHs identified, the concentration was significantly high on the road area (CR1, SR) compared to that recollected out of the road (CR2, SH). This confirms previous observations that road traffic is one of the sources of PAH emulsion.

Tableau 1 : the different PAHs identified on the leaves of *G. sepium* collected on the road and out of the road.

	Nap	Acy	Ace	Fln	Phe	Ant	Flt	Pyr	Bn21T	BghiF
CR1	0.033	0.02059	0.01784	0.05923	0.0766	0.0142	0.0346	0.0267	0.0194	0.05631
CR2	0.0025	0.0031	0.00623	0.0012	0.0021	0.0023	0.0026	0.0017	0.0031	0.0016
SR1	14.371	0.5956	0.2127	3.5225	3.0186	0.4871	4.2443	5.3182	0.1368	2.8261
SR2	14.7237	0.2868	0.2247	3.3637	2.8923	0.16	3.7286	4.9045	0.0517	1.9975
SR3	13.2	0.1904	0.2445	3.5419	2.6991	0.1851	3.5185	4.5002	0.0311	1.9979
SH1	3.2745	0.01977	0.0182	0.613	0.6989	0.00934	0.2854	0.2219	0.029	0.5452
SH2	3.2214	0.0138	0.01823	0.4842	0.6126	0.01444	0.1747	0.3366	0.0396	0.5314
SH3	3.3909	0.0699	0.02797	0.5777	0.4003	0.00712	0.9292	0.8653	0.032	0.4084
	BcP	Bn12T	Bn32T	BaA	CcdP	Tph	Chr	BbF	BkF	BjF
CR1	0.001853	0.009	0.005	0.008647	0.002842	0.003346	0.001121	0.002941	0.006745	0.007432
CR2	0.00543	0.003452	0.0012	0.00219	0.005632	0.00128	0.005321	0.002945	0.002934	0.001965
SR1	1.0599	0.841	0.388	5.2879	2.8413	1.3283	5.6339	5.2194	3.1308	3.4109
SR2	0.3606	0.157	0.0373	1.6244	1.4775	1.6282	4.3375	4.0197	3.5231	2.7816
SR3	0.3308	0.135	0.057	1.6094	1.4866	1.5935	4.1343	5.3962	3.1476	2.3702
SH1	0.02158	0.00101	0.056	0.9807	0.2522	0.2961	1.3682	1.6697	0.8627	0.9599
SH2	0.1839	0.00131	0.00373	0.9152	0.2783	0.3599	1.2042	1.2996	0.6365	0.7756
SH3	0.1396	0.0096	0.00269	0.6295	0.1824	0.2649	0.9051	1.3356	0.728	0.7686

Concentrations of 20 PAH congeners in the samples analyzed, expressed as ng g-1 leaf mass for the leaf samples (Nap: naphthalene; Acy: acenaphthylene; Ace: acenaphthene; Fln: fluorene; Phe: phenanthrene; Ant: anthracene; Flt: fluoranthene; Pyr: pyrene; Bn21T: benzo[b]naphtho[2, 1-d]thiophene; BghiF: benzo[ghi]fluoranthene; BcP: benzo[c]phenanthrene; Bn12T: benzo[b]naphtho[1, 2- d]thiophene; Bn32T: benzo[b]naphtho[3, 2-d]thiophene; BaA: benz[a]anthracene; CcdP: cyclopenta[cd]pyrene; Tph: triphenylene; Chr: chrysene; BbF: benzo[b] fluoranthene; BkF: benzo[k]fluoranthene; BjF: benzo[j]fluoranthene;

**2- Bacterial community in the leaves of *G. sepium* species**

After sequencing the 16S rRNA genes, the number of OTUs identified in the different leaves of the plant was significantly higher compared to those identified in the control (CR1 and CR2). In the different experimental groups, 93626 and 96954 OTUs were identified respectively in the leaves collected on the road (SR) and out of the road (SH) (Table 2). No significant difference

was observed when comparing the results of the bacteria identified on the leaves collected on the road and those collected out of the road. The OTUs identified were different in the three different zones, taking into account the level of the collect (apical, basal and middle). The richness estimated by the Shannon and Chao indices showed no difference between the results obtained on the leaves collected on the road and those out of the road.

Tableau 2 : numbers of identified bacterial OUT, and the relative abundance of bacteria estimated in the different experimental groups as well as the diversity indices of Shannon and Chao.

Experimental group	Bar code	Seq_Num	Num- OTUs	Shannon index	Chao index
CR1	ATCGAC	5372	68563	2.06 ± 0.23	356.28 ± 36.33
CR2	GCCTAG	5387	59564	2.02 ± 0.24	346.14 ± 41.33
SR1	ATGACG	61408	95303	3.18 ± 0.23	476.18 ± 46.33
SR2	GACGAT	62803	90873	3.39 ± 0.67	411.14 ± 30.87
SR3	AGCATA	62494	94703	3.48 ± 0.22	445.11 ± 28.42
SH1	CGACAT	59882	98373	2.39 ± 0.24	478.17 ± 32.86

<b>SH2</b>	ACTATT	61075	97330	3.34 ± 0.26	467.16 ± 30.59
<b>SH3</b>	TGGCGG	61930	95160	3.53 ± 0.45	483.15 ± 34.61

Data shown are the mean of three replicates ± SD and were compared by Duncan's multiple range tests. Seq-Num is the number reads of the samples, Num OTU is the number of 16S rRNA OTUs sequences obtained by grouping and normalizing the samples.

### 3- Bacterial abundance and diversity on *G. sepium* leaves based on different taxa

#### 3.1. Based on the phylum

The relative abundance of bacteria was assessed at the phylum level (Figure 1). According to the results, Proteobacterium and Bacilota are the two main phyla

identified in the leaves of the plant *G. sepium* with respectively 24.27% and 72.06%. No difference was observed when considering the results obtained outside and on the road.

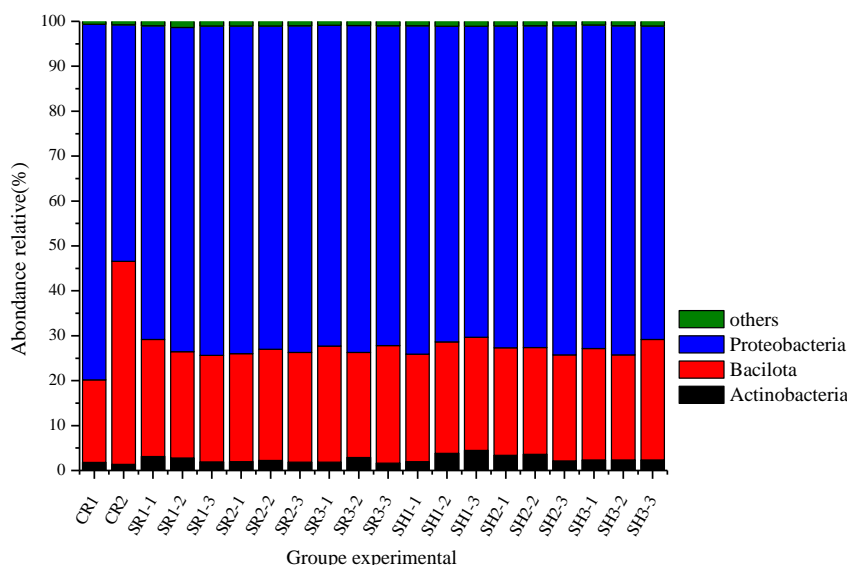


Fig.1: Relative bacterial abundance at the phylum level. The horizontal and vertical axis represent respectively the name of each sample and the abundance ratio in three repetitions. Each color corresponds to the name of the phylum and at the same time indicates the abundance of the different classes. SR= on-road, SH= out-of-road, CR1= on-road control and CR2= out of-road control.

#### 3.2 Based on the class level

Figure 2 represents the relative abundance of bacteria according to the different classes. It was found that the distribution of taxonomic classes differ by the relative abundance of bacteria in each class. In the leaves collected on the road (SR), Actinobacteria, Bacilli and Gammaproteobacteria were the most represented classes with 17%, 26% and 33% respectively. On the other hand, in the leaves collected outside the road (SH), Alpha, Beta and Gamaproteobacteria were the most abundant with respectively 24%, 29% and 38%. Compared to the two experimental groups, the relative abundance of Betaproteobacteria was significantly high in the two controls (CR1 and CR2)

#### Based on the genus

The relative abundance of bacteria was finally evaluated at the genus level (figure 3). In both experimental groups, several genera were identified. *Pantoea* was the most abundant genus with 18% followed by *Lactococcus* with 7% and *Pseudomonas* with 5%. These three genera show no significant difference between the different experimental groups.

#### 3.3. Correlation between bacterial community in different samples

The scatterplot matrix presented in the figure 4 highlight the correlation between different phyla identified in the experimental group collected on the road and out of the road. The phylum Proteobacteria was strongly

correlated with, Actinobacteria and Baciliota ( $r = 0.83, p < 0.05$ ). While the genera *Xanthobacter* was however correlated to *Pseudomonas*, *Marteella*, *Altererythrobacter* and *Sphingobium* ( $r = 0.86, p < 0.05$ ). The phylum Baciliota was strongly correlated with Actinobacteria ( $r = 0.88, p < 0.05$ ), while the genera *Altererythrobacter* was

positively correlated to *Pseudomonas* and *Sphingobium* ( $r = 0.81, p < 0.05$ ) and finally, the genera *Sphingobacter* was correlated to *Altererythrobacter* and *Kordiimonas* ( $r = 0.77, p < 0.05$ ).

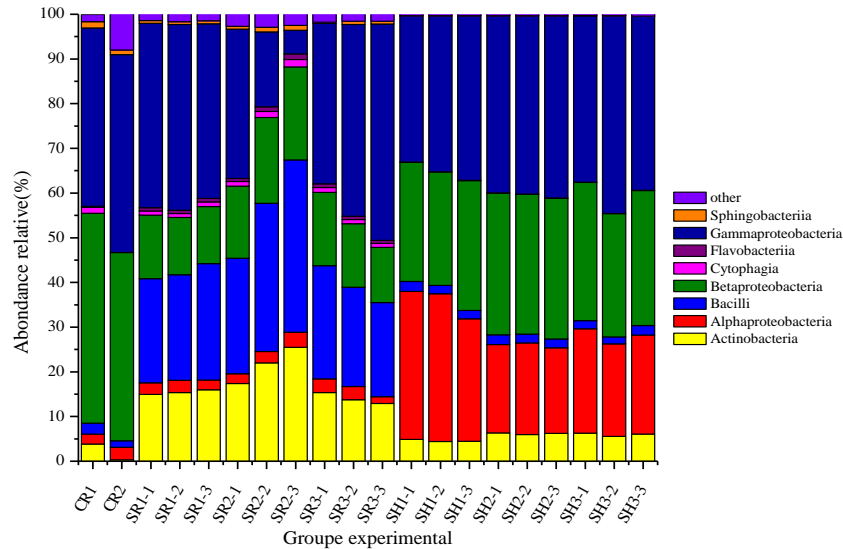


Fig.2: Relative bacterial abundance at the class level. The horizontal and vertical axis represent respectively the name of each sample and the abundance ratio in three repetitions. Each color corresponds to the name of the class and at the same time indicates the abundance of the different classes. SR= on-road, SH= out of-road, CR1= on-road control and CR2= out of-road control.

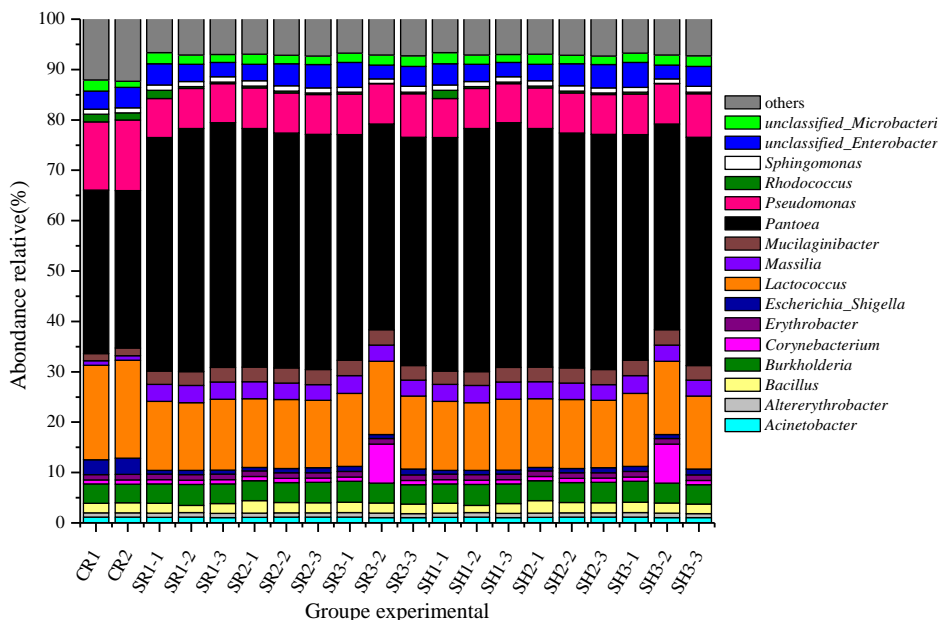


Fig.3 : Abondance relative bactérienne au niveau du genre. L'axe horizontal et vertical représente respectivement le nom de chaque échantillon et le rapport d'abondance en trois répétitions. Chaque couleur correspond au nom du genre et indique par la même occasion l'abondance des différentes classes. SR = sur la route, SH=hors de la route, CR1= contrôle sur la route et CR2= contrôle hors de la route.

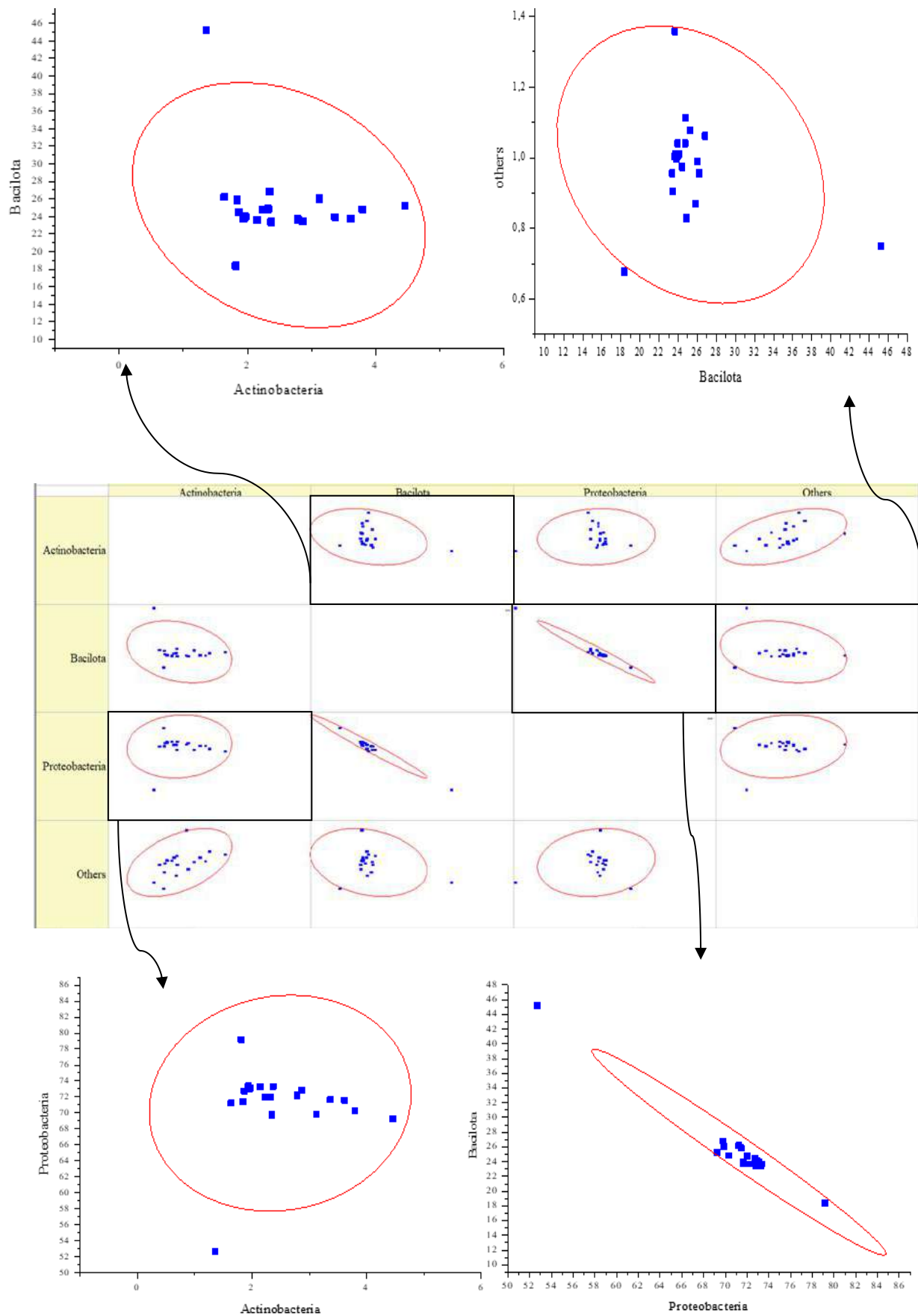


Fig.4: The scatterplot matrix presented highlight the correlation between different phyla identified in the experimental group for the leaves collected on the road and out of the road



#### IV. DISCUSSION

The critical role of plants in removing PAHs from the atmosphere has been known for over 20 years, when Simonich and Hites in 1994 estimated that over 40% of atmospheric PAHs were trapped by vegetation and released into the soil, while more recent works report lower values (Zhang et al. 2019a). The spatial patterns of atmospheric concentrations of PAHs that we observed in this present study were consistent with those reported in previous studies, which showed higher concentrations of PAHs are rather observed in rural areas where road traffic is high. The spatial trend of PAH concentration extracted from leaf samples in the present study was generally consistent with airborne concentrations. This finding is consistent with several previous reports of PAH deposition on plant leaves which showed leaf concentrations to be higher in urban areas compared to per urban or remote areas (Andrea et al. 2020). *Gliricidia* leaves are known to have a high wax content (Aranda et al. 2017). Yet previous scientific reports indicate that the concentration of PAHs on leaves increases with wax content (Wang et al. 2008). Therefore, in this present study, only one species of plant was used, the relation "wax content-PAH concentration" cannot be a strong argument to explain the different concentrations of PAH on the leaves collected on the road contrary to those collected out of the road.

Among the PAHs identified in this study, naphthalene was the most abundant compound in most leaf samples. Such an abundance of naphthalene on the leaves could be due to the high vapor pressure of the lower molecular weight PAHs, which facilitates both direct uptake by the atmosphere through the stomata and particulate phase exchange at the wax-rich surface of the plants leaves. The stomatal conductance of a leaf, in particular, can determine the capture efficiency of semi-volatile pollutants such as low molecular weight PAHs (Abdullah et al. 2020), while high molecular weight PAHs are usually deposited on the plant surface bound to particles in wet and dry deposition (Alagic et al. 2016).

Epiphytic bacteria, living in the aerial parts of the plant and on the surface of the leaves in particular, are directly exposed to many variable environmental factors, but especially to atmospheric pollutants (Lindow and Brandl 2003). For this reason, they were able to develop a kind of adaptive and metabolic capacities towards these atmospheric pollutants, which can play a potential role in the processes of air bioremediation. Despite their continuous exchange with airborne populations, phyllosphere bacteria are not random assemblages, but rather form true communities resulting from certain selection processes (Vorholt 2012; Rastogi et al. 2012).

These communities undergo selection processes resulting in predictable microbial communities represented by a few dominant phyla and other less represented taxa. The few bacteria holding the power of resistance due to different genetic assets are essential in these environments where living conditions are constantly changing. In this present study, the leaves collected on the road which are more exposed to PAHs present a strongly elevated relative abundance of Actinobacteria and Bacilli. We can therefore easily deduce that these bacteria could have developed a kind of resistance to these road PAHs. On the other hand, bacteria belonging to the Alphaproteobacteria class are significantly less represented in this road area. This could be explained simply by the fact that PAHs are toxic to these bacteria.

#### V. CONCLUSION

The present study not only identified the major different PAHs released as a result of Moroni road traffic, and analyzed the phyllosphere bacterial population of *Gliricidia sepium* leaves, but also established a correlation between the abundance of the phyllosphere epiphyte bacterial population living in the leaf surface of *Gliricidia sepium* with the PAHs identified in the study area. It was therefore demonstrated that the spatial trends of atmospheric concentrations of PAHs were consistent with those reported in previous studies, showing that the higher concentrations of PAHs are rather observed in rural areas where road traffic is high and where their concentrations in the air are quite substantial. The variation of bacteria in the road area and that outside the road is simply a consequence of the development of resistance to PAHs by certain taxonomic groups which were able to impose themselves unlike other less resistant groups. However, although a great information has been gained from individual plant microbiome studies, we suggest that meta-analyses controlling for differences in methodology are needed to better understand leaf-microbe associations in plants. Acclimatization studies in crops subjected to PAH stress would be of great use to better apprehend and understand PAH-microbe interactions in the phyllosphere of the leaves.

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## Strawberries of hope: food security and strawberry production in times of pandemic scarcity

## Morangos de esperança: segurança alimentar e produção de morangos em tempos de carestia pandêmica

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*“Um homem caminhava por uma floresta. Estava escuro, porque a noite se aproximava. De repente ele ouviu um rugido terrível. Era um leão. Ele ficou com muito medo e começou a correr. Mas ele não viu o caminho por onde ia, porque estava escuro, e caiu num precipício. No desespero da queda, ele se agarrou ao galho de uma árvore que se projetava sobre o abismo. Lá em cima, na beirada do abismo, o leão. Lá em baixo, no fundo do abismo, as pedras. E foi então que, olhando para a parede do abismo, ele viu que ali crescia uma planta verde que tinha um fruto vermelho: era um morango. Ele então estendeu seu braço, colheu o morango e o comeu. Estava delicioso.”*

(Rubem Alves)

Received: 01 Jul 2022,

Received in revised form: 30 Jul 2022,

Accepted: 03 Aug 2022,

Available online: 09 Aug 2022

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**Keywords—** Family agriculture, Food security, Pandemic crisis, Strawberry production.

**Palavras-chave—** Agricultura familiar, Crise pandêmica, Produção de morangos, Segurança alimentar.

**Abstract—** The Covid-19 pandemic devastated thousands of lives, causing a health and socioeconomic crisis, with direct effects on increasing poverty and hunger. However, these aspects are rarely associated with semi-hydroponic fruit production and its role in food security. Therefore, the objective of this investigation was to identify a successful case of food production in family farming in a small municipality called Diamante do Sul, located in the state of Paraná, Brazil, which has one of the worst Municipal Human Development Indexes of the state. This article was based on a case study. The data were collected from non-participant observation and a semi-structured interview, applied to a farmer selected by convenience. We verified that the technological innovation of semi-hydroponics represents an excellent alternative for the production of strawberry fruit, in quantity and quality. This production system, implemented through the access to rural credit, besides the fast return on investment, acts in the generation of income for the family and the strengthening of their productive autonomy. Thus, the production of strawberries in times of pandemic famine has an influence on food security and the movement of the local economy, since production occurs throughout the year.

**Resumo—** A pandemia de Covid-19 assolou milhares de vidas, causando

*uma crise sanitária e socioeconômica, com efeitos diretos no aumento da pobreza e fome. No entanto, raramente esses aspectos são associados à produção semi-hidropônica de frutos e seu papel na segurança alimentar. Portanto, o objetivo desta investigação foi identificar um case de sucesso na produção de alimentos na agricultura familiar de um pequeno município denominado Diamante do Sul, localizado no estado do Paraná, Brasil, que possui um dos piores índices de Desenvolvimento Humano Municipal do estado. Este artigo se baseou no estudo de caso. Os dados foram coletados a partir de observação não-participante e de uma entrevista semiestruturada, aplicada a uma agricultora selecionada por conveniência. Verificamos que a inovação tecnológica da semi-hidroponia representa uma ótima alternativa de produção de frutos de morangos, em quantidade e qualidade. Esse sistema de produção, implementado a partir do acesso ao crédito rural, além do rápido retorno do investimento, atua na geração de renda para a família e fortalecimento de sua autonomia produtiva. Assim, a produção de morangos em tempos de carestia pandêmica tem influência na segurança alimentar e na movimentação da economia local, já que a produção ocorre ao longo do ano inteiro.*

## I. INTRODUÇÃO

No terceiro ano da pandemia de COVID-19 os desafios da pesquisa se agigantam para alcançar alternativas à sobrevivência das populações, submetidas ao isolamento social e a perda de empregos e renda. As ações negacionistas na área da saúde e, de modo geral, com relação às ciências, empreendidas por políticas populistas com o intuito de beneficiar o grande capital, que, no caso do Brasil, a produção agrícola beneficiou somente ao agronegócio exportador nos últimos seis anos e, assim, se agravou com a pandemia concomitante ao desmonte da agricultura familiar produtora de alimentos para a mesa dos brasileiros. Isto fez o Brasil retornar ao Mapa da Fome.

“Um dos criadores do Fome Zero e um dos principais pesquisadores em segurança alimentar no Brasil, Walter Belik, professor aposentado do Instituto de Economia da Unicamp, defende que o governo Bolsonaro conduz uma política deliberada de desmonte das iniciativas contra a fome no país. (...) O país voltou ao Mapa da Fome em 2018 e, em 2020, registrou 55,2% da população convivendo com a insegurança alimentar, segundo pesquisa da Rede Penssan” (Petropouleas, 2022).

O desmonte das políticas voltadas à agricultura familiar vem acirrando os caminhos para uma insegurança alimentar crescente. Um dos caminhos de enfrentamento da pandemia com relação à insegurança alimentar, poderia ter sido um aporte de recursos federais na compra e distribuição de alimentos produzidos pelos mais de 4,5 milhões de famílias na agricultura familiar. Entretanto, o agronegócio exportador, constituído por não mais de 600 famílias, é o grande beneficiado das políticas de agricultura do atual governo.

“O Bolsa Família, desidratado, passou de um programa de transferência de renda com condicionalidades para um de doação. Com o Auxílio Brasil, a ideia de proteção e assistência social dessas famílias foi escanteada. O Pronaf [Programa de Fortalecimento da Agricultura Familiar] foi desidratado e os valores cortados em 35%. O programa de reforma agrária, a Secretaria de Agricultura Familiar, o programa de estoques de regulação da Conab e o programa de cisternas, todos foram descontinuados” (Petropouleas, 2022).

Esta realidade suscita desafios para a academia a proceder leituras e investigações de alternativas para o

enfrentamento da insegurança alimentar. A frase em epígrafe tem justamente esta conotação. Se o Brasil, de dimensões continentais, um dos maiores produtores do agronegócio, se debate com a insegurança alimentar, a imagem do leão se configura na imagem do agronegócio, empurrando para o precipício a agricultura familiar e as populações vulneráveis que integram um grande contingente de seres humanos em insegurança alimentar. A imagem quer apontar para a necessidade de construirmos alternativas para o enfrentamento dessa triste realidade.

Diante disso, o objetivo da presente investigação foi identificar um *case* de sucesso na produção de alimentos na agricultura familiar de um pequeno município do meio Oeste do estado do Paraná, Brasil, mais precisamente em Diamante do Sul. Trata-se da produção de morangos através da hidroponia, uma forma rápida de produzir alimentos e gerar incremento econômico para agricultores familiares e, assim, se constituir em modelo de empreendimento para outros agricultores familiares e, inclusive, para comunidades próximas a cidades de maior concentração urbana.

Portanto, buscamos responder as seguintes perguntas:

1-) Qual é a importância que podemos encontrar em um único *case* de sucesso de produção de morango semi-hidropônico para segurança alimentar no município Diamante do Sul do estado do Paraná, Brasil? 2-) Como este *case* pode se tornar um exemplo bem-sucedido para outros agricultores familiares na região?

### 1.1 Segurança alimentar e nutricional

Há diversas conotações histórias para o conceito de segurança alimentar. O conceito, entretanto, ganhou notoriedade mundial ao ser reconhecido como um direito de todo o ser humano, vinculado à Carta dos Direitos Humanos de 1948, pela Conferência Mundial sobre Direitos Humanos, realizada em Viena, na Áustria, em 1993. É um direito que decorre da universalidade dos direitos humanos, como “[...] esto es, responsabilidades universales para con la crisis ecológica, las prácticas económicas excluyentes, el desempleo, el hambre, la miseria, la falta de ciudadanía, etc.” (Ahlert, 2007, p. 7). Nessa evolução, existem três dimensões fundamentais para se falar em segurança alimentar, isto é, ‘[...] três aspectos principais: quantidade, qualidade e regularidade no acesso aos alimentos’ (Belik, 2003, p. 14).

No Brasil, a segurança alimentar e nutricional foi tornada lei federal em 2006, estabelecendo “[...] definições, princípios, diretrizes, objetivos e composição do Sistema Nacional de Segurança Alimentar e Nutricional”. Em seu Artigo 3º a segurança alimentar e nutricional é definida como a,

“[...] 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” (Lei nº 11.346, de 15 de setembro de 2006).

Esse direito humano fundamental está interligado com a capacidade da produção de alimentos em quantidade, qualidade e disposição de acesso. Neste contexto, a agricultura familiar é determinante, pois, é ela que produz os alimentos que vão para a mesa dos brasileiros. Estima-se que a agricultura familiar é responsável por 70% desse montante.

Em sua discussão sobre o papel da empresa de Assistência Técnica e Extensão Rural - ATER e a criação da PNATER - Política Nacional de Assistência Técnica e Extensão Rural, Fialho e Lopes (2020) desenvolvem a relação entre a agricultura familiar com a Segurança Alimentar e Nutricional. ‘O debate em torno da forma de trabalho das ATER fizeram com que 2003, fosse proposto a Política Nacional de Assistência Técnica em Extensão Rural – PNATER, que apresentaram alguns princípios norteadores’ (Fialho e Lopes, 2020, p. 784), que as autoras elencaram em forma de figura com os termos:

“Contribuição para a segurança e soberania alimentar e nutricional. Equidade nas relações de gênero, geração, raça e etnia. Adoção dos princípios da agricultura de base ecológica. Adoção de metodologias participativas, buscando cidadania e democratização das políticas públicas. Gratuidade, qualidade e acessibilidade aos serviços de ATER. Desenvolvimento rural sustentável” (Fialho e Lopes, 2020, p. 784)

A partir desses princípios, as autoras apresentam os objetivos da PNATER:

“Promover o desenvolvimento rural sustentável, igualdade de gênero e étnicas inclusão da sociedade civil. Apoiar iniciativas econômicas que promovam as potencialidades e vocações regionais e locais. Aumentar a produção, a qualidade e a produtividade das atividades e serviços agropecuários e não agropecuários. Promover a melhoria da qualidade de vida de seus beneficiários. Assessorar as diversas fases das atividades econômicas, a gestão de negócios, sua organização, a produção, inserção no mercado e abastecimento. Desenvolver ações voltadas ao uso, manejo, proteção, conservação e recuperação dos recursos naturais, dos agroecossistemas e da biodiversidade. Construir sistemas de produção sustentáveis a partir do conhecimento científico, empírico e tradicional. Aumentar a renda do público beneficiário e agregar valor à sua produção. Apoiar o associativismo e o cooperativismo. Promover o desenvolvimento e a apropriação de inovações tecnológicas e organizativas adequadas ao público beneficiário. Promover a integração da Ater com a pesquisa. Contribuir para a expansão do aprendizado e da qualificação profissional e diversificada. Assessorar as diversas fases das atividades econômicas, a gestão de negócios, sua organização, a produção, inserção no mercado e abastecimento” (Fialho e Lopes, 2020, p. 785).

Com base nesses objetivos, as autoras mostram a importância da agricultura familiar na sustentação da

segurança alimentar e nutricional. Segundo elas, tais atividades permitem ‘[...] estabelecer maiores possibilidades de consolidação de mercados e consequentemente contribuir com a Segurança Alimentar e Nutricional’ (Fialho e Lopes, 2020, p. 786).

Nesse sentido, a agricultura familiar pela sua diversificação produtiva, engloba uma riqueza de espécies, culturas e cultivos, que vão muito além da geração de renda, mas dizem respeito às formas específicas de produção e cuidados com o meio. Isso, inclui, portanto, a área da olericultura, que abrange o cultivo de morangos, por exemplo.

## 1.2 Agricultura familiar e a produção de morangos

A garantia da soberania alimentar, envolve, necessariamente, ~~pe~~a agricultura familiar, cuja dinâmica é enlaçada pela vida e o cultivo, ou seja, é uma forma de vida que se opõe à lógica industrial de produção e não busca a obtenção extensiva de lucros. Pelo contrário, é a busca por uma vida digna no meio rural, portanto, representa a conjunção entre desenvolvimento e produção (Ploeg, 2014).

Como se trata de uma forma de vivência, a produção de morangos na agricultura familiar representa uma prática altamente inovadora, capaz de favorecer a geração de renda e produção em curto período. Essa ideia se fortalece ainda mais pelo fato de que o morango é uma fruta que faz parte de um mercado em crescente expansão e demanda, em função de suas características físicas, aroma, sabor e valor nutricional (Senar, 2019). Por isso torna-se uma importante espécie de cultivo na agricultura familiar.

No setor dos pequenos frutos, no Brasil, a cultura do morangueiro (*Fragaria x ananassa*) é a mais explorada, porque pode ser cultivada durante o ano inteiro, em condições clima e solo diferentes. Pode ser cultivado em sistema convencional (a campo aberto), orgânico e hidropônico. Geralmente, no âmbito dos mercados locais é comercializado especialmente como fruta fresca, embora, existam demandas de sua industrialização na forma de geleias, chás, sorvetes e sucos (Madaíl, 2016).

Cabe destacar que o morangueiro é uma cultura sensível, tanto no manejo, quanto nos elementos necessários ao seu desenvolvimento, já que possui ciclo curto, e qualquer impasse pode colocar em risco toda a produção. Portanto, quando se considera a qualidade, produtividade e a segurança dos frutos, é preciso ressaltar alguns aspectos, como altas temperaturas, fotoperíodo, persistência de períodos chuvosos e incidência de patologias e pragas (Oliveira e Antunes, 2016).

No sistema convencional, o/a agricultor/a precisa estar atento na hora de selecionar o local de plantio, que precisa dispor de água para o suprimento da demanda. A área deve ser preparada e adubada adequadamente, além da rotação de culturas que também é importante, pois a não adoção dessa prática aumenta a ocorrência de pragas e doenças. O preparo dos canteiros, com largura adequada, demarcação de covas e a forma de condução do plantio ou replantio, são elementos decisivos na produtividade, pois o morangueiro é considerado sensível ao estresse (Picolotto et al. 2016).

A cobertura do solo do canteiro era geralmente feita com materiais palhosos, como capim seco, que apesar de ser altamente eficiente na retenção de umidade no solo, é menos eficiente no controle de plantas daninhas. Por isso, nos últimos anos, o solo passou a ser recoberto com material sintético, o plástico polietileno, que além de impedir o desenvolvimento de plantas invasoras, impedem a lixiviação dos minerais do solo e evitam que os frutos se deteriorem, já que impedem seu contato com o solo. Outra técnica utilizada no plantio a campo, é a adoção de túneis de plástico baixo nos canteiros; funciona como proteção em dias ensolarados e protege a produção de ventos fortes. A abertura ou fechamento desses irá depender das condições climáticas e, não menos importante, é fundamental considerar o acesso às flores pelos insetos polinizadores (Picolotto et al. 2016).

Em meio a uma diversidade de sistemas de cultivo, destacam-se também aqueles fora do solo, como o cultivo em substrato, caso da semi-hidroponia. Neste caso, o cultivo em bancadas suspensas feitas de madeira, vem ganhando cada vez mais espaço na agricultura familiar, onde o substrato com características físicas, químicas e biológicas adequadas é acondicionado em sacos de polietileno brancos dispostos nas bancadas, que sustentam o cultivo do morangueiro e contemplam o sistema irrigação, geralmente realizado por gotejamento, exemplificando que a quantidade de água é um dos requisitos fundamentais ao bom desenvolvimento do morangueiro (Calvete et al., 2016).

As variedades de morangos mais indicadas para este tipo de sistema são: Camarosa, Per Cinque e Festival (dias curtos) e, Albion, San Andreas, Portolas e Aromas (dias neutros), sempre optando por mudas de qualidade. Apesar de as de dias curtos serem predominantes no Brasil, as cultivares neutras estão se destacando por facilitarem a produção na entressafra em ambientes protegidos, como estufas, garantindo rentabilidade ao longo do ano ao produtor (Calvete et al., 2016; Emater-RS, 2019) e fortalecendo sua permanência no campo.

Na semi-hidroponia o cultivo do morangueiro é realizado sob estufas, que protegem a cultura dos efeitos diretos do ambiente. É uma estrutura simples, de cobertura plástica, estruturada por palanques de madeira ou metal, que atua como efeito guarda-chuva; não possui cortinas de plástico, permitindo maior ventilação (Emater-RS, 2019). Neste caso, o agricultor ainda pode adotar telas do tipo ‘sombrite’ para as laterais, elaborando-se uma espécie de cortina, para proteger o cultivo do sol e/ou pragas, porém, deve considerar o acesso dos polinizadores.

As principais vantagens desse sistema consistem na qualidade de trabalho do agricultor, permitindo que trabalhe em pé, com mais conforto em comparação ao cultivo a campo. Garante um melhor controle fitossanitário, no entanto, requer mão-de-obra nas diversas etapas, principalmente na colheita. Por isso, ao adotar este sistema o agricultor precisa definir previamente o tamanho da área a ser explorada (Madail, 2016; Emater-RS, 2019), a quantidade de mão-de-obra disponível, condições de disponibilidade de água, variedade mais adequada e infraestrutura.

O cultivo do morango além de ser uma atividade capaz de gerar renda para as famílias, se aglutina ao uso de pequenas áreas rurais para a produção rentável, flexível e sustentável. Aponta, pois, para a importância de difundir esses sistemas a outras dimensões que ultrapassam o rural, como espaços urbanos ociosos; na proposição de modelos de produção saudável e repleta de possibilidades educacionais, ambientais, econômicas e outras, capazes de fortalecer a noção de sociedade sustentável.

### 1.3 Novos horizontes na produção de morangos semi-hidropônicos: doce sabor urbano

A dimensão atingida pela pandemia de Covid-19 reorientou olhares para diversas áreas da sociedade, uma delas se refere aos modos de produção e distribuição de alimentos; na dimensão da sustentabilidade, equidade e segurança alimentar. Nesse sentido, ‘a agricultura urbana está sendo reconhecida como uma importante alternativa visando resguardar o direito à segurança alimentar num planeta que está se tornando a cada dia mais e mais urbanizado’ (Altieri e Nicholls, 2021, p. 253).

O controle de espaços ociosos nas áreas urbana e peri-urbanas ainda constituem um desafio de ordem pública, saúde e infraestrutura em grandes e pequenos centros, assim como periferias, pois muitas vezes essas áreas ocupam lugar de destaque no acúmulo de resíduos, proliferação de vetores de doenças ou até mesmo como local de descarte irregular de resíduos de construção civil, por exemplo. Segundo Fonseca, Morais e Chiariello (2021), nos últimos anos houve avanços no desenvolvimento da agricultura urbana, especialmente no

planejamento territorial e agendas de formulação de políticas públicas como fundamento de preservação ambiental e segurança alimentar.

Entretanto, o principal impasse é a sistematização desses planejamentos, que devem ser repensados para além dos espaços ociosos; mas abranger quintais de propriedades e instituições, como escolas; hospitais; penitenciárias; terraços, sacadas ou lajes de edifícios; e quaisquer outros espaços que estejam disponíveis. Com isso, poderiam ser melhorados, de acordo com Altieri e Nicholls (2021) os circuitos produtivos e o consumo de alimentos nutritivos, a partir da produção agroecológica ou orgânica, o que tende a fortalecer o sistema imunológico do ser humano, melhorando a resistência a diferentes tipos de viroses e suprimindo necessidades de comunidades, famílias e grupos marginalizados.

A implementação de sistemas de produção de morangos semi-hidropônicos constituiu-se uma alternativa extremamente rica para a agricultura urbana e peri-urbana. Sua sistematização poderia ser realizada por programas educativos em diferentes organizações e instituições, no estímulo de novas práticas ambientais e oferta de frutos saudáveis para a alimentação ou comercialização. Em áreas de periferias, por exemplo, poderia auxiliar na redução das desigualdades socioeconômicas, como fonte de renda para as famílias, redução da insegurança alimentar a partir do compartilhamento do excedente da produção e como ferramenta de inclusão social.

Esses elementos se tornam ainda mais significativos quando são pensados a partir da implementação de sistemas de produção morangos na perspectiva do estabelecimento de uma nova relação do ser humano com o alimento. O fortalecimento da consciência crítica e releitura das formas e espaços de produção de frutos, se traduz na mudança das '[...] relações homem-mundo, relações de transformação, e se aperfeiçoa na problematização crítica da realidade' (Freire, 1977, p. 26). Mais importante do que a simples crítica da realidade é a adoção de novas posturas produtivas, de vivência, consumo e respeito pelos alimentos, como será apresentado neste estudo.

## II. METODOLOGIA

A presente investigação englobou a análise de uma *case exitoso* envolvendo elementos relacionados à

agricultura familiar, sistema de produção semi-hidropônico e segurança alimentar no contexto da pandemia de Covid-19. Esta pesquisa é de caráter exploratório e cunho qualitativo, desenvolvida a partir do estudo de caso, pois a seleção estratégica de um caso gera pesquisas mais robustas, com enfoque preciso (Yin, 2015).

Buscamos apresentar um *case* de sucesso na produção de alimentos na agricultura familiar de um município de pequeno porte, mais precisamente em Diamante do Sul (25° 2' 21" S e 52° 41' 29" W), região meio Oeste do estado do Paraná, Brasil. Este município possui área territorial de 347,168 km<sup>2</sup>, uma população de cerca de 3.510 habitantes, onde aproximadamente 59,9% vivem na área rural, formados em sua maioria por pequenos estabelecimentos, caracterizados pela agricultura familiar, na produção de hortaliças, sericicultura e pecuária. Atualmente, Diamante do Sul tem um dos mais baixos índices de Desenvolvimento Humano Municipal (IDH-M) do estado do Paraná (Prefeitura Municipal de Diamante do Sul, 2016; Instituto Paranaense de Desenvolvimento Econômico e Social, 2022).

Este estudo foi realizado na propriedade rural denominada Sítio Funayama. O levantamento de dados foi realizado a partir de observação não-participante e de uma entrevista semiestruturada, de um roteiro compostos por 15 perguntas, aplicado a uma agricultora selecionada por conveniência, considerando-se a presença do sistema semi-hidropônico de cultivo de morangos.

O roteiro da entrevista foi organizado e efetuado em dois momentos: I) caracterização da área de estudo; II) manejo e técnicas produtivas; e, III) vantagens e impasses na semi-hidroponia de morangos. A coleta de dados foi realizada *in loco*, durante o mês de fevereiro de 2022, após a concordância do Termo de Consentimento Livre e Esclarecido pela participante. A entrevista foi gravada na forma de áudio e, posteriormente seu conteúdo transcrito, levando-se em conta a não adequação linguística do idioma português, para manter a essência das falas da agricultura e para seguir o rigor científico desta análise.

Para analisar os dados da entrevista, formaram-se 21 códigos e 3 grandes categorias de análise, a partir da entrevista de 2 horas de duração. Na Fig. 1 é possível verificar as categorias de análise.



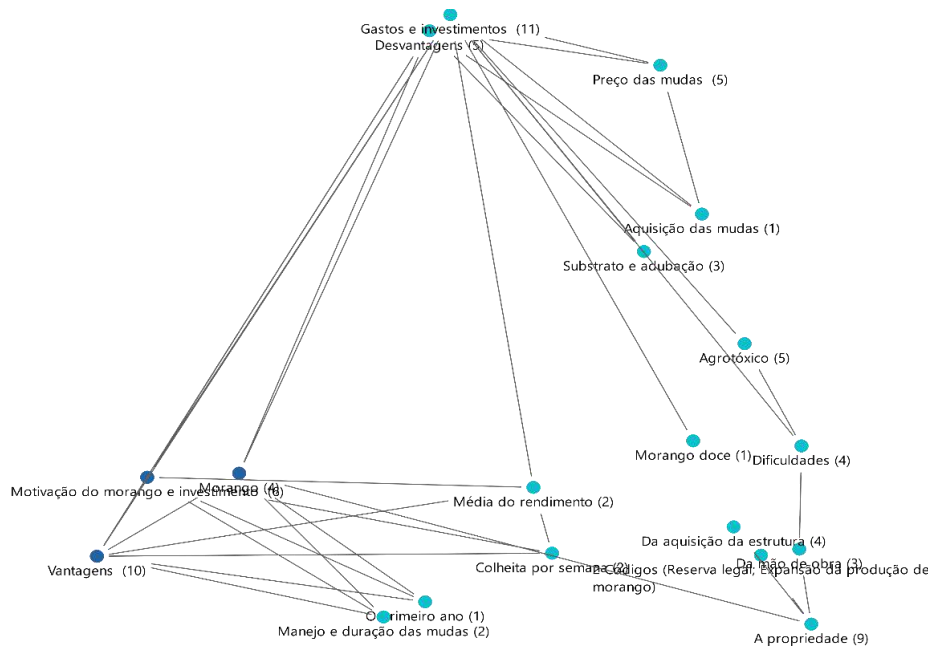


Fig. 1: Os códigos de distribuição analíticos utilizados na análise da entrevista

Fonte: dados da pesquisa (2022).

Cada fala da entrevistada, foi registrada como **agricultora**. Para organização e análise dos dados, utilizou-se a ferramenta MAXQDA, *software* líder mundial para pesquisa de métodos qualitativos e mistos (Maxqda, 2021).

### III. RESULTADOS E DISCUSSÃO

#### 3.1 As características da propriedade e a produção de morango

Cada espaço da unidade familiar é importante, devido aos impactos diretos sobre as produções, especialmente na obtenção das possibilidades de garantir renda para sua manutenção. Desta forma, julga-se necessária a aplicação de novas tecnologias, fundamentais para impulsionar os produtos da agricultura familiar, com o compromisso de incentivar a segurança alimentar no seu contexto social mais amplo (Schneider et al. 2009; Altieri, 2012). Entende-

Quadro 1: Características da propriedade da produção semi-hidropônico dos morangos em Diamante do Sul, Paraná, Brasil.

<b>Propriedade</b>	12 alqueires (29 hectares)
<b>Estufa do morango</b>	15 m x 5 m
<b>Rio na propriedade</b>	sim
<b>Poço de água na propriedade</b>	sim
<b>Maquinários na propriedade</b>	somente trator
<b>Quantidade plantada de morango</b>	1.450 mudas
<b>Instalações na propriedade</b>	casa da família
	1 estufa para produção de morango

Fonte: dados da pesquisa (2022).

se que com o passar do tempo, as tecnologias aplicadas no meio rural ou urbano acabam por desenvolver um papel evolucionista. A revolução verde, com início da década de 1960, envolveu a modernização e o aumento na produção agrícola (Santilli, 2009; Matos, 2011), por outro lado excluiu muitos agricultores familiares, principalmente aqueles com menos condições econômicas.

Na perspectiva deste artigo, a experiência espetacular da produção de morango semi-hidropônica, a partir das inovações tecnológicas, pode ser entendida como uma excelente alternativa para ajudar a garantir a produção de morangos, em qualidade e quantidade, embora no Brasil ainda não exista grande produção de morangos, em exceção das propriedades rurais dos estados do Rio Grande do Sul e Minas Gerais (Richter et al. 2018; Vignolo et al. 2011). Desta forma, o Quadro 1 apresenta as características da propriedade pesquisada.

Percebe-se que se trata de uma propriedade de 29 hectares, que se configura dentro de quatro módulos fiscais de Diamante do sul, caracterizando-a, portanto, como propriedade de agricultura familiar, segundo a Lei nº 11.326, de 24 de julho de 2006. A propriedade contém uma estufa de produção de morango semi-hidropônico, capaz de produzir a média de 1 quilo mensal por cada

muda de morango, cuja produção é vendida atualmente por 24 reais o quilo, segundo relatou a agricultora. Isso mostra que a produção de 1.450 mudas, requer dedicação para alcançar produtos de qualidade. Na Fig. 2, se verifica o sistema de semi-hidroponia de morangos na propriedade do Sítio Funayama.



Fig. 2: Sistema de semi-hidroponia de morangos no Sítio Funayama, município de Diamante do Sul, estado do Paraná, Brasil.

Fonte: dados da pesquisa (2022).

Desta forma, se faz necessário entender como funciona o processo da produção de morangos, de acordo com a agricultora: “o morango é rapidinho, dentro de cinco mês ele já tá produzindo morango ‘[...] dava até antes, mas a primeira florada cê tem que derrubá, cê não pode deixar que os pés tá novo, por causa do enraizamento deles’.

Mesmo com a sensibilidade dos morangos, percebe-se que o fluxo na produção depende da agilidade da agricultura, principalmente em entender o processo de desenvolvimento dos morangueiros, incluindo fragilidades, tempo e cuidados permanentes (Oliveira e Antunes, 2016). A partir disto, julga-se a aquisição das mudas para a plantação como um dos passos mais importante neste processo, conforme relato:

Eu pego tudo pronto as mudinhas [...] tudo pronto já. Pra mim sai seis (6) centavos as mudinhas; cada mudinha.

Daí tem o adubo, mas o adubo eu não fiz as contas ainda [...] caro ele não é, porque daí cê usa no morango e na alface né? Pra dizê [...] tudo é em pó. [...] as mudinhas eu pego com o cara que vem tuda segunda aqui, de Laranjeiras, aí eu pego direto dele [...] eu sempre pego sete (7) bandeja, daí se eu pegá em agropecuária o preço vai sai lá em cima, o dobro. Eles (agropecuária no município) tá cobrando vinte centavo a muda e pra mim sai seis centavo (Agricultora).

Dito isto, no primeiro momento, o trabalho da agricultura se resume em efetuar o plantio adequado, para

evitar perdas significativas, já que é necessário um investimento inicial para a aquisição das mudas. Outro aspecto importante é a distância para comprar as mudas, o que envolveria mais investimento de tempo e recursos financeiros, o que impactariam diretamente no rendimento da propriedade, alinhado ao pensamento de Matos, (2011), sobre rendas a partir da agricultura.

Outra variante importante é manejo e duração das mudas, segundo Oliveira e Antunes (2016), o manejo representa um dos maiores desafios dos morangueiros, em razão da temperatura, momentos chuvosos, além das pragas, que podem surgir. Com isto, a agricultura enfatizou o processo da duração das mudas:

“Duram uns dois (2) ano, só que daí não compensa cê deixa mais porque a produção [...] a toçera vai aumentando ali e a força do morango já vai diminuindo o tamanho dos morangos [...] essa semana que vem eu tenho que entrá tirá aquelas toçera que tá muito e deixa só três [...] ele falo (técnico da Sicredi que dá assistência pra ela) que o que não tive fror cê já pode derrubá tudo, dexa só os pé novo que tá com frorzinha, né? O que não tive é pra deixa no máximo três (3) por cova [...] tem cova lá que tem 8 pé, então é amuntado, daí ali não produz que presta mais, por isso que ele diminuiu [...] acho que a adubação tá fraca, tem muito pé. A dosage vai tê que aumenta pra vortá a produção, porque daí vai tomando a força né?” (Agricultora)

Contudo, a produção dos morangos, possui mais desafios do que aparentar. No parágrafo anterior, ficou claro que ao passar do tempo os morangos vão sofrendo alterações em tempo de vida, tamanho e até o gosto. Outro ponto interessante nesta perspectiva é a diminuição da quantidade das mudas, que no começo faziam parte da produção, um fato que se relaciona com necessidade de fazer novos investimentos em adubação, por exemplo, novas mudas e aquisição da estrutura, para não afetar a produção. Em relação à aquisição da estufa, disse a

agricultora: ‘veio tudo pronto [...] tudo pronto, daí cê só pranta ali e agora cuida na adubação na água [...]’.

Na produção de morangos, a estrutura é simples, de ponto de vista dos componentes que uma estufa precisa para funcionar; além de ser construída a partir de materiais com fácil acesso e menos investimentos na produção (EMATER-RS, 2019). Como relata Calvete et al. (2016), esse tipo de produção pode acarretar uma excelente rentabilidade, já que pode ser produzido em vários momentos do ano, uma vantagem do cultivo em estufa. Por esse motivo, vale apenas investir, como disse a agricultora: ‘até o fim do ano não sei se não vai sair mais estufa [...] o de morango é certeza’.

Desta forma, certamente haverá na propriedade um aumento significativo na produção, mas também na mão de obra. Contudo, a agricultora trabalha individualmente:

“A verdade é quase eu sozinha [...] ele sai trabaia. Assim, ajuda muito poco. A parte de limpeza é só eu lá. Mas é eu que faço o serviço, ele trabalha com maquinário pra fora [...] assim trabaia pros outro [...] mais é eu mesma, é eu, porque se for espera pelos home [...] mais quanto eu tô muito apurada nós divide lá daí o serviço” (Agricultora)

A primeira conclusão desta fala, se deve a dedicação da agricultora. Percebe-se a dedicação e o comprometimento com o trabalho, a produção. O termo ‘ele’ se trata do esposo, que trabalha em outros empregos no mesmo meio rural para completar a renda da família de quatro membros.

Além disso, ao serviço fora da propriedade realizado do esposo da agricultora, se caracteriza no contexto do novo rural, no sentido econômico e social. Desta forma, o novo rural engloba impactos direto na economia familiar, normalmente por rendimentos insuficientes, que impulsionam esta saída ou o próprio desenvolvimento da comunidade (Silva, 2001; Rodrigues e Campanhola, 2003).

Faz parte do novo rural, a agricultura interligada com os avanços tecnológico, o modo de consumir e produzir, no sentido da transformação econômica e social (Silva, 2013). Contudo, percebe-se, na propriedade pesquisada, que a produção de morangos serve como para o impulsionamento econômico, obtenção de renda para a manutenção familiar, além de contribuir para a segurança alimentar, de ponto de vista nutricional, social e econômico. Com isso, na sequência discutiremos os dados

na perspectiva da segurança alimentar interligado com a produção dos morangueiros.

### 3.2 Segurança alimentar na perspectiva da produção de morangos

Neste estudo, leva-se em conta os aspectos da segurança alimentar. Logicamente, existem diversas interpretações da segurança alimentar no contexto local, nacional e internacional, portanto, a abordagem dela, não se afasta da qualidade dos produtos na perspectiva da aquisição da alimentação. Por outro lado, entende-se que é necessária a produção suficiente para alimentar os povos do mundo ou de uma comunidade, que, está interligada com o acesso ao alimento (Belik, 2003).

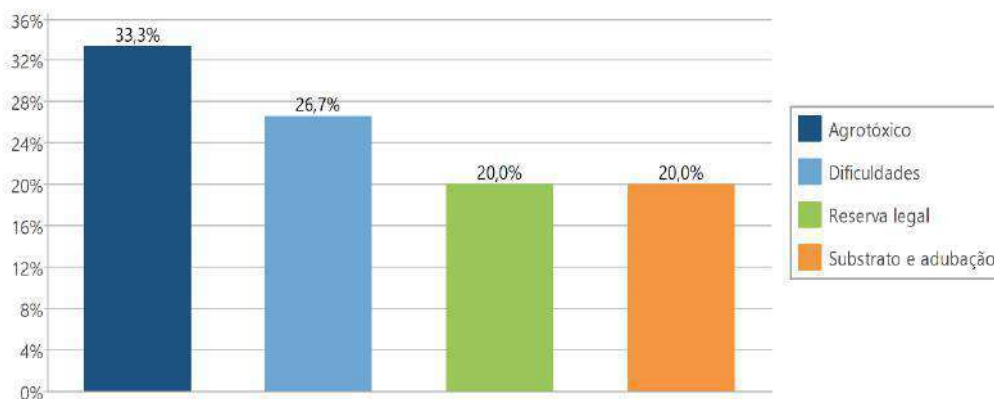
É importante evitar que a desnutrição tome conta das sociedades do mundo, diminuir a fome e a pobreza, dando ênfase ao volume de produção que se fundamenta no fortalecimento das produtividades de qualidade. Tais apontamentos ajudam a implementar uma justiça a favor da igualdade nutricional e social. Com base nisso, a

agricultura familiar tem este papel, de atuar na qualidade, na segurança de alimentar em função das necessidades humanas (Maluf et al., 2000; Exime et al., 2021).

É essencial, portanto, garantir uma alimentação digna no presente e no futuro, sem perder a qualidade alimentícia, além de permitir a distribuição justa, para implementar o acesso ao consumo (Maluf et al., 2000; Burity et al., 2010). Para que a luta contra a desnutrição e a fome aguda permaneça e vença, deve-se também trabalhar para o desenvolvimento agrícola de qualidade, suficiente e sustentável.

Ademais, verificou-se outros (Gráfico 1), que impactam a segurança alimentar e a produção dos morangos semi-hidropônica. Esses aspectos fazem jus aos desafios que se enfrentam no campo da produção de alimentos e muitas vezes impactam o trabalho cotidiano da agricultora, limitando econômica e socialmente o desenvolvimento agrícola da comunidade e da propriedade.

Gráfico 1 - Quatro desafios que impactam na produção de morango em Diamante do Sul, Paraná, Brasil.



Fonte: dados da pesquisa (2022).

O aspecto mais desafiador para a agricultora é o agrotóxico, que representa 33,3% dos desafios ao longo da vida dos morangueiros. Ou seja, além da aquisição, existem os cuidados específicos de aplicação. Nas palavras da agricultora, pode ser entendido o processo que envolve os desafios de manter saudável os morangos produzidos:

“Quando ele tá muito avançado cê usa mais, tem que ser com três dia. Menos de 3 dia você não pode colhe daí [...] só que ele já é lá do ministério lá que pode usá né? Não pode usá outras coisa [...] o valor deles tem vários preços ali que eu peguei. Tem

um de pó lá que é de meio quilo é trezentos (330) e trinta reais, só que cê usa mínimo ali, é graminhas que cê usa [...] daí cê dissolve na água e depois passa naquelas máquinas por cima, na folha, só quando tá muito avançado com aqueles pulgões que tem, aqueles tripes, daí cê tem que passa na folha. [...] daí como tava muito atacado eu tive que entrá com esse aí, três dia de carência, depois pode colhe normal [...]” (Agricultora)

Sendo assim, um dos cuidados principais é compreender quando usar o produto, que depende do tamanho dos frutos, tempo de vida das mudas e a estação do ano. Esta situação impacta diretamente no tempo da colheita, a salubridade dos consumidores, seguir à risca as recomendações dos técnicos e do ministério da agricultura, como disse ela no parágrafo anterior. Todos esses cuidados são importantes, segundo Ueno (2004), os agricultores devem estar atentos à frequência e quantidade de aplicação, já que consiste em frutos de alto grau de contaminação ao longo da produção até a distribuição.

Essas dificuldades se expandem até o manejo, que representa 26,7% dos aspectos desafiadores na produção, como relata a agricultora este é um dos aspectos mais complicados:

“No manejo [...] é muito, eu acho muito complicado ali, eu penso só no manejo, de limpá as folhas e tirá tudo, deixa tudo limpinho aquelas coisas velhas, porque precisa tirá tudo que vai saindo [...] o que tá saindo novo tem que deixa sempre ele limpo né? Ele vai ali tempo de sol tem que tirá, porque ele viu tirando a força [...] cê fica dexando coisa velha lá [...] é mudinha por mudinha, meu marido até briga comigo porque anoitece eu tô lá dentro [...] as vezes nem to enxergando” (Agricultura).

Porém, nas palavras da agricultora se percebe a dedicação necessária para produzir e manter as 1.450 mudas de morango, que envolve o manejo, o replantio e demais componentes, que podem afetar a produção. Sendo assim, esta realidade vai de encontro Picolotto et al. (2016), que relembram que além dos desafios mencionados, é preciso evitar qualquer estresse aos morangueiros.

Nesta perspectiva, deve-se considerar as ondas de calor que afetam as mudas e a temperatura ao redor da estufa dos morangueiros, cuja deve ocorrer a partir das reservas legais ou reflorestamento. Desta forma, a reserva legal tem a função da preservação da natureza, com rol importante para o equilíbrio ecológico, que abrange a necessidade de manter e respeitar o reflorestamento, por questões jurídicas, ambientais, além das econômicas (Bacha, 2005; Rodrigues et al., 2007).

Sob a ótica deste artigo, os desafios da reserva legal representam 20%, similar à adubação das mudas dos morangueiros. A agricultora afirma que o problema da reserva legal tem a ver ao desconhecimento da quantidade de hectares envolvidos e reitera: ‘Paguemos a reserva, ela é isolada lá perto do rio lá no final [...] a reserva de mata’.

Em relação às dificuldades relacionadas ao substrato e à adubação, o primeiro desafio é o econômico, incluindo os valores de aquisição das caixas dos produtos; segundo envolver a conservação e aplicação durante todas as semanas; e, o terceiro se deve ao mercado de substratos para os morangueiros na região, como se verifica:

“[...] o substrato eu não compro, porque já vem as mudinhas lá [...] dai a gente táca lá, né? Eu só compro os adubos memo, que eu tempero a água [...] daí quando é dia de compra adubo, cinco (5) de uma vez [...] tem um lá que é quatrocentos e pouco, só que cê usa mínimo, é bem poquinho o adubo. Agora do resto lá é mais barato [...] Daí o adubo que é pra pohná uma vez por semana, aquele lá é 100 real a caxinha de um (1) quilo [...] Quando eu comprei as coisa do morango já vem dentro já o substrato que fica dentro dos pacotes [...] agora você conserva só na adubação na água” (Agricultura).

Além das dificuldades citadas anteriormente, ficou claro que o maior desafio é encontrar fornecedores do substrato específico para o morango sem hidropônico na região. Cada aspecto apresentado tem papel fundamental na produção dos morangos, portanto, a resiliência da agricultura é essencial para que ela continue neste ramo. A partir disso, destaca-se a segurança alimentar para uma sociedade livre da fome e pobreza, que afetam diretamente o desenvolvimento de diferentes contextos. Conforme Burity et al. (2010), na ótica de garantir a segurança alimentar, vale destacar que os impactos socioeconômicos contribuem para avançar na busca de melhorias nas condições de vida das pessoas.

### 3.3 Impactos socioeconômicos e os efeitos da pandemia da Covid-19

No contexto dos impactos, a pandemia de Covid-19 que teve início em 2020, na cidade de Wuhan, na China, logo se propagou para outras partes do planeta. Ela se

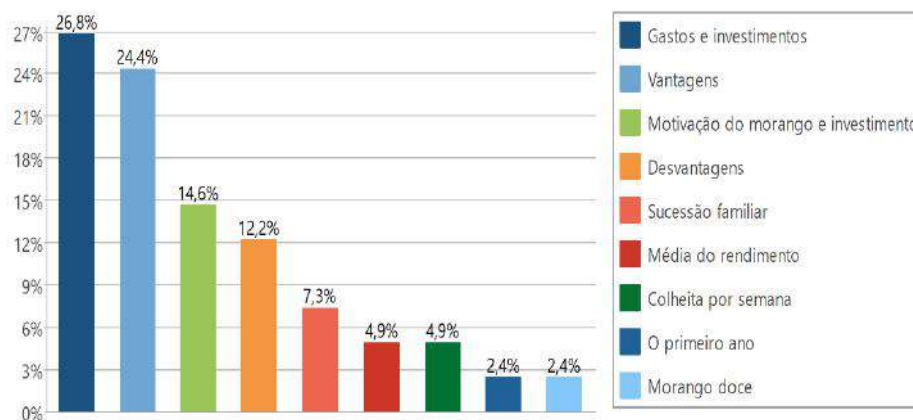
configurou como uma verdadeira luta em 210 países, impactando a vida das pessoas numa conjuntura econômica de produção e distribuição, entrelaçada com a vida cotidiana, que exigiu mudanças de comportamento de vivência. Contudo, Covid-19, não se tratou apenas de uma questão sanitária, sobretudo os impactos socioeconômicos foram ampliados, aumentando a desigualdade extrema, a fome e a pobreza sem precedentes (Gama Neto, 2020; Matta et al., 2021).

Entende-se que ela gerou impactos extremos na economia, principalmente quando se pensa sob a ótica de inúmeros setores da agricultura, que sofreram aumentos significativos de preço, gerando escassez de alimentos pelas restrições impostas para combater a doença (Bacen, 2020). Na perspectiva brasileira, vale lembrar que país não estava economicamente saudável. Entre 2015 e 2017 houve recessão da economia, causando o aumento do desemprego, acima de 13%. Antes da pandemia, o Brasil estava se recuperando timidamente, contudo, com a chegada da Covid-19 a recuperação passou para uma pesada degradação socioeconômica (Matte e Heinen, 2020).

Desta forma, os impactos negativos da economia afetaram também os agricultores do estado do Paraná em quase todas as regiões. Foi um duro golpe no início de 2020, em particular por falta de circulação de pessoas, cancelamentos das feiras livres de ruas, até a recuperação gradual. Isto se deve a importância da agricultura familiar para a economia e principalmente para a segurança alimentar (Claudino, 2020). Por outro lado, foi necessário mais coletivismo para enfrentar os desafios, com medidas de conservação ambiental, produção sustentável, além do combate à desnutrição alimentar (Ribeiro-Silva et al., 2020; Exime, Pallú e Plein, 2021).

Ao combater esses problemas, se faz necessário encontrar motivações suficientes, sejam elas no contexto econômico com o intuito de obter ganhos, para suprir as necessidades básicas familiares, transbordando o cunho social. Desta forma, no Gráfico 2 é possível verificar as características dessas motivações, entrelaçadas com as falas da agricultora desde case de sucesso da produção de morango.

Gráfico 2 - Motivações identificadas na produção de morango semi-hidropônico em Diamante do Sul, Paraná, Brasil.



Fonte: dados da pesquisa (2022).

As nove motivações são de suma importância para compreender se vale a pena, de fato, investir na produção de morango. Sobre os gastos e investimentos que representam 26,8% das motivações encontradas, quando separamos entre gastos e ganhos, segundo a agricultora os gastos são vistos como desvantagem (12,2%), porque são ‘embalagens, combustível para vir até a cidade’ e dos ganhos existem fatores que devem ser considerados na produção. Dentre eles, o tempo de vida das mudas dos morangueiros e sua manutenção, para poderem oferecer rentabilidade suficiente, como relata a agricultora: ‘eu

mesma tirei a minha com um ano e dois mês eu tirei meu investimento lá no morango’.

Neste caso, ficou claro que a agricultora teve mais ganhos que gastos. Por isto, entende-se, no relato, como funcionou o processo de aquisição e investimentos, que representa 14,6% nos aspectos de motivações. Ela relatou que já havia se planejado para investir na produção de morango:

“o morango há muitos anos a gente já pensava [...] via aqueles coisa mais linda tudo

pendurado, os moranguinhos. Eu fui até aqui no Campo Bonito vê [...] o que a mulher prantava, ela tinha nos potinhos, desses que pranta fror dentro, dentro dos vasilhos, tudo penduradinho assim [...] a muié tinha colhido assim, recém tinha colhido que nós ia lá, aí ela colheu porque era dia de entrega né? Tava tudo no depósito embalando, ainda tinha uns meio verde [...] aí eu achei é muito lindo, falei é meu sonho [...] agora consegui meu sonho” (Agricultara).

Desta forma, os investimentos não foram apenas para a infraestrutura, mas garantir estar alcançando um sonho de vida, que a incentivou a investir 24 mil reais, a partir do crédito rural. O investimento foi apoiado pelo Sistema Cooperativo de Crédito - SICREDI, que atua para facilitar acesso a créditos para produtores da agricultura familiar, com suporte técnico disponível para auxiliar nas decisões (Dambros, De Lima e Figueiredo, 2009). Por esse motivo e com força de vontade, o sonho foi realizado. Em razão disto, quando foi perguntado para agricultora sobre o significado do morango, ela respondeu: ‘Sonho, vida e trabalho’, uma definição que vai ao encontro dos pensamentos de Alves (1998, p. 77), com a seguinte reflexão: ‘De repente, olhando para a parede do precipício, viu uma plantinha e, nela, uma fruta vermelha. Era um morango. Ele estendeu o seu braço, colheu o morango e o comeu. Estava delicioso [...]’.

De fato, os morangos podem ser deliciosos e bonitos, mas, existem mais vantagens, que representam 24,4% do Gráfico 2, desde o preço, quantidade disponível para vender, consumir e deter uma renda mensal, além dos impactos sobre a segurança alimentar e a movimentação da economia local. O fato de a agricultora ter obtido o retorno do investimento inicial nos primeiros 14 meses, se deve à abundância dos frutos e a capacidade de evitar desperdícios,

“No primeiro ano ali o morango deu que nem água, no começo ali você não vencia, sobrava ... você tinha que fazê um preço ali meio barato pra você vende tudo, porque o morango você tira já

era né? Daí eu não sabia fazê geléia [...] agora nós fizêmo curso, nós sabe fazê coisa de geléia daí não vai fora [...] daí entreguei pra merenda essa geléia [...] sempre sai os miúdo né? Daí os miúdo vai tudo pra geléia [...] tinha as polpa de suco também, só que sai menos a polpa, eu oferecia no Valdir<sup>1</sup> daí ele disse que tinha poca saída, já não pegava, só que ele já não fica que nem o morango que cê tira na hora [...] mandei até pra São Paulo, uma irmã do compadre Juca levo pra lá os pacote congelado” (Agricultura).

Além de comercializar, normalmente a agricultora evitava o desperdício, aumentando seu faturamento, com os derivados, a citar: geleias e polpas de morango congeladas para suco. Outro fato é o impacto socioeconômico, que por consequência aumentou sua média de receita do rendimento total, que representa 4,9%, sendo a percentagem de motivação similar a colheita por semana. Além disso, os morangos doces (2,4%) aumentam os lucros não só no primeiro ano, mas, durante toda a produção.

Na perspectiva da média do rendimento, a agricultora disse: ‘calculo que sai 1 quilo por pé. Só que todo mês não vai dá a quantia que tá dando né? Têm mês que dá menos, tem um mês que dá mais, o morango [...]’. Esta variação por si só não afeta o rendimento total, porque com o passar do tempo vai aumentando, uma das maiores vantagens na produção.

Outro investimento vantajoso lembrado pela agricultora é um produto para deixar os morangos adocicados. Segundo ela: ‘comprei essa semana uma caxinha de um (1) quilo custo cem reais [...] cê faz os produto normal daí ponha mais esse na caixa, uma vez por semana pra ele fica mais saboroso [...]’. Além de um aumento considerável nos lucros, o uso do produto ajuda a aumentar a competitividade e o retorno mais rápido do investimento inicial.

Verificamos que a sucessão familiar representa (7,3%) das motivações, mesmo sendo uma incógnita para ela até o momento da produção deste artigo, relatou: ‘pelo jeito só o Rafael (filho), mas ainda ta indeciso. A Patrícia (filha) não,

<sup>1</sup> Mercado local.

ela que ir pra frente, ela não que roça não [...]'. Essa é uma situação comum na agricultura familiar, o trabalho pesado, a falta de acesso às tecnologias e de reconhecimento, são alguns dos fatores que impossibilita a permanência dos jovens no campo. Este é um problema que no futuro irá impactar seriamente a produção da agricultura familiar, responsável por 70% dos alimentos produzidos (Mello et al., 2003).

Nesta case, entendemos a importância da sucessão familiar na propriedade, além do possível impacto da falta da produção de morango, caso a sucessão não seja bem-sucedida. Apresenta-se na Fig. 3 a lista dos 21 códigos utilizados para compreender as características da propriedade, interligando a produção de morangos, motivações e desafios.

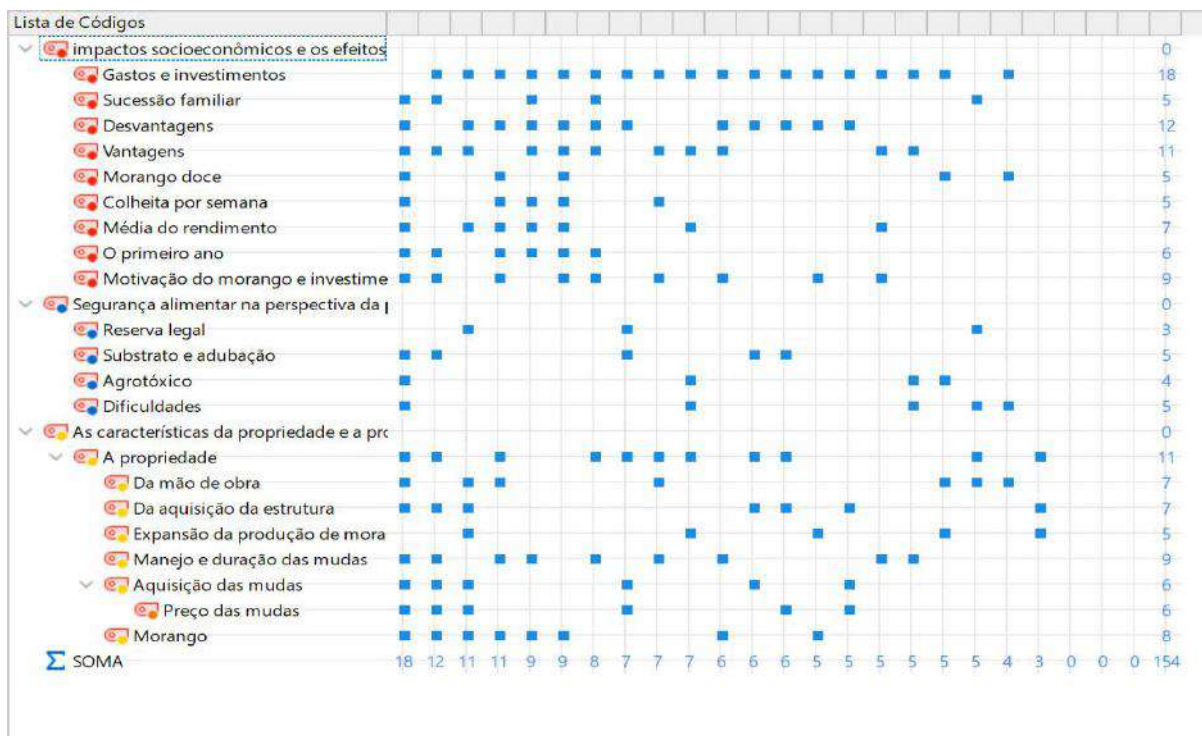


Fig. 3: Códigos de referências interligando desafios, motivações e características da produção de morangos.

Fonte: dados da pesquisa (2022).

No total das combinações entre os 21 códigos e os 3 tópicos, uma conexão de 154 repetições entrelaçados para entender a importância das características da propriedade, onde a agricultora pode aumentar sua produção por mais que 100 vezes e ainda assim teria espaço disponível para outras atividades diversificadas.

No contexto dos desafios e desvantagens, o manejo é principal desafio, seguido pela aquisição da adubação, agrotóxicos e o tempo destinado. Por outro lado, define-se a produção de morango como um negócio rentável, com fortes impactos socioeconômicos no município Diamante do Sul. Nesta perspectiva, o negócio se tornou viável e competitivo a partir da rentabilidade advinda da agricultura familiar (Moreira, 1999).

Em período pandêmico, a agricultora afirmou que não houve impactos negativos sobre as vendas, na produção e nem na distribuição dos morangos. Caracterizando-o como um sistema de cultivo excepcional, já de acordo com Matte

e Heinen (2020) durante a pandemia de Covid-19, o mundo foi afetado como nunca visto principalmente no contexto econômico. A partir do estudo de caso, empregue nesta pesquisa, mostramos que um único case pode influenciar positivamente a segurança alimentar e a rentabilidade de uma família de agricultores.

#### IV. CONSIDERAÇÕES FINAIS

Neste estudo apresentamos um case de sucesso sobre a produção de morango semi-hidropônico em Diamante do Sul, estado do Paraná, Brasil. Verificamos, que a produção de morango é de suma importância para o desenvolvimento local, auxiliando na geração de renda na perspectiva de redução de desigualdades sociais. Sendo assim, a produção de morangos semi hidropônicos está interligada com as inovações tecnológicas presentes na agricultura familiar, não apenas para a garantia da



produção ao longo do ano, mas também com o propósito de auxiliar na segurança alimentar.

Este *case* de sucesso compensa o investimento inicial de 24 mil reais (US\$ 4.678,36), pelo seu impacto socioeconômico na vida da família da agricultora. Portanto, este sistema merece novos investimentos para sua produção em uma escala maior, fortalecendo a autonomia produtiva e promovendo ainda mais o papel da agricultura familiar em tempos pandêmicos. Defende-se o compartilhamento deste *case*, para que mais agricultores possam conhecer uma nova forma de cultivar, produzir e obter renda significativa, além da melhoria da satisfação com o rural.

Finalmente, reivindica-se propostas de políticas públicas para incentivar outros agricultores na região a investirem neste tipo de produção, para facilitar o acesso ao substrato específico para morangos, os custos dos insumos ou até mesmo estimular o turismo rural nas pequenas propriedades. Este artigo contém algumas limitações. Estudos futuros poderiam explorar e aprofundar as discussões a respeito da sucessão familiar, desenvolvendo propostas para uma política pública concreta sobre a produção de morangos em semi-hidroponia em pequenos municípios.

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## Bacterial population of Rhizospheres and non-Rhizospheres of the mangrove species *Rhizophora mucronata* from 0 to 10 cm deep

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Received: 05 Jul 2022,

Received in revised form: 28 Jul 2022,

Accepted: 02 Aug 2022,

Available online: 09 Aug 2022

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**Keywords—** Mangrove, Rhizosphere, Non-rhizosphere, depths, Bacterial community.

**Abstract—** The interaction of plants and microorganisms in the rhizospheres and non-rhizospheres of plants is well studied and mastered in the terrestrial environment. In general, given the rhizosphere effect exclusively defining the effectiveness of root exudates to promote multiplication, development and microbial growth in the rhizosphere zones, studies unanimously tend to report that the microbial biomass is rather high in the rhizosphere than in the non-rhizosphere. However, the trend may change in the marine environment. This study was conducted in both the rhizosphere and non-rhizosphere of the mangrove species *Rhizophora mucronata* at different depths ranging from 0-10 cm, to assess the bacterial community in the rhizosphere and non-rhizosphere and to also address the profile of bacterial community changes. The result showed no difference regarding the bacterial abundance in the rhizosphere and in the non-rhizosphere. However, the abundance of bacteria at 0-5 cm depth was significantly higher in rhizosphere and non-rhizosphere. This could be attributed to the large amount of nutrients available in the surface layer. The unequal distribution of nutrients in the rhizosphere and non-rhizosphere of the mangrove species *Rhizophora mucronata* could be the consequences of mineralization, immobilization of nutrients in the soil and especially root exudation. The general results of this study can be summarized by showing that if the abundance of bacteria in the rhizosphere zones of terrestrial plants is often high, the trend may be different in aquatic plants, more particularly mangroves, which constitute a separate ecosystem.

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## I. INTRODUCTION

The interaction of plants and microorganisms in the rhizospheres and non-rhizospheres of terrestrial plants is well studied and mastered in the terrestrial environment. Most plants host diverse communities of microorganisms such as bacteria, fungi, archaea and protists (Ankati and Podile 2019). Various microorganisms can be encountered in the internal parts of the leaves, stems, roots, fruits and flowers, they are called endophyte microorganisms. Others can be encountered on the surfaces of the roots, these are the rhizoplanes, while others parts live on the aerial parts such as the leaves, fruits and flowers known as the phyllosphere. There are others microorganisms living in the vicinity of the roots known as the rhizosphere.

The rhizosphere is defined as the narrow volume of soil near root surfaces, with chemical properties directly affected by root exudates (O'Brien et al. 2018). In this environment heterotrophic microbes, including bacteria, fungi, protozoa, archaea and nematodes are attracted by organic compounds released by plants (Meng and Chi 2017). Chemotaxis, electronic signals characterized by electrical root surface potentials are among the causes of the attraction of various microbial species to root surfaces (Miura et al. 2019). Thus, cross-communication between plant roots and the associated microbiome is developed, and is necessary for the selective microbial colonization of roots (Huang et al. 2014). Studies of the microbial community of the rhizosphere compared to that of non-rhizosphere on terrestrial plants have shown great variation. This may be related to the fact that rhizosphere microorganisms benefit not only from organic compounds contained in the soil but also those released by plant roots. On the other hand, non-rhizosphere microbial communities obtain only mineral contents that make up the soil. On the aquatic and marine environment such as mangroves, studies comparing rhizosphere and non-rhizosphere community bacteria are rare and divergent.

Mangroves are particular plants developed in a complex ecotone between terrestrial and marine environments (Alzubaigy et al. 2016). The mangrove ecosystem is of great ecological importance not only for the various marine species that use this area as a refuge and feeding place, but also for the multitude of microorganisms that it harbors (Rigonato et al. 2018; Thatoi et al. 2012). This environment is subject to constant variations in water level, salinity, temperature and oxygen content, making these sites a reservoir of microbial species adapted to these changing conditions (Wanapaisan et al. 2018). The microbial diversity and abundance of the rhizosphere and non-rhizosphere in mangrove ecosystems may well be distinguishable from those on the terrestrial,

due to these changes in living conditions that remain poorly documented.

This study is interested in establishing the bacterial community of the rhizosphere and non-rhizosphere of a species of mangroves (*Rhizophora mucronata*) in Ouroveni in the Mbadjini-East region, Grande-Comoros. Therefore, rhizosphere and non-rhizosphere sediment samples are collected at a depth of 0-10cm. The aim of this study was to (i) compare the bacterial population of the rhizosphere of *R mucronata* with that of non-rhizosphere; (ii) identify the different nutrients present in the two media and (iii) establish a correlation between the different factors influencing bacterial diversity and dispersion in these two areas.

## II. MATERIALS AND METHODS

### 1- Collection of samples

Samples of rhizosphere (R) and non-rhizosphere (NR) mangroves were collected in the coastal area of Orouveni in Mbadjini-Est, Grande-Comoros (longitude: 11°54'45 S, latitude: 43°41'08 E and altitude: 0m). Three places along the closure of the intertidal zone to deep in the mangrove forest were chosen for the collection of rhizosphere sediments noted R1, R2 and R3 respectively. Sediment adhering to mangrove roots was collected as rhizosphere sediment, while non-rhizosphere sediment was collected away from plants and roots in particular. Polyvinyl chloride (PVC) tubes of 4.2 cm in diameter and 50 cm of length were used to collect sediment to a depth of 10 cm. Different depths are denoted as follows: Ni-1 (0-5 cm) and Ni-2 (5-10 cm), (N can be R or NR and i varies from 1 to 3). The stones or roots were removed and then the samples were transported to the laboratory of Animal and cellular biology at the university of Comoros to be preparing and sent to the environmental microbiology laboratory at Shantou University, Guangdong in China, for further analysis. The samples were divided into two groups, the first was stored at -4°C for the determination of the physical and chemical characteristics of the sediments and the other group used for the DNA analysis was stored at -20° C before DNA extraction.

### 2- Determination of physical and chemical properties

The temperature, pH and the value of the oxidation-reduction potential (ORP) at different depths, from the surface layer (0-5 cm) to the lower layer (5-10 cm) were measured respectively by using a hand-held thermometer, pH meter and ORP meter. Soil sediments were air-dried, crushed and sieved to 2 mm. For the determination of other characteristics, approximately 0.5 g of crushed sediment

was added in an Erlenmeyer flask, and digested by using the aqua-regia extraction method in three replicates (Victorio et al. 2020). Indeed, 10 mL of HCl/HNO<sub>3</sub>:O<sub>4</sub> (3:1) was added in the flask and digested at 180-200°C on a hot plate. The digested solution was diluted to 50 mL using deionized water and filtered. Fe, Mn, Zn, Mg, K and Ca were analyzed by inductively coupled plasma optical emission spectrometry (ICPOES). The standard concentration of 1000 mg/L was prepared for the calibration curves. Total nitrogen (TN), nitrate and nitrite were determined using the Kjeldahl method as described in (Willis et al. 1996). Phosphorus contents were analyzed using a double digestion with H<sub>2</sub>SO<sub>4</sub>/HClO<sub>4</sub>. Carbon and sulfur were determined by dry combustion using a high temperature induction furnace as described in (Lavkulich et al. 1970).

### 3- DNA extraction and amplification

Total genomic DNA of the different sample was extracted using an Ultra-Clean Microbial DNA Isolation Kit (MoBio Laboratories, Carlsbad, CA, USA). Polymerase Chain Reaction (PCR) amplification of the 16S rRNA genes from the V3-V4 region of each sample was conducted by using the universal primers, 338F (5'-ACTCCTACGGGAGGCAGCAG-3') and 806R (5'-GGACTACHVGGGTWTCTAAT-3') as was described in (Huang et al. 2014). The extracted DNA was sent to Sangon Biotec Institute (SBI) platform at Shanghai, China, to be sequenced. DNA concentrations and purity were measured using a NanoDrop 2000 spectrophotometer (Thermo Fisher Scientific, USA).

### Computational analysis

The de-duplication and filter-qualification of the raw fastq files, sequences classification, annotation and beta diversity distance calculation were performed by using Quantitative Insights Into Microbial Ecology (QIIME Version 1.9). UPARSE software (version 7.0.1001) was used to group the filtered sequences OTUs clustered with a 97% similarity cutoff. At 97% of confidence threshold, the taxonomy of each 16S rRNA gene sequence was analyzed using 16S rRNA database and the RDP Classifier (version 2.11). Different functional genes composition of bacterial community was determined by using PICRUST.

### Statistical Analysis

Data were subjected to statistical analysis of variance (ANOVA) in SPSS (20) software. Differences between means and multiples stepwise were performed using the appropriate post-hoc with a 95% confidence level. ANOSIM was used to evaluate similarities among different experimental group. The Shannon index was calculated to describe  $\alpha$  diversity and the richness of

microbiota. Different graphs were performed by using SigmaPlot and Origin pro.

## III. RESULTS

### 1- Physical and chemical characteristics of rhizospheres and non-rhizosphere

The in situ environmental properties of the rhizosphere and non-rhizosphere are presented in the following Table 1. Although no significant difference was noted, the pH value in the rhizosphere (R) was slightly low compared to that of the non-rhizosphere (NR).

#### 1.1- Concentration of ORP, nitrate and nitrite

The ORP was determined in the different experimental groups and in the different depth zones. What was interesting is that in the deep zone of non-rhizosphere 2 (NR2-2) and rhizosphere 3 (R3-2), the ORP was negative, indicating a reduction phenomenon and positive in the layer upper, indicating an oxidation process. By comparison of ORP in rhizosphere and non-rhizosphere, no significant difference was found.

Compared to the non-rhizosphere, the nitrate (NO<sub>3</sub>-) concentration in the rhizosphere was significantly ( $p < 00.5$ ) considerable. Considering the non-rhizosphere, the surface nitrate concentration (NR1-1, NR2-1 and NR3-1) was large compared to that of the underlying sampling area (NR1-2, NR2-2 and NR3 -2). Unlike in the non-rhizosphere, in the rhizosphere the situation was totally different. In the deep sampling area (R1-2, R2-2 and R3-2), the nitrate concentration was slightly higher than that recorded in the surface levels.

#### 1.2. Concentration of ammoniacal nitrogen, calcium, potassium and phosphorus

The concentration of ammoniacal nitrogen (NH<sub>3</sub>-N) was considerable in the rhizosphere compared to that of the non-rhizosphere, especially in R2-1. However, taking into consideration the "depth" factor, no difference was observed in the rhizosphere and non-rhizosphere samples. The carbon concentration in the rhizosphere was significantly higher compared to that determined in the non-rhizosphere. The calcium concentration was significantly higher in the rhizosphere at the surface level (R1-1, R2-1 and R3-1) compared to that observed in the non-rhizosphere and especially at deeper areas (5-10 cm). Although no significant difference was noted between rhizosphere and non-rhizosphere with respect to potassium (K) concentration, the trend on non-rhizosphere was slightly larger than that of rhizosphere. However, considering the different layers of depths, the concentration on the surfaces (0-5 cm) was significantly low compared to that of the deep zones (5-10 cm). The

phosphorus concentration was found to be significantly significant in the rhizosphere at the surface layer (R1-1, R2-1 and R3-1), while the lowest concentration was observed in the non-rhizosphere samples and especially in deep areas (NR1-2, NR2-2 and NR3-2).

### 1.3. Concentration of microelements

Microelements including iron (Fe), magnesium (Mg) and zinc (Zn) were also determined (Table 1). In the non-rhizosphere (NR1-1 and NR1-2), the Fe concentration was low, while in the remnants of the rhizosphere and non-rhizosphere samples it was significantly more considerable. Statistically no significant difference was

noted between rhizosphere and non-rhizosphere. However, a considerable difference was observed when considering the variation in depth. The samples at the surface were significantly rich in iron unlike those at depth. The concentration of Mg measured in rhizosphere and non-rhizosphere showed no significant difference. However, the distribution of Zn in different experimental groups and different depths sampling was satisfactory and similar. Additionally, the lowest concentration was noted in some rhizosphere sampling areas such as R3-1 and R3-2.

Table 1: Identified bacterial OTU number, different microelements and others physicochemical properties of rhizosphere and non-rhizosphere at different depths layer

	OTUs	pH	ORP	Nitrate (mg/L)	NH3-N (mg/L)	C (%)
NR1-1	118861	6.59	56.0 ± 0.10	1.99 ± 7.10	0.75 ± 2.9	1.32 ± 6.8
NR1-2	115117	6.64	23.6 ± 6.6	1.76 ± 0.3	0.73 ± 1.5	1.45 ± 1.4
NR2-1	118129	6.71	17.5 ± 0.10	1.76 ± 4.10	0.10 ± 3.9	1.93 ± 5.9
NR2-2	117628	6.82	-19.1 ± 6.6	1.61 ± 4.10	0.51 ± 0.2	1.80 ± 2.1
NR3-1	119080	5.76	84.3 ± 3.3	1.88 ± 2.10	0.35 ± 5.7	1.12 ± 5.9
NR3-2	117956	6.50	62.6 ± 6.6	1.73 ± 2.10	0.31 ± 5.9	1.23 ± 7.4
R1-1	121902	6.24	17.0 ± 0.10	2.25 ± 2.10	1.26 ± 1.2	2.19 ± 9.6
R1-2	121109	6.36	19.3 ± 3.3	2.56 ± 4.10	1.51 ± 2.4	2.09 ± 6.2
R2-1	127342	6.66	41.6 ± 6.6	2.42 ± 6.10	1.98 ± 6.9	2.16 ± 6.04
R2-2	122111	6.60	51.6 ± 6.6	2.93 ± 0.10	1.20 ± 5.3	2.29 ± 9.08
R3-1	123649	6.48	40.6 ± 6.6	2.74 ± 2.10	1.22 ± 1.6	2.08 ± 9.1
R3-2	122178	6.28	-101.3 ± 3.3	2.92 ± 8.10	1.22 ± 1.6	2.40 ± 7.9
	Ca (mg/kg)	K (mg/kg)	P (mg/kg)	Fe (mg/kg)	Mg (mg/kg)	Zn (mg/kg)
NR1-1	12.54 ± 7.4	114.84 ± 7.1	3.5628 ± 0.5	7.87 ± 3.6	3.38 ± 2.4	0.22 ± 0.5
NR1-2	13.81 ± 9.00	146.50 ± 5.9	4.1681 ± 6.2	9.01 ± 6.5	3.69 ± 8.3	0.24 ± 1.6
NR2-1	14.72 ± 7.5	161.23 ± 4.2	5.0207 ± 4.3	13.27 ± 3.2	4.71 ± 5.7	0.23 ± 6.4
NR2-2	13.70 ± 2.3	179.54 ± 9.7	4.7709 ± 6.3	12.28 ± 9.3	4.66 ± 6.6	0.24 ± 7.9
NR3-1	12.85 ± 8.8	126.44 ± 1.9	4.99 ± 8.05	13.68 ± 7.1	4.48 ± 3.3	0.24 ± 5.2
NR3-2	12.03 ± 6.7	153.09 ± 4.10	3.02 ± 1.6	17.68 ± 1.2	5.43 ± 9.4	0.23 ± 5.9
R1-1	16.64 ± 7.5	150.05 ± 6.9	7.56 ± 6.3	18.76 ± 6.1	5.51 ± 9.1	0.21 ± 8.7
R1-2	15.63 ± 6.5	165.15 ± 1.2	6.67 ± 1.07	15.75 ± 7.3	4.58 ± 3.3	0.22 ± 3.1
R2-1	17.72 ± 7.1	131.87 ± 3.1	7.53 ± 4.6	12.89 ± 8.1	4.64 ± 2.3	0.21 ± 0.3
R2-2	16.85 ± 7.6	156.46 ± 6.7	8.25 ± 1.4	19.08 ± 3.8	5.79 ± 6.7	0.23 ± 9.2
R3-1	15.44 ± 9.3	133.14 ± 3.8	6.40 ± 8.6	12.71 ± 4.9	4.92 ± 3.03	0.17 ± 2.5
R3-2	15.23 ± 3.0	142.30 ± 1.9	5.33 ± 1.5	14.16 ± 5.9	5.02 ± 4.4	0.14 ± 3.7

Data are the mean of the three replications ± standard deviation and were compared using post-hoc Duncan's multiple range tests at  $p < 0.05$

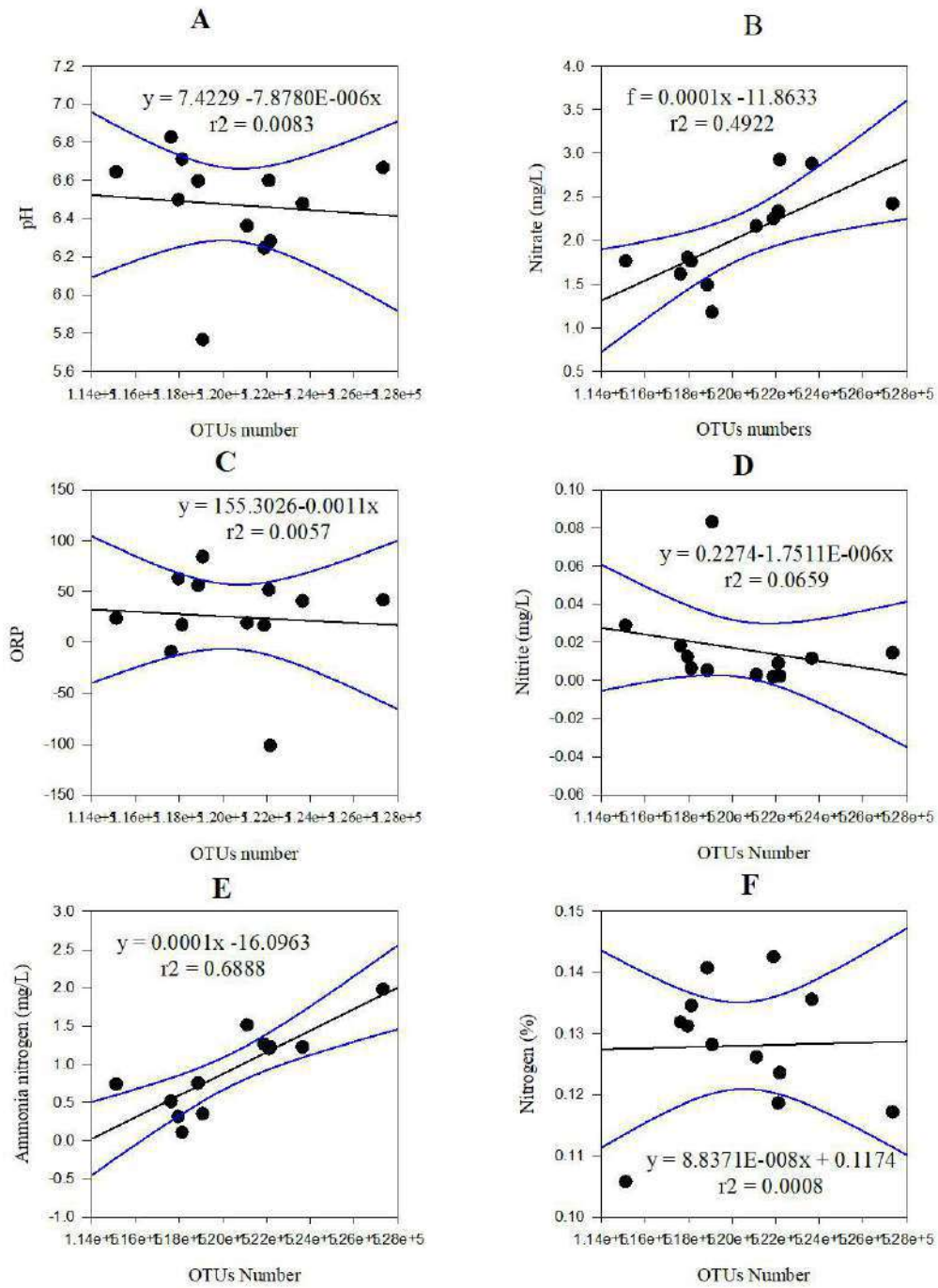


Fig.1: Correlation between pH (A), content of nitrate (B), nitrite (D), amoniacal nitrogen (E), nitrogen (F) and ORP (C) with identified OTU number.

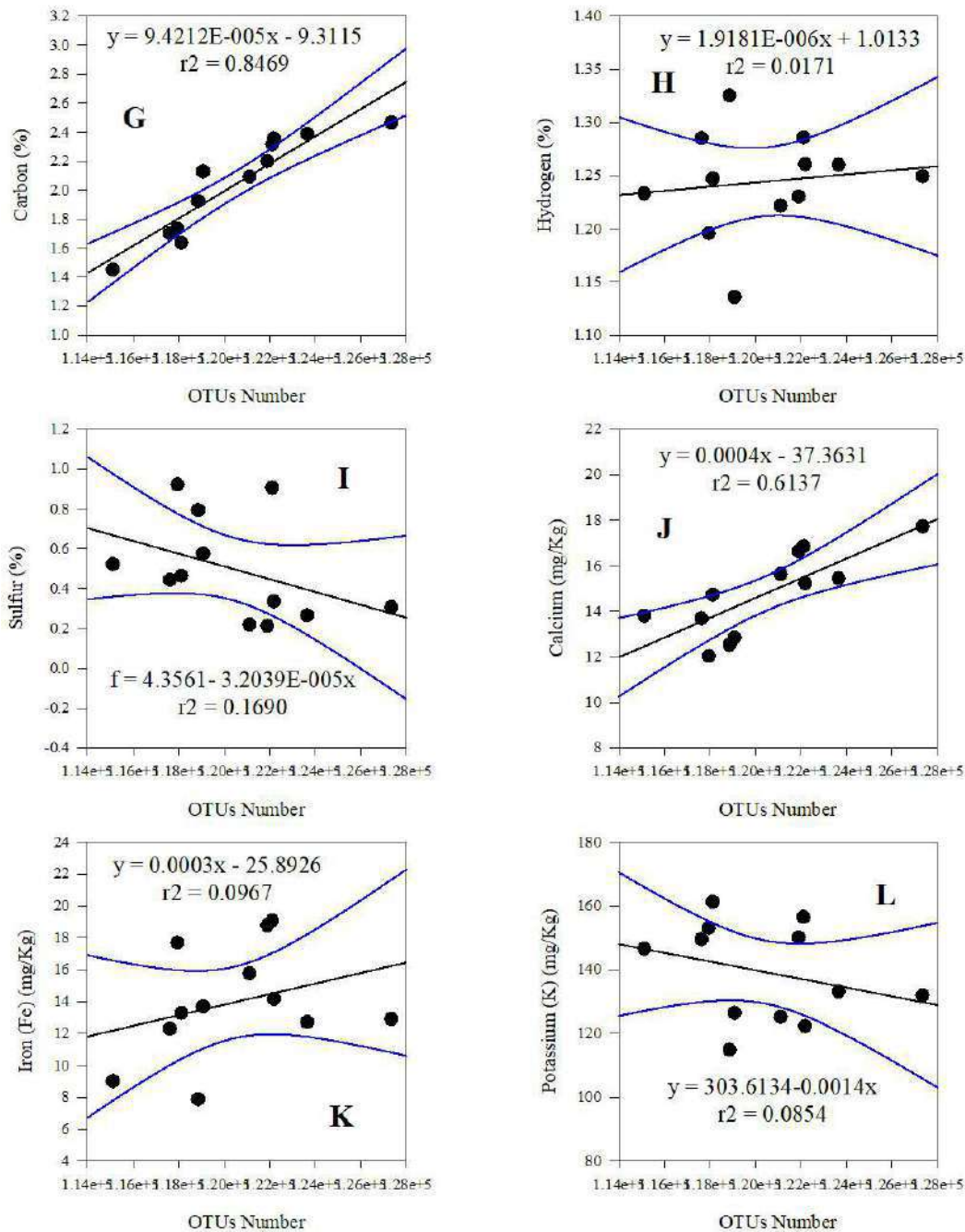


Fig.2: Correlation between carbon (G), hydrogen (H), sulfur (I), calcium (J), iron (K) and potassium (L) content with identified OTU number

**2- Bacterial abundance in the rhizosphere and non-rhizosphere**

Through 16S rRNA gene sequencing, 233978, 235757 and 237036 OTUs are identified in non-rhizosphere NR1, NR2 and NR3 respectively and 243011, 249453 and 245827 are identified in rhizospheres R1, R2 and R3 respectively (Table 1). The identified OTUs showed a slight difference between the NR and R samples. Taking into account the ‘depth’ factor, in the non-rhizosphere and

rhizosphere samples, the more depth we gain, the number of identified OTUs decreased. The richness estimated by the Shannon and Chao 1 indices was significantly higher in the upper layer compared to that of the underlying samples (data not shown). This corroborates the fact that in the upper layer (0-5 cm), the relative abundance of microorganisms is more considerable compared to that of the sample taken in the deep zone, whether in the rhizosphere or in the non-rhizosphere.



### 3- Correlation between identified OTUs and environmental parameters

The correlation test was used for the possible impacts of different environmental parameters on the abundance of bacteria (Figure 1). It was found that the abundance of bacteria shows no correlation with pH (Figure 1A,  $r^2 = 0.0083$ ), neither with nitrate (Figure 1B,  $r^2 = 0.4922$ ), nor with nitrite (Figure 1C,  $r^2 = 0.0659$ ), neither with ORP (Figure 1D,  $r^2 = 0.0057$ ), nor with nitrogen content (Figure 1F,  $r^2 = 0.0008$ ). On the other hand, a positive correlation is observed between the abundance of bacteria with ammoniacal nitrogen (figure 1E,  $r^2 = 0.6888$ ).

The abundance of bacteria in the mangrove was high and positively correlated with soil carbon (Figure 2G,  $r^2 = 0.8469$ ), and moderately with soil calcium (Figure 2J,  $r^2 = 0.6137$ ). However, no correlation was observed between the identified OTUs and the hydrogen content (Figure 2H,  $r^2 = 0.0171$ ), or that of sulfur (Figure 2I,  $r^2 = 0.1690$ ), or with the iron content (Figure 2K,  $r^2 = 0.0967$ ) nor with that of potassium (Figure 2L,  $r^2 = 0.0857$ ).

Furthermore, the correlation test showed no relationship between the identified OTUs and the content of magnesium (Figure 3M,  $r^2 = 0.1500$ ), manganese (Figure 3N,  $r^2 = 0.0047$ ), phosphorus (Figure 3O,  $r^2 = 0.3291$ ) and zinc (Figure 3P,  $r^2 = 0.2827$ ).

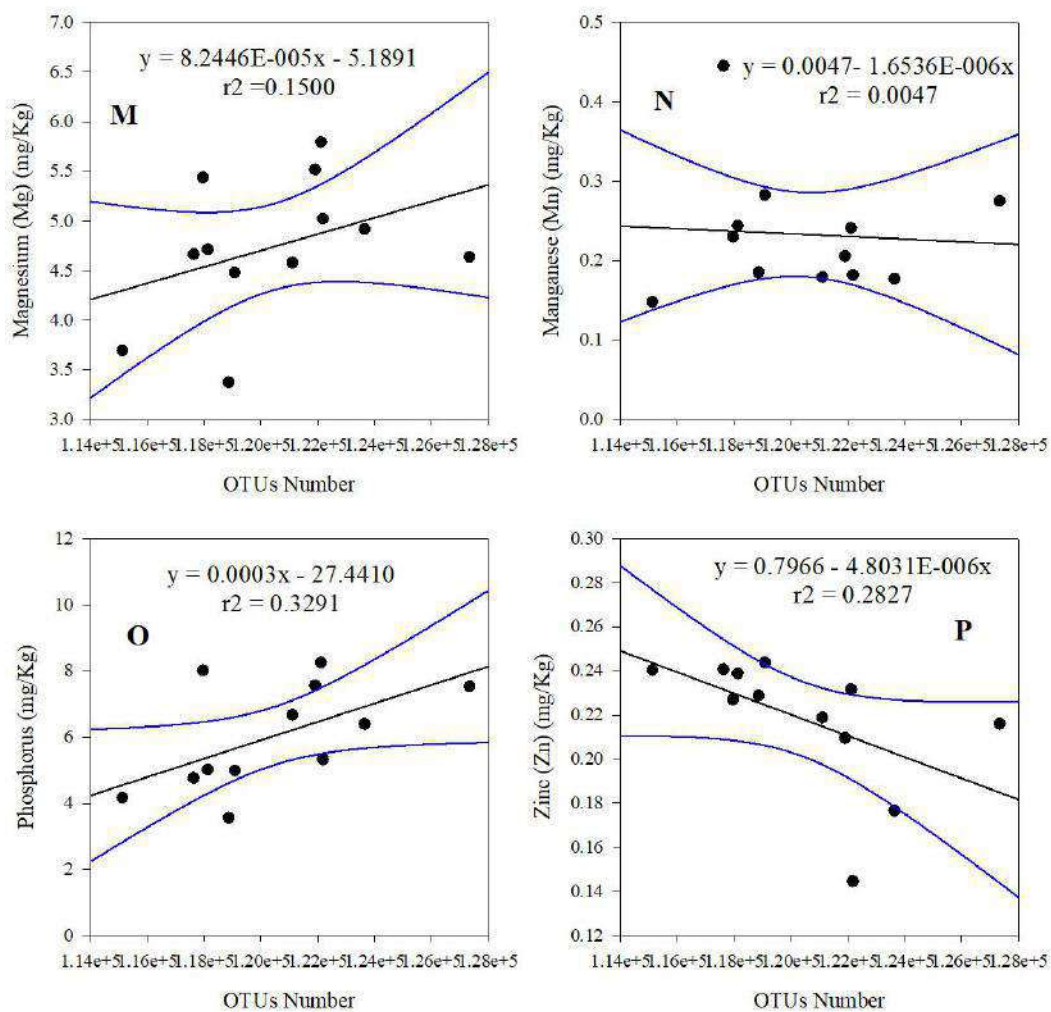


Fig.3: Correlation between magnesium (M), manganese (N), phosphorous (O) and zinc (P) content with the identified bacterial OTU

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### Relative diversity and abundance based on the different taxa

#### Based on class level

Figure 4 shows the relative abundance of bacteria according to the different classes. Generally, microbial diversity in rhizosphere and non-rhizosphere was not felt. The distribution of taxonomic classes in the two experimental groups and that for all the different depth levels was similar. On the other hand, considering the relative abundance, the difference was much more evident between the experimental groups according to different depth levels. It is important to emphasize here that bacterial taxa less than or equal to 1% have been classified

as others. The most presented bacteria belong to Gammaproteobacteria, Alphaproteobacteria, Desulfobulbia, Anaerolineae and Desulfuromonadia with respectively, 14.18%, 12%, 13.4%, 12.57% and 10.81% in the rhizosphere samples against 13.28%, 11.86%, 11.63%, 9.18% and 9.10% in the non-rhizosphere. Moreover, taking into account the depth factor, the deeper we get, the more the bacterial abundance decreased. Indeed, in the upper layer (0-5 cm), the microbial abundance was significantly higher, while in the deeper zone (5-10 cm), only microbes with a concentration less than or equal to 1% increased. This result corroborates the existing data according to which, in the ground, the bacteria are more important on the surface than in depth.

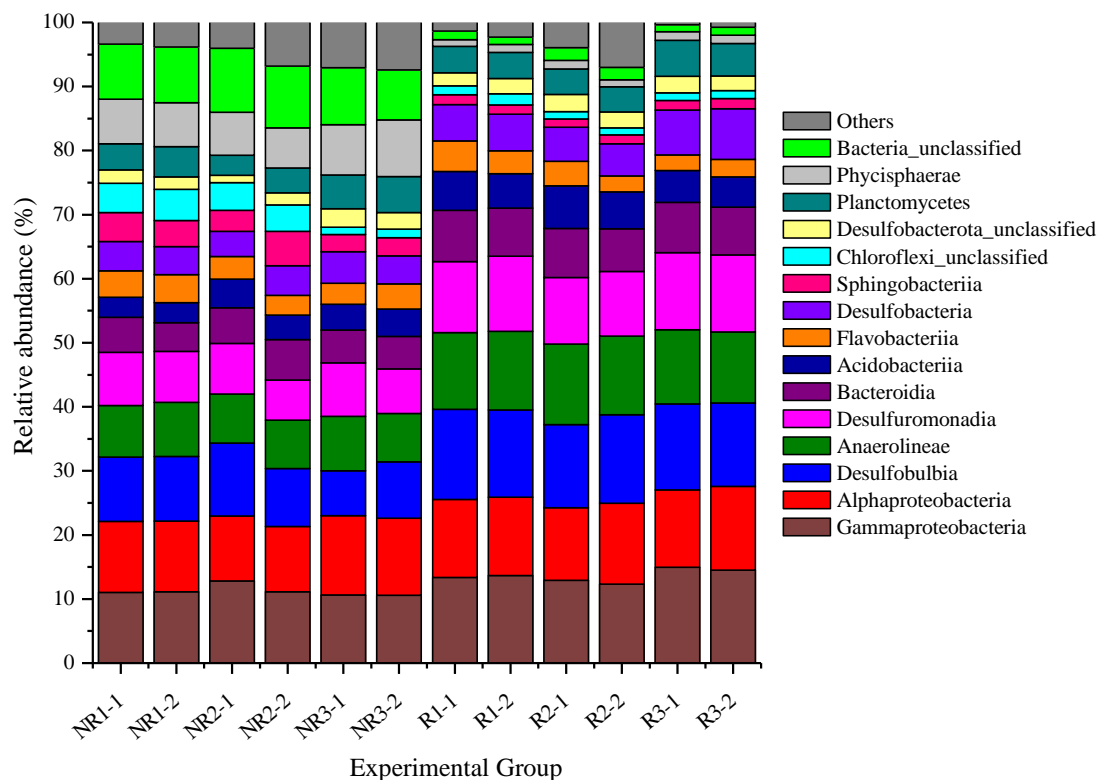


Fig.4: Relative bacterial abundance at the class level. The horizontal and vertical axis represent respectively the name of each sample and the abundance ratio in three repetitions. Each color corresponds to the name of the class and at the same time indicates the abundance of the different classes. NR = non-rhizosphere, R = rhizosphere

#### Based on genus level

The relative abundance of bacteria in the rhizosphere and non-rhizosphere of *R. mucronata* was further assessed at the genus level (Figure 5). The relative abundance of *Luteibacter*, *Alcanivorax*, *Pararhodobacter*, *Sphingobacterium* and *Pseudomonas* were significant in rhizosphere samples compared to non-rhizosphere with 10.66% # 4.12%, 16.20% # 6.31%, 9.55% # 3.39%, respectively, 9.50% # 5.48%, and 13.95% # 9.76%. In the

non-rhizosphere samples, the genus *Dyella*, *Acidiphilium*, *Defluviimonas* and *Altererythrobracter* were identified as significantly abundant with 13.25%, 7.13%, 16.28% and 8.86% against 9.13%, 2.70%, 9.46% and 0.40% in those of the rhizosphere. Taking into account the depth factor, in the non-rhizosphere, the upper layer (0-5 cm) was more frequented by microbes than the deeper zone (5-10 cm). However, the situation in the rhizosphere showed no significant difference.

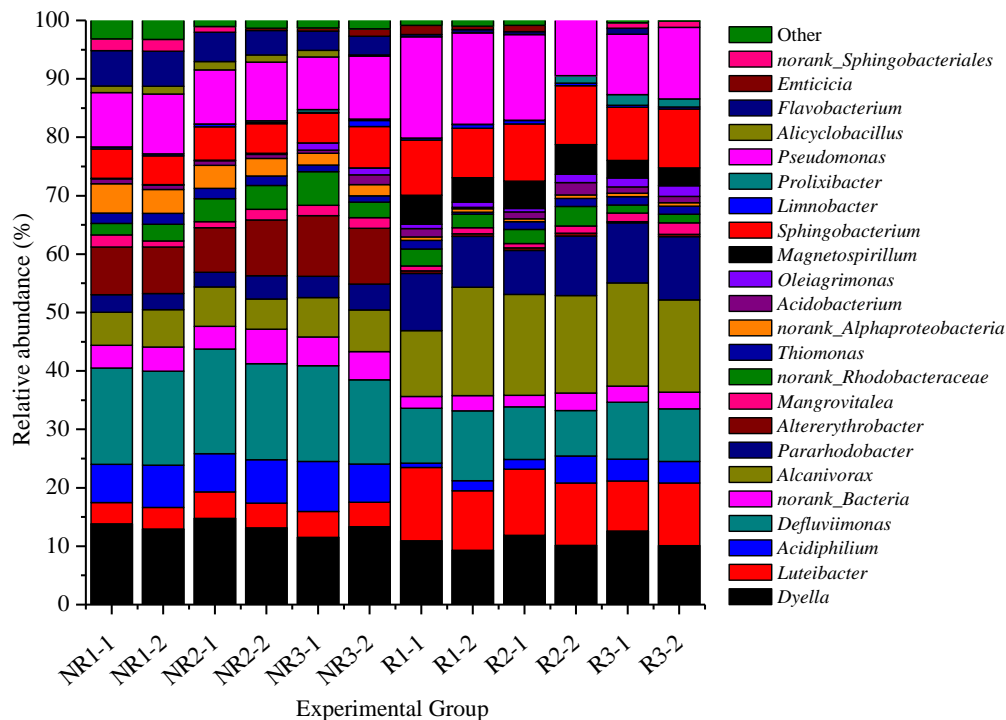


Fig.5: Relative bacterial abundance at the genus level. The horizontal and vertical axis represent respectively the name of each sample and the abundance ratio in three repetitions. Each color corresponds to the name of the class and at the same time indicates the abundance of the different genus. NR = non-rhizosphere, R = rhizosphere

#### IV. DISCUSSION

##### 1- Modifications of the physical and chemical properties of the rhizosphere and the non-rhizosphere

It is evident that the availability of nutrients and the speciation of essential metals in plants are pH dependent (Schneider et al. 2013). Although no significant differences were noted when comparing pH in the rhizosphere and non-rhizosphere, root respiration and soil microorganisms are known to be a source of pH-lowering proton H<sup>+</sup> production in the rhizospheres (Hinsinger et al. 2003). This could explain the slight variation in pH observed in the two experimental groups. The different forms of nitrogen determined vary from the rhizosphere to the non-rhizosphere and especially from one depth to another. This can be attributed to the process of net mineralization and sediment immobilization (Liu et al. 2020). Indeed, in the rhizosphere, the components of root exudates contribute not only to mineralization by enrichment in microorganisms, but also to immobilization via organic matter and by modifying redox conditions in the rhizosphere. Root activity through Root exudates of organic acids or root debris was the source of high organic carbon and nitrogen content in rhizosphere soil. High amounts of organic carbon in rhizosphere sediments may

be due to high organic excretion and high levels of organic colloids.

The microelements in the rhizosphere can be influenced by their ionic species and their contents depending on the pH and the chemical composition of the root exudates (Chiu et al. 2002; Mishra et al. 2017). Fe and clay oxides can adsorb cationic heavy metals or form co-precipitates. In mangrove sediments, the potential for oxidation and reduction is highly variable (Wang et al. 2016). In the present study, it was observed that the oxidation occurs in the surface, while in the depths the reduction occurs. The trend of Zn availability in rhizosphere and non-rhizosphere was similar. The low concentration of Zn is explained by the fact that the oxides of Fe can specifically absorb it (Chiu et al. 2002). In the non-rhizosphere however, the low concentration of carbon molecules limited soluble complexes with Zn. This could explain the high concentration of Zn at the different depth layers.

##### 2- Influence of physical and chemical properties on the bacterial community of the rhizosphere and non-rhizosphere

The dispersion of bacterial communities in the rhizosphere and non-rhizosphere was significantly different according to the different depth layers (Table 1).

This variation is mainly attributed to the different available nutrients, which in turn are conditioned by the physical and chemical properties of the sediments. Although these properties influence the bacterial community abundance of rhizosphere and non-rhizosphere sediments, their effects were variable with different depth variations. The abundance of the bacterial community on the superficial layers (0-5cm) was much greater. This would be related to the available nutrients, since the microbial richness in the vicinity of the rhizosphere is due to the excretions of root exudates (González-López and Ruano-Rosa 2020). However, on non-rhizosphere, nutrients would have their origin on the mineralization constituting an essential source of soil nutrients (Liu et al. 2020), or/and by the fact of tides and water runoff upstream of the mangroves. The correlation of the different factors and the abundance of bacteria in the different experimental groups (Figures 1, 2 and 3) would in fact be a consequence of the unequal distribution of resources. Numerous reports have shown that the correlation is always positive between the concentration of nutrients in the site and the abundance of microbes (Chen et al. 2016; Baumert et al. 2018). In general, given the rhizosphere effect exclusively defining the effectiveness of root exudates to promote multiplication, development and microbial growth in rhizosphere areas, studies unanimously tend to say that the microbial biomass is rather high. in the rhizosphere than in the non-rhizosphere (Gqozo et al. 2020; Li et al. 2016). Root exudates are an excellent source of nutrients for the development of microbes, which would be reasonable if the abundance of microbes is quite large in the rhizosphere, unlike non-rhizospheres. However, in our present study, although a slight abundance of bacteria was noted in the rhizosphere, no significant difference was observed, which contrasts with multiple published reports. Indeed if in general the root exudates increase the microbial biomass in the rhizosphere, this is not always the case in all circumstances. Studies by (DeAngelis et al. 2009; Mukerji et al. 2006) demonstrated that a selective effect on microorganisms can occur in areas of the rhizosphere, due to variations in root exudates depending on soil type, plant and microbial species. This can therefore lead to a large variation in the microbial biomass in the rhizosphere. Our study was conducted in mangroves which are quite particular plant species, not only by their distinctive abilities to grow in areas of high salinity and other waterlogging conditions, but also by their roots in structure and function unique. With the pneumatophore and stilt structure of mangrove roots, the excretion of root exudates and their mobility by seawater would be a consequence of the variation of nutrients on either side of the rhizospheres and non-rhizospheres. This could well

lead to a variation in bacterial biomass between non-rhizosphere zones and rhizosphere zones.

## V. CONCLUSION

In sum, through the present study, it was illustrated that the unequal distribution of nutrients in the rhizosphere and the non-rhizosphere of the mangrove species *Rhizophora mucronata* could be the consequences of mineralization, immobilization of nutrients in the soil and especially root exudation. The phylotypes identified in this study show that mangroves can serve as major discovery areas for microorganisms that can be used in various fields including bio-remediation of the polluted environment. Analysis of changes in the genomes of specific bacterial species would be one of the future works to illustrate the mechanism of their abilities to tolerate or degrade organic pollutants. Meta-genomics, meta-proteomics and meta-transcriptomics studies would also reveal the co-acclimatization and co-evolution of the bacterial community for better insight.

## ACKNOWLEDGMENTS:

The authors gratefully acknowledge the laboratory of environmental microbiology of Shantou University for their remarkable support.

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# A brief account of the 2030 agenda and its implications for Brazil and the Amazon Region in achieving Sustainable Development Goal 6: Clean Water and Sanitation

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Received: 03 Jul 2022,

Received in revised form: 26 Jul 2022,

Accepted: 03 Aug 2022,

Available online: 09 Aug 2022

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**Keywords**— *Agenda 2030, water and sanitation, sustainable development.*

**Abstract**— *The 2030 Agenda prepared by the United Nations (UN) in 2015 contains 17 Sustainable Development Goals (SDGs) broken down into 169 goals and 231 indicators to be implemented by 2030, among them, we highlight the goal Sustainable Development Goal 6: which deals with Water and sanitation for all and aims to achieve universal access to water services and collection and treatment of sewage by 2030 and the objective of this article was to highlight the challenges for the fulfillment of this goal, highlighting the indicatives 6. 1 and 6.2 with a focus on Brazil and Amazonas. The information related to the situation of SDG 6 in the Amazon region is presented and compared with the national realities or other regions of Brazil. To achieve the results, the information National Water and Basic Sanitation Agency (ANA), National Sanitation Information System (SNIS), Brazilian Institute of Geography and Statistics (IBGE), Institute of Applied Economic Research (Ipea) and National Household Sample Survey (PNAD) were analyzed in the period from 2016 to 2020, with scientific research methods with qualitative and quantitative data that examine the performance of Sustainable Development Goal 6. It was possible to identify that it is necessary to invest in water infrastructure in projects to alleviate the lack of sewage treatment that bothers Amazonian citizens. And the conclusion was that the participation and knowledge of different areas in integrated water management increases the likelihood of achieving the goals of Sustainable Development Goal 6 (SDG) by 2030, because the sustainable development of the country is linked to its population*

## I. INTRODUCTION

The contents of each section may be provided to understand easily about the paper. In 1953, the Legal Amazon was defined for land planning purposes, covering

approximately 60% of the Brazilian territory. The region that has 21 million inhabitants, about 12% of the country's population, 70% of whom live in cities and towns, became the target of many development policies in the 20th century and has structural and economic characteristics

different from the rest of Brazil, mainly because it has the largest rainforest in the world<sup>[1]</sup>

The Amazon biome is one of the essential locations in this process, locating and providing data for research and policy development, including coverage for a sustainable society. According to the National Institute for Space Research<sup>[2]</sup> (INPE, 2013), in 2012, the total area of deforestation in the Legal Amazon was about 755,000 square kilometers, equivalent to approximately 15% of its geographic area. Therefore, most deforestation is around 570,000. The square kilometers occurred between 1977 and 2004.

In this case, the environment is seen as an infinite source of resources that can be used to meet human needs and misused over time. However, over the years, its use has required a new form of planning to meet future demands<sup>[3]</sup>

The continuity of human existence today depends on healthy ecosystems and the flow of goods and services they provide. However, the current level of human intervention in natural ecosystems has altered sources of income, making it necessary to take steps to minimize environmental impact and develop sustainable systems.<sup>[4]</sup> Thus, Miola & Sciltz<sup>[5]</sup> report that the adoption of the 2030 Agenda aims to achieve a better and sustainable future for all. Therefore, to address the major challenges we face, recognize that poverty eradication requires strategies that can play a role in economic growth, ensure environmental protection, and manage a range of social needs, including health, education, and gender equality. Basic requirements for planning and monitoring public policies aimed at sustainable development. Therefore, this article aims to make a brief report on the objective of SDG number 6 and its main impacts on Brazil and the Amazon region.

## II. METHODOLOGY

A narrative and critical review of the literature was conducted. Articles in English, Spanish, French, and Portuguese, published in the last ten years, were searched in the PubMed/MEDLINE, Scielo, Sco-pus, Web of Science, google academic, Capes periodic, and Cochrane Library databases.

## III. THE DEVELOPMENT PROCESS

Of the multiple dimensions that encompass the development process of a society, it is possible to mention: economic development, social development, human development, endogenous development, underdevelopment, sustainable development,

organizational development, urban development, rural development, eco-development, regional development, and territorial development<sup>[6]</sup> The<sup>[7]</sup> idea of formulating a concept for regional development is utopian. That is, development is a multidisciplinary concept and is not only linked to the policy of incentives or income increase but, above all, to the ultimate objective of the well-being of specific populations. For example, the coordination of projects with a view to a virtuous cycle for the promotion of education, health, employment, social protection, and respect for diversity. This means that despite all the efforts, technologies, innovations, and methods to describe, measure, and evaluate a region in its development process, its true meaning is when people are able to cooperate among themselves. In order for this to happen, knowing the region is one of the main factors for the formulation of policies and programs focused on regional development in a way that is adequate to the characteristics and identity of each place<sup>[8]</sup>. Given this,

IPEA<sup>[9]</sup>, presented the proposal to adapt the global goals of the 2030 Agenda for Sustainable Development to the Brazilian reality, in compliance with the assignment received from the National Commission for the Sustainable Development Goals (CNODS) and in line with its mission to provide technical and institutional support to governmental actions for the formulation and reformulation of public policies and national development programs. Kronemberger<sup>[10]</sup> studying the challenges of building global SDG indicators, reports that building national platforms for the dissemination of indicators and/or other information on SDGs is very important because it creates a collaborative environment between different actors—such as different data producers—, allows for the gathering and presentation of SDG indicators, and becomes a database (statistical and geospatial)) that facilitates data sharing, visualization, and dissemination. Among the 17 indicators for development, in this article, we want to highlight SDG 6, which deals with drinking water and sanitation. Its establishment portrays the increased attention to the problems related to water and sanitation in the global political agenda. Carvalho; Barcelos<sup>[11]</sup> describe that the indicators aim to protect, restore, and promote the sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, halt and reverse land degradation, and halt biodiversity loss, with SDG 6 being one of those that most deserves attention around the globe, especially in socioeconomic development processes. According to FAO<sup>[11]</sup>, in Brazil, for instance, approximately 40 indicators have no data available in the country, covering topics such as economic losses attributed to disasters, sustainable agriculture, use of family planning methods, consumption

of materials, and several others. Therefore, the links between the dimensions of development are flawed or non-existent when it comes to the production of the indicators, as in "health and environment" or "health and living conditions."

**IV. DEVELOPMENT GOALS AND BRAZIL**

The Millennium Development Goals (MDGs) diverge from the Sustainable Development Goals (SDGs) on the basis that the MDG processes boil down to social issues with some financial underpinnings, whereas the SDGs are both more global and environmentally inclined. [12] It is worth mentioning that the SDGs can be considered as an extension of the MDGs. [13]

The 17 agreed Sustainable Development Goals include targets on a wide range of themes, such as poverty eradication, agriculture and food security, education, health, inequality reduction, electricity, water and sanitation, sustainable production and consumption, climate change, conservation and sustainable use of terrestrial and marine ecosystems, inclusive economic growth, infrastructure and industrialization, sustainable cities, governance, and implementation strategies. [14],[15],[16] They provide an integrated, holistic, and coherent framework to address the world's most pressing sustainability challenges and to create a better future for all, and among such SDs is access to "Water and Sanitation" (SDG 6). Water resources and related services underpin efforts to eradicate poverty, economic growth, and environmental sustainability. The main challenges related to water resources are the conservation and sustainable use of oceans and seas, freshwater resources, and combating water scarcity and pollution [14] According to the PNRH [17] the management of national water resources should be based on the goal of rationalizing management and integrating it with environmental management. The water sector is central and strategic to sustainable development, and the application of the Environmental Integration Principle (EIP) is one of the prerequisites for achieving this goal. The access to treated water as well as all the benefits generated by this process is the role of the State. However, in Brazil, some shortcomings are particular to each region analyzed.

TABLES 1, 2, and 3 show the analysis of households with access to the public water network, using data from the 2019 National Household Sample Survey (PNADC), and demonstrate the situation by region, especially the Northern area of the country.

Focusing on the main interest, which is the evaluation of inequalities in household access between services throughout the national territory, it is noted that Brazil had

a result of 85.5% of permanent private households served by the public water supply network. The Southeast region stands out, with 92.3%, while the North region presented a percentage of 58.8% in 2019, with the difference between these two being 33.5 percentage points. The result for the North region is lower than that of Brazil and the other geographic regions analyzed, showing regional disparities. It also shows that the percentages in the Northeast, Midwest, and South regions are much lower than in the Southeast.

On the other hand, data from the North region on supply by deep well or artesian well (21.3%), shallow well, underground well or water hole (13.4%), fountain or spring (2.8%), and 3.6% other forms of water supply are much higher than in the other geographic regions analyzed.

*Table 1-Household by source of water supply Country and macro-regions (%)*

Indicator:	Year	Brazil	North	Northeast	South	Southeast	Central-West
Households by source of supply in Brazil and by geographic region (%)	<b>General distribution system</b>	85,5	58,8	80,0	87,9	92,3	87,2
	<b>Artesian or deep well</b>	7,1	21,3	8,7	6,6	3,9	7,4
	<b>Shallow well or cistern</b>	3,2	13,4	3,9	2,2	1,4	3,5
	<b>Fountain or spring</b>	2,1	2,8	1,3	3,2	2,2	1,5
	<b>Another form of supply</b>	2,0	3,6	6,1	0,1	0,2	0,4

Fonte: IBGE. [18]

*Table 2- Index Share of the total population living in households with access to treated water in the country and in the macro-regions (%)*

Indicator	Year	Brazil	North	Northeast	South	Southeast	Central-West
Share of total population living in households with access to treated water (%)	2020	84,1%	58,9%	74,9%	91,3%	91,0%	90,9%
	2019	83,7%	57,4%	74,0%	91,1%	90,5%	89,7%
	2018	83,6%	57,1%	74,2%	91,0%	90,2%	89,0%
	2017	83,4%	57,3%	73,2%	91,3%	89,6%	90,1%
	2016	83,3%	55,4%	73,6%	91,2%	89,4%	89,7%
	2015	83,3%	56,9%	73,4%	91,2%	89,4%	89,5%

Fonte: SNIS [19]



Table 3- Rate of population with regular water supply (%)

Indicator	Year	Acre	Amapá	Amazonas	Pará	Rondônia	Roraima	Tocantins
Share of population with regular water supply (%)	2019	22,0%	46,9%	71,4%	48,3%	42,3%	73,7%	79,6%
	2018	22,4%	42,4%	67,3%	42,1%	37,8%		79,4%
							85,7%	
	2017	44,0%	80,9%	90,5%	88,1%	91,4%	98,0%	93,3%
	2016	40,7%	96,3%	89,5%	85,9%	89,9%	96,4%	98,7%

Fonte: IBGE<sup>[20]</sup>

When we take the analysis to the field of sewage treatment and minimum health conditions, which directly impacts the SUS (Brazilian Unified Health System), the data are even more astounding, revealing how far we are from reaching some of the goals proposed within the 17 SDGs.

As shown in TABLES 4, 5, and 6, and concerning the sanitation component, in Brazil, the share of the population living in households with sewage connected to the public collection network<sup>1</sup> rainwater network, or septic tank<sup>2</sup> connected to the public network increased from 65.9% in 2016 to 68.3% in 2019. It is registered, therefore, a slight improvement in sanitation conditions in Brazil. Differently, the Southeast region presented a percentage of 88.9%, considerably higher than the other demographic regions, and remained stable compared to previous years. The Northern region corresponded to 27.4% in 2019 and presented the lowest percentage in the analyzed period among the macro-regions. According to Lins <sup>[21]</sup> it is evident that there is an excessive difference among the Brazilian regions when it comes to investment and infrastructure that guarantee the health of the population. For this reason, the North is among the regions with the worst indexes regarding quality water and sanitation and, consequently, among those with the worst infant mortality indicators, for not having an adequate structure for the population.

<sup>1</sup> When the sewage pipe from a bathroom or toilet is connected directly to the sewage collection system, even if the system has no sewage treatment plant, it results in a general drain in the area

<sup>2</sup> When toilet sewage is connected to one or more tanks made of concrete, plastic, fiberglass, or other impermeable material, the liquid part is directed into the public sewage system

Table 4 - Index of households with mains or septic tanks connected to the mains in the country and in the macro-regions (%)

Indicator	Year	Brazil	North	Northeast	South	Southeast	Central-West
Domiciles with general network or septic tank connected to the general network in the country and in the macro-regions (%)	2019	68,3	27,4	47,2	68,7	88,9	60,6
	2018	66,3	21,8	44,6	66,8	88,6	55,6
	2017	66,0	20,3	44,9	66,0	88,9	52,7
	2016	65,9	18,9	44,2	64,8	89,0	54,7

Fonte: IBGE<sup>[20]</sup>

Table 5- Index Portion of the population without sewage collection in the country and in the macro-regions (%)

Indicator	Year	Brazil	North	Northeast	South	Southeast	Central-West
Share of population without sewage collection	2020	45,0%	86,9%	69,7%	19,5%	52,6%	40,5%
	2019	45,9%	87,7%	71,7%	20,5%	53,7%	42,3%
	2018	46,9%	89,5%	72,0%	20,8%	54,8%	47,1%
	2017	47,6%	89,8%	73,1%	21,4%	56,1%	46,1%
	2016	48,1%	89,5%	73,2%	21,4%	57,5%	48,5%
	2015	49,7%	91,3%	75,3%	22,8%	59,0%	50,4%

Fonte: SNIS<sup>[19]</sup>

Table 6- Index Portion of the population without sewage collection (%)

Indicator	Year	Acre	Amapá	Amazonas	Pará	Rondônia	Roraima	Tocantins
	2020	88,6%	93,1%	86,2%	92,2%	93,3%	36,7%	73,1%
	2019	90,0%	93,0%	85,1%	94,2%	94,1%	39,7%	70,5%
Share of population without access to water (%)	2018	89,9%	92,9%	90,0%	94,8%	95,1%		73,6%
							48,3%	
	2017	89,3%	93,4%	90,6%	93,7%	95,5%	58,2%	74,1%
	2016	87,8%	94,1%	92,7%	91,0%	95,9%	61,6%	78,3%
	2015	87,5%	96,2%	92,3%	95,1%	96,0%	61,9%	78,0%

Fonte: IBGE<sup>[20]</sup>

Goals 6.1 and 6.2, which deal with the provision of and access to safe drinking water and sanitation services, bring within them the concept of access to safely managed sources. The security character augments the understanding of mere access (called basic access) and is based on the idea that these services must be accessible on premises, available when needed, and free from contamination. <sup>[22]</sup>

Access to drinking water, sewage collection, and treatment is a right that must be guaranteed to all, as it is exactly this set of criteria that aims to preserve or modify,

if necessary, the environmental conditions of a certain place. Sanitation is intended to prevent disease and promote health, improving the quality of life of the population. In this way, the individual will also be able to develop productively and even reduce public spending on the treatment of illnesses. According to Instituto Trata Brasil, considering the progress in sanitation, it is estimated that, between 2015 and 2035, over BRL 7 billion will be spent in Brazil on hospitalizations or absences from work related to gastrointestinal infections.<sup>[23]</sup>, it is important to emphasize the role of the State and the conditions for the creation of public policies that aim to improve the quality of services in this sector, as it is imperative that countries that wish to develop increasingly distance themselves from this reality. For this purpose, it is necessary to carry out specific research and studies to identify the issues that concern sanitation, economy, and health.

## V. CONCLUSION

To face this disparity, actions, investments in engineering and technology, qualification, sustainable management alternatives, awareness raising, and social mobilization are essential, aiming at a way to compensate for this lack sustainably and employ governance models to study resorts in which community management can work together to alleviate this inequality in Brazilian society.

Investments in water infrastructure, based on a participative model with the entire population, are equally crucial so that they can prepare basic sanitation plans and adopt the public policies necessary to achieve universal basic sanitation by 2030. Therefore, in face of a national and local panorama of severe financial restriction, it becomes urgent to raise more and more public policies, seeking a more comprehensive approach among its various participants, so that higher levels of availability can be achieved and allow the sustainable development of Amazonas. These are very relevant challenges that, in some cases, require a large amount of financial and material resources to be tackled in a convenient way

## ACKNOWLEDGMENTS

CAPES, CNPq, FAPEAM e INMETRO.

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# Eucalyptus growth and initial productivity in response to different sources of boron

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Received: 06 Jul 2022,

Received in revised form: 30 Jul 2022,

Accepted: 04 Aug 2022,

Available online: 09 Aug 2022

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**Keywords**— *boric acid, boron tetraborate,  
forest nutrition, micronutrients, ulexite.*

**Abstract**— *Boron (B) deficiency in forest production systems has been reported in several eucalyptus species. The low biochemical cycling of B and the leaching losses justify the need for effort to get the fertilization of this nutrient right. In this context, the efficiency of three sources of boron with different solubilities was evaluated in a dystrophic Red Latosol, with a sandy loam texture, in eucalyptus crops at juvenile age. Ulexite (10% boron), boric acid (17,2%), and sodium tetraborate (15%) were evaluated, providing 800 g ha<sup>-1</sup> of B. For comparison, a control without boron was used, totaling four treatments in a randomized block design. To evaluate growth and productivity, total height (Ht) and diameter at breast height (DBH) were analyzed at 12 months, in addition to analysis of plant tissue at the end of this period. There was an influence of borate fertilization on the initial growth of eucalyptus (Clone I 144). Although there was no interaction between the sources of boron in the development of the initial dendrometric attributes, there was variation between the sources in relation to the concentration of boron in the plant tissue.*

## I. INTRODUCTION

Eucalyptus plantations have expanded in Brazil in soils with great variation in natural fertility, including areas of the cerrado, where low fertility, sandy textured, high acidity soils are common. At times still with great rainfall irregularity and where constant short mini droughts (veranicos) are observed. Compared to agricultural crops in general, some eucalyptus species have been considered to have a low nutritional requirement, in part due to their ability to develop in these edaphoclimatic conditions [1].

In early stages of growth, typically in sandy soils and in periods of intense water deficit, severe morphological symptoms, characteristic of micronutrient deficiencies such as Zn and B, are frequent. In less adapted genetic

materials, the death of the apical meristem is common, conditioning to overbudding and internode shortening, respectively.[1], [2]. In fact, hyposufficient availability of B or limitations of transport in the soil in dry periods, lead to nutritional disorders in plants, since this nutrient has, in general, low phloem mobility [3], suggesting the need to adopt adequate fertility management [4], [5].

On the other hand, there is a great lag in the recommendation of micronutrient doses for forest plantations in general, including eucalyptus, with generally generic recommendations [6]. This may be due to the greater financial expenditure and the greater frequency of responses to the addition of macronutrients in relation to micronutrients.

Despite the “supposed” low nutritional requirement of eucalyptus and high tolerance to  $Al^{3+}$  [7], plantations has shown great variation in response to fertilization with micronutrients [8], [9]. For B and Zn, regardless of soil class and genetic material, responses to fertilization have not been observed when there are no water restrictions [1]. In fact, under optimal conditions of humidity, the dynamics of mineralization of organic matter and decomposition of residues, when they exist, associated with low restriction of transport of ions or molecules in the soil, seem to be sufficient for the adequate supply of these nutrients to eucalyptus.

The main sources of B used as fertilizers include borax ( $Na_2B_4O_5(OH)_4 \cdot 10H_2O$ ), a colemanite ( $Ca_2B_6O_{11} \cdot 5H_2O$ ), ulexite ( $NaCaB_5O_9 \cdot 8H_2O$ ), sasolite ( $H_3BO_3$ ), datolite ( $CaB_2(SiO_4)(OH)$ ), boracite ( $Mg_3B_7O_{13}Cl$ ) e sodium tetraborate ( $Na_2B_4O_7 \cdot 5H_2O$ ). These sources present wide variations in solubility, so it is expected that they present different rates of B release in the soil, which can significantly affect the availability of the nutrient to plants over time [10]. Ulexite is one of the most used sources of B as a fertilizer and is characterized by its low solubility (1,09 g/100 ml) and variable concentration of B (~ 10%). A recent source on the market is sodium tetraborate, more concentrated in B (~15%) and highly soluble in water (2,65 g/100 ml). More concentrated than tetraborate, boric acid has around ~17,2% B, with a water solubility of 3,45 g/100 ml

Regarding nutritional deficiencies in eucalyptus when there is no adequate supply of B, symptoms of B “hunger” can be seen in leaves, young branches, and apical meristems. Initially, the lack of the nutrient promotes the degeneration of the meristematic tissues, generating malformation of the leaves and stem, directly influencing the shape of the tree. The non-cylindrical or conical shape greatly influences the use of wood, mainly harming the debarking in the production of cellulose, and the stacking of ovens to produce charcoal. The symptom begins with chlorosis on the leaf margins, which can progress to necrosis of the apical buds, known as “dry point” and manifests itself mainly in periods of drought, with accentuated water deficit, being easily observed in commercial plantations, due to decreased mineralization of organic matter, the main source of B in soil [3], [5].

Boron deficiency in forest production systems has been reported in several eucalyptus species. The low biochemical cycling of B in the plant (low mobility) suggests the need for a constant supply of the nutrient to

meet the demands of the crop throughout the cycle [3]. As a nutrient that is poorly retained by the soil, it is also subject to leaching losses. Therefore, depending on the soil and climate conditions, cultivation and the clone cultivated, the use of soluble fertilizers can be effective in the short term, so gradual release sources or combinations (soluble sources + low solubility sources) can be more effective for nutrient supply. in the medium and long term [11].

When the importance of fertilization with B (boron) was studied in the adaptive mechanisms related to drought tolerance and the better understanding of the relationships involving nutritional efficiency in different genetic materials and its influence on the selection of tolerant genotypes, a high increase in the efficiency of the water use in plants under drought and supplemented with B, due to the combination of high photosynthetic rate and high concentration of potassium [12].

Additionally, the low phloem mobility limits the internal cycling of the nutrient. Unlike most nutrients, the supply of B is more delicate, since the limits between optimal and phytotoxic levels can be narrow [13], thus requiring greater accuracy in fertilization recommendations. The tolerance of plants to B toxicity seems to depend directly on the translocation rate of the element from the roots to the shoot.

The phytotoxicity of B has been commonly found soon after planting or in the early stages of crop development [14]. Visually, the symptoms are characterized by chlorosis followed by reddening or necrosis of the leaf margins. Among the causes is the application of very soluble sources at planting in an inappropriate location, such as sodium borates or boric acid, or the use of high doses in the first topdressing fertilization [15].

Given this context, the effects of boron fertilizer sources that present different solubilities in a dystrophic Red Latosol with sandy loam texture were evaluated in eucalyptus plantations at juvenile age.

## II. MATERIALS AND METHODS

The experiment was installed in the city of Uberlândia, Minas Gerais, located in the geographic coordinates 19°06'17.50''S e 48°20'56.87'' W. According to the Brazilian Soil Classification System, the soil of the experimental area is classified as a dystrophic Red Latosol, with a sandy loam texture. (210 g de argila/kg) with the chemical characteristics shown in Table 1:

Table 1 - Soil chemical characterization of the experimental area at two depths.

Prof.	pH	P	K	Al <sup>3+</sup>	Ca <sup>2+</sup>	Mg <sup>2+</sup>	H+Al <sup>3+</sup>	SB	t	T	V	m
cm	H <sub>2</sub> O	---mg dm <sup>-3</sup> ---			-----cmol <sub>c</sub> dm <sup>-3</sup> -----				--- % ---			
0 – 20	5,2	3,41	103,7	0,30	0,44	0,53	1,52	1,23	1,53	2,75	44,74	19,61
20 – 40	4,9	3,04	25,56	0,35	0,27	0,27	1,37	0,61	0,96	1,97	30,74	36,57

Prof.	S	B	Zn	Cu	Mn	Fe	Ca/Mg	Ca/K	Mg/K	O.M
cm	-----mg dm <sup>-3</sup> -----									-dag kg <sup>-1</sup> -
0 – 20	19,80	0,24	2,33	0,04	2,86	8,34	0,9	1,7	1,9	0,52
20 – 40	16,71	0,14	1,15	0,13	1,35	11,43	0,6	3,3	5,2	0,68

P, K, Fe, Zn, Mn e Cu (Mehlich 1 extractor); Ca<sup>2+</sup>, Mg<sup>2+</sup>, Al<sup>3+</sup> (extractor KCl 1 mol L<sup>-1</sup>); H+Al = potential acidity, t = Cation exchange capacity (t = SB + Al); T = Cation exchange capacity at pH 7,0; SB = Sum of exchangeable bases; V = Base saturation; m = Aluminum saturation; O.M = Organic matter (Colorimetric Method) [16].

The local climate is characterized as Cwb according to the Koppen classification, with dry winters and rainy summers [17]. The area has an average altitude of 803 m. The average temperature of the hottest month during the experiment was 26.01 °C and the annual rainfall in 2021 was 1186.06 mm. It is also noteworthy that in the period from December 2021 to January 2022, rainfall was above the historical average for the region, with approximately 499.67 mm of rainfall in just two months. (Figure 1).

The following sources of boron were used: Ulexite with a concentration of 10% boron (granulated fertilizer), boric acid with a concentration of 17% boron (powdered

fertilizer) and sodium tetraborate with a concentration of 15% B (granulated fertilizer). The experimental design was randomized blocks, with a total of 4 treatments, each treatment with a source of boron and a control treatment (without addition of B). 6 replicates per treatment were used. The plots consisted of 4 rows with 5 plants, with a useful plot of 2 rows and 8 plants.

The plants received in the bed of the planting furrow at a depth of 40 cm: 380 kg ha<sup>-1</sup> of the NPK formulated 9:18:15 + 135 kg ha<sup>-1</sup> of Simple Superphosphate (SS) + 06% S + 03 Cu kg ha<sup>-1</sup> + 03 Zn kg ha<sup>-1</sup> (1,5 kg ha<sup>-1</sup> of Zn (ZnSO<sub>4</sub>); 1,0 kg ha<sup>-1</sup> of (MnSO<sub>4</sub>); 1,5 kg ha<sup>-1</sup> (CuSO<sub>4</sub>).

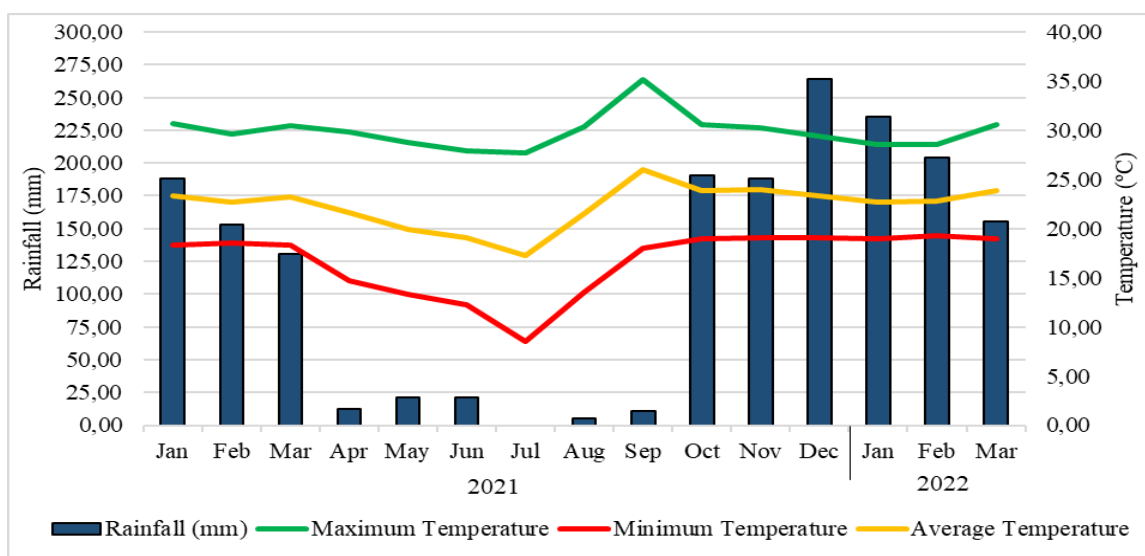


Fig.1: Minimum (°C), average (°C) and maximum (°C) temperatures and precipitation (mm) during the experiment.

In turn, the boron used in planting was applied in two covettes lateral to the seedling, at a dose of 800 g ha<sup>-1</sup> of

B, each treatment with its respective source, except for the control treatment. The application took place in the first

week of planting. The planting was carried out in February 2021 at a spacing of 3,4 m x 2,3 m. Each seedling received an irrigation of 2 liters of water per basin/hole after planting. The genetic material used was the clone of *E. urophylla* x *E. grandis*, named I 144, demanding in boron.

Every 15 days after planting until 3 months of age, visual evaluations were carried out in order to verify possible symptoms of B toxicity in the plants.

In the evaluation of growth, the height and diameter at breast height were measured at 1,3 m (DBH) of the eucalyptus at 08 and 12 months after planting the seedlings, using a wooden ruler and tape measure, respectively. Diameter data were grouped through prior analysis and empirical criteria into six diameter classes with 2,0 cm intervals for distribution checks.

For plant tissue analysis, mature leaves indicative of nutrition ("sample leaves") were collected at the end of February 2021, two in each quadrant of the middle third of the tree canopy, around 200 leaves from each plot.

In the determination of N and B, in addition to P, K, Ca, Mg, S, Zn, Cu, Fe and Mn, Malavolta and EMBRAPA methodologies were used, respectively [18], [19].

Data were submitted to analysis of variance. For analysis of plant diameter and height data, Tukey test was used up to 5% probability.

### III. RESULTS AND DISCUSSION

#### 3.1. Boron toxicity after planting

No symptoms of boron toxicity or deficiency were observed at 30, 60 and 90 days after planting the seedlings. The rainfall data show the occurrence of mild rains in the months following planting (Figure 1). As can be seen, there were occurrences of intense drought in the months of July, August, and September. It is also added that there were low temperatures in the dry season and even frost in the vicinity of the experimental area, which may have hampered the diffusion of boron to the vicinity of the radicle.

It should also be noted that in August, the relative humidity remained below 12% for more than 10 consecutive days. Prolonged droughts reduce the level of assimilable boron, both due to the absence of diffusion of the nutrient in the soil and the reduction of mineralization of organic matter [20]. In addition, these climatic conditions considerably reduce the photosynthetic rate and consequently the absorption of nutrients [21].

#### 3.2. Initial plant growth in height

The evaluation of plant height in mid-October did not show a statistically significant difference for the three sources tested, with a difference only for the control with reduced growth, in the absence of boron (Table 2).

Some authors verified that the critical level of boron, that is, the content of the available nutrient in the soil necessary to obtain at least 90% of the productivity, must be around 0,31 mg dm<sup>-3</sup>[15]. This value is above that found in the soil at the time of implantation. This justified the low increase in height of the control treatment that did not receive boron addition at planting.

Table 2: Average plant height variation considering boron sources at 8 months.

Boron sources	Height (m)	ANOVA (95%)
Control	0,43	b
Boric acid	0,67	a
Ulexite	0,65	a
Sodium tetraborate	0,66	a

From mid-October to the following February, there was abundant rainfall (Figure 1), promoting intense plant growth. Boric acid treatment had a 9,8-fold increase in height at 12 months of age compared to 8 months, while sodium tetraborate had a 10-fold increase in height at the eighth month assessment. On this occasion, the plants reached more than 4.5 meters in height in all treatments, except for the control, exceeding the expectation of 1,8 to 2,2 meters after the second year of planting, as is common in Brazil. On this occasion, the control plants continued with an average height statistically lower than the three sources of boron tested, as shown in Table 3.

Table 3: Average plant height variation considering boron sources at 12 months.

Boron sources	Height (m)	ANOVA (95%)
Control	6,34	b
Boric acid	6,56	a
Ulexite	6,58	a
Sodium tetraborate	6,60	a

It is noteworthy that despite the control having a lower growth than the other treatments, it had a notable increase in height. Some authors observed that in eucalyptus stands after 9 months, plants may develop fine roots more than 2 meters deep [22]. With precipitation above the historical average, the complementation arising from atmospheric

deposition of nutrients is also added [23], [24]. Thus, it is inferred that these aforementioned factors contributed to the height development of the Control treatment.

### 3.3. Evaluation of the average diameter of plants

The diameter of the plants, after the first year, showed no difference between the control without boron and the other treatments (Table 4). In fact, one of the functions of boron is the formation of the cell wall, with more pronounced effects on growth in height than in diameter.

Table 4: Variation of the average diameter of the plants, in the sources of boron at 12 months of age.

Boron sources	DBH (cm)	ANOVA (95%)
Control	6,12	a
Boric acid	6,16	a
Ulexite	6,18	a
Sodium tetraborate	6,19	a

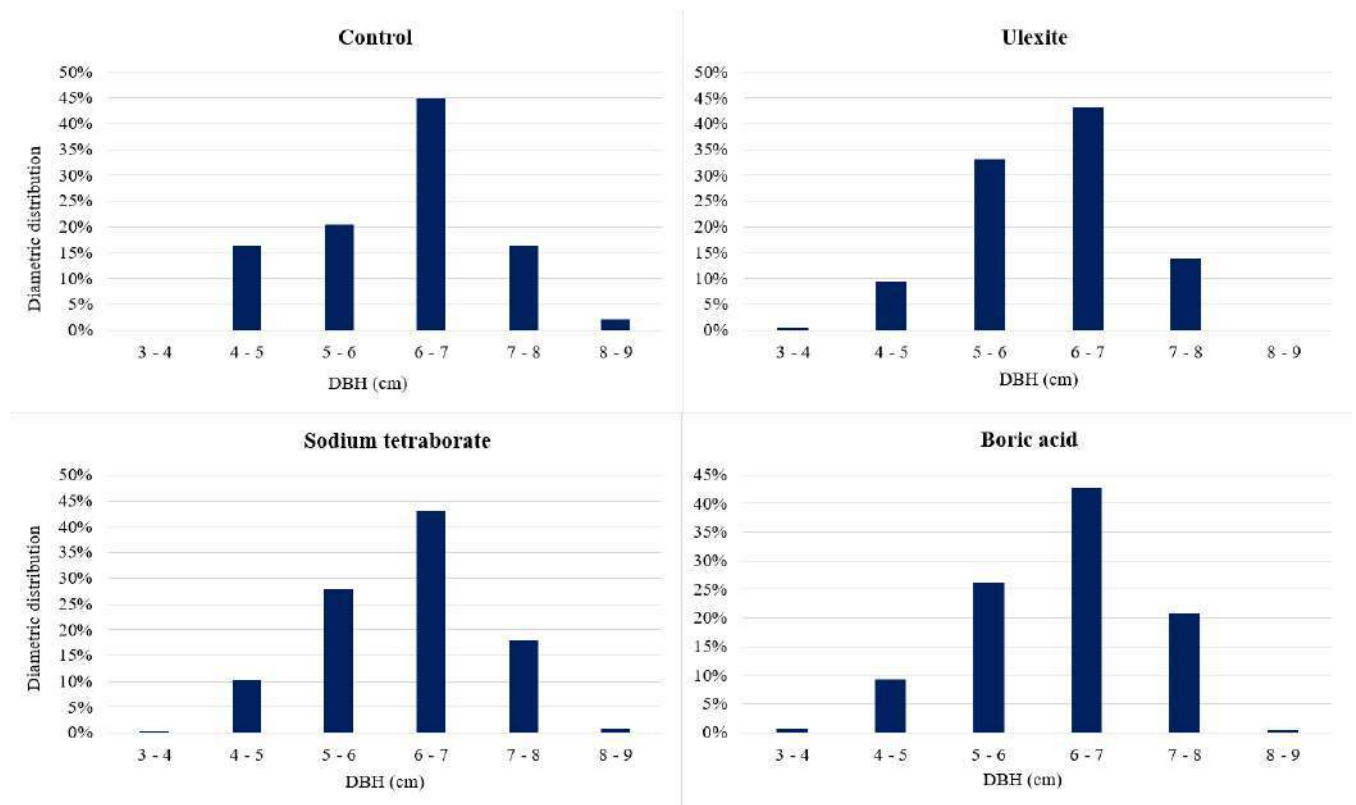


Figure 2: Diametric distribution for each boron source at 12 months of age.

The data set of the diameters of all trees in the different treatments presented a variation from 3,50 cm to 8,28 cm, with an amplitude of 4,77 cm. The distribution of the number of trees per class showed a tendency towards a normal distribution with mean, median and mode values close to each other, being 6,16 cm, 6,21 cm, and 6,68 cm, respectively, influenced by the presence of more individuals in the 4th class (Figure 2).

The diametric distribution curve has negative asymmetry in all treatments, which demonstrates that there are more individuals in the largest classes. The diameter production curve will be steeper, the more productive the site, and thus the earlier the maximum current annual

increase in diameter will occur, and the higher these values will be when compared to less productive sites [25].

However, the Control treatment is the one with the highest percentage of individuals in the 3-4 cm and 4-5 cm classes, totaling 16%. Some authors also observed that in less productive sites it is to be expected that a higher concentration of trees is found in lower classes [26], [27] which was not observed in this experiment.

### 3.4. Nutritional deficiency

At 12 months, some plants with dieback were found, as shown in Figure 3. This behavior did not have a pattern of occurrence between treatments. It was to be expected that it would be more frequent in the control plots, since the



soil had only 0,12 mg/dm<sup>3</sup> of boron, indicated below the critical level for this nutrient in the soil [15]

However, satisfactory precipitation between the 8th and 12th month seems to have facilitated the diffusion of boron in the soil for most plants, including the control. However, it should be noted that the “dieback” occurred in the middle of the rainy season, regardless of the source of boron, demonstrating that the initial dose of 800 g ha<sup>-1</sup> of B was not satisfactory to avoid deficiency of this nutrient (Figure 3). This behavior also contradicts the expectation that 10% of the final dose of boron should always be provided at planting[15], without observing climatic variations such as optimal precipitation and robust initial growth (“optimal start up”).

There were also some tortuosities between 2,0 and 2,5 meters, indicating a possible boron deficiency, but this symptom was not frequent in all plants of the different treatments.

The result of the leaf analyzes even before the dosages were complemented for each boron source showed that the boron concentrations in the leaves were identical for the Ulexite and the Control.

However, there was a statistical difference between the treatments with Tetraborate and Boric Acid in relation to the Control, and there was greater absorption of boron in the first two sources.



Fig.3: Loss of apical dominance observed at 12 months.

This can be explained by the higher solubility of these sources compared to ulexite in that condition of good precipitation in sandy-clay soil.

Thus, even though there were optimal humidity conditions, there was not enough ulexite dissolution and/or mass flow to supply boron to the plants in quantity to meet the demand (Table 5). Similar results were obtained by other authors comparing ulexite with more soluble sources, verifying that the low initial availability and slow release in the soil [28], [29].

Table 5: Nutrient concentrations in eucalyptus leaves, at 12 months of age, according to the variation of the Boron source and in the control. Equal letters in the column do not differ from each other.

Treatments	N g/kg	P g/kg	K g/kg	Ca g/kg	Mg g/kg	S g/kg	B Mg/kg	Cu Mg/Kg	Fe Mg/kg	Mn Mg/kg	Zn Mg/kg
Ulexite	18,45 ab	1,23 a	7,68 a	9,90 a	2,25 a	0,92 a	27,89 ab	6,17 a	87,52 a	567,66 a	22,86 a
Boric acid	19,33 a	1,33 a	8,23 a	10,87 a	2,38 a	1,05 a	30,41 a	6,24 a	83,60 a	581,76 a	14,96 a
Sodium tetraborate	19,35 a	1,32 a	8,32 a	10,44 a	2,40 a	1,01 a	30,45 a	6,30 a	78,96 a	487,74 a	15,09 a
Control	17,61 b	1,22 a	7,64 a	10,09a	2,24 a	0,89 a	23,00 b	6,10 a	73,42 a	513,48 a	13,44 a

A synergistic effect between nitrogen and boron is observed in eucalyptus. The combination of boron with nitrogen favored a better assimilation of the macronutrient, which may partially contribute to increase the synthesis and accumulation of carbohydrates and proteins [30].

The nutritional concentrations observed in the experimental area at 12 months for all sources are in sufficiency ranges that represent a relative growth of 90% according to the methodology proposed by some researchers [31], [32].

#### IV. CONCLUSION

1. The absence of boron negatively influences the height of clone I 144 in the initial stage of development
2. There was no difference in diameter and height in relation to boron sources in the initial growth of eucalyptus.
3. The less soluble source provided a lower concentration of boron in leaves at 12 months.

4. A synergistic interaction between boron and nitrogen was observed in the eucalyptus leaf until the end of the first year of cultivation.

### ACKNOWLEDGEMENTS

We thank the operational team at Fazenda Água Limpa at the Federal University of Uberlândia, and the teams at Eldorado Brasil and the Rio Tinto group (US Borax).

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## Handling of Peripherally Inserted Central Catheter (PICC) in Neonatal ICU

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Received: 05 Jul 2022,

Received in revised form: 31 Jul 2022,

Accepted: 05 Aug 2022,

Available online: 09 Aug 2022

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**Abstract**— This study has as research line Nursing Education and predominant area Nursing in Child and Adolescent Health Care. Where we will address as a theme the complications related to the handling of the picc catheter (peripherally inserted central catheter) in the NEONATAL ICU. The object of the study is the Iatrogenies related to the management of PICC in UTINEO. The interest in researching the subject arose after a technical visit made in a hospital unit of the public network in the ICUNEO sector, where it was observed the use of the catheter and its

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**Keywords—** Nursing, Intensive care, Neonatal ICU, Picc.

implementation, being carried out by the nurse at the bedside, a fact that motivated us to carry out the study, since it brings great benefits to neonates. Qor being an invasive procedure does the correct manipulation if necessary to avoid contamination, which caused us to question whether complications in handling the PICC catheter can be avoided? Through this questioning we are ready to conduct a research that aims to identify the main complications that cause the interruption of treatment in neonates. Metodologically is a quantitative research, where the exploratory-descriptive method of bibliographic typology was used. Conclusion Given what was exposed and explored during the research trajectory, we realized that it is necessary to invest in training and continuing education programs, as well as establishment of protocols and care that allow better monitoring of the occurrence of complications related to the insertion and handling of PICC.

## I. INTRODUCTION

This study has as research line Nursing Education and predominant area Nursing in the health care of children and adolescents. Where we will address as a theme the complications related to the handling of the PICC catheter (peripherally inserted central catheter) in neonatal ICU.

"Technological advances in the health area have brought several benefits in several areas and lately a technology has been widely used in neonatal icu, picc (peripherally inserted central catheter), which was developed for drug administration and intravenous solutions. This being a long and flexible catheter, inserted through a peripheral vein that, through an introductory needle, progresses to the distal third of the superior vena cava or inferior vena cava, thus acquiring properties of central venous access "(Nogueira et al 2004).

"It is a device that nurses have legal support for performing this procedure, so it is necessary that they have scientific knowledge that supports clinical decision-making and favors good care outcomes, continuously improving the quality of

nursing care." Vendramim (2007, p.28).

The object of the research is the Iatrogenies related to the handling of PICC in neo ICU. The interest in researching the subject arose from a technical visit to a hospital unit of the public network in the ICUNEO sector, where it was observed the use of the catheter and its implantation being performed by the nurse at the bedside, a fact that motivated us to carry out the research, in which we identified that by COFEN resolution no. 258/2001, in Article 1, it considers it lawful for nurses to insert the PICC, but complements in Article 2 that every nurse to perform this procedure, must undergo a properly regulated qualification course.

Because it is still a new and invasive procedure, it is necessary to correct manipulation, thus avoiding contamination of the catheter insertion site, and one of the problems observed in our research made us question: Can complications in the handling of the PICC catheter be avoided?

Based on this questioning, we were ready to conduct a research that aims to identify the main complications that result in treatment interruption in neonates.

The use of this therapy requires certain practical peculiarities ranging from blood vessel selection to access conservation. Therefore, it is extremely important that nurses have knowledge of the anatomy and physiology of the vascular system requiring professional qualification and qualification

(Rodrigues, Chaves & Cardoso, 2006 p.59).

In order to bring comfort and decrease the exposure of the NB to painful procedures, it is necessary for nurses to continuously seek training.

In neonates, peripheral venous puncture is one of the procedures performed with a very delicate technique. For this assistance there are different types of peripheral devices on the market and the most used are: Scalp Needle Catheters, Abocath Flexible Catheters and Central Peripheral Insertion Catheters (PICC). (Rodrigues, Chaves&Cardoso,2006 p.59).

The justification for this study is due to the fact that the PICC device is an alternative of peripheral central venous access, which can be inserted by the nurse (a) bedside and which today has been used as a device of first choice in neonatal intensive care units.

The academic relevance of this study aims to contribute to educational measures, improving the quality of nursing care and the actions of professionals in this issue, because it is a still new and invasive procedure, introduced in Brazil in 1990, it is necessary to correct manipulation avoiding for neonates the various punctures throughout their hospitalization, which greatly increases the risk of complications.

The social relevance of this study lies in the benefits it may generate for neonates (reducing the number of venous puncture, in the safety of work and in improving the use of this procedure in neonates, thus minimizing pain, stress, exposure to risks and complications) and for the family facilitating the link between parents and the NB.

## II. METHOD

The present study is characterized as an integrative review is a research method that allows the search, critical evaluation and synthesis of the available evidence of the theme investigated, and its final product is the current state of knowledge of the theme investigated, the implementation of effective interventions in health care and cost reduction, as well as the identification of gaps that direct the development of future research (Mendes, 2008)

Bibliographic research uses extensive literature to study and analyze different aspects of a theme,

contributing to a more structured future research. The bibliographic research was operationalized through the electronic search of scientific articles in the database of the Virtual Health Library from the descriptors: "PICC, CCIP". We chose to use scientific articles as material because they consider the accessibility of this type of publication for health professionals (Dyniewicz, 2009).

This is a quantitative approach, where the method used will be exploratory-descriptive, a bibliographic review of scientific articles, books and theses will be carried out, and these are carefully selected and existing material. It is noteworthy that the main advantage of bibliographic research is the fact that it allows the researcher to cover a series of phenomena more widely than it could be in direct research.

For Gil (2006) bibliographic research is developed based on material already elaborated, that is, officially published material. They are composed mainly of books and scientific articles.

*Table one. Inclusion and exclusion criteria for the construction of the research.*

INCLUSION CRITERIA	EXCLUSION CRITERIA
Articles addressing the topic	Publications related to other paediatric diseases
Articles published in Portuguese	Publications related to the adult audience
Bibliographies related to picc management in neonatal ICU	Articles published in other languages
Articles published from 2010 to 2016	Publications prior to 2010

**Source:** Own elaboration.

## III. LITERATURE REVIEW

### Nursing, the newborn, the neonatal icu

Modern care in neonatology appeared in France in 1880. The incubator was created by obstetrician Stephane EtienneTarnier and there was in this period a sophistication of techniques and equipment, thus increasing the survival of preterm drinks, until then considered unviable.

In 1914, pediatrician Julius Hess, created a care center for premature newborns at Michael Reese Hospital in Chicago, which was supported by nurse Evelyn Lundeen. The objective of this care center

was that the premature infant could receive immediate care as soon as he left the delivery room, ensuring specialized nursing care, making use of specific technologies to control and maintain the life of premature newborns (Rodrigues,2010).

It is important to emphasize that nursing was of paramount importance in the development of neonatology, and this fact was ratified by pediatrician Julius Hess with the publication of a scientific article that reports the best results in the care of premature newborns, when performed by nurses who received specialized training.

In the 1960s (between 1960 and 1970) the American Academy of Pediatrics began to consider neonatology as a specialty. Among the technologies that contributed to advances in the care of preterm and high-risk newborns, we can mention: thermoregulation, development of radiant heat appliances (incubator), ventilators with low pressure (inspiratory and expiratory), parenteral nutrition, use of catheters for venous infusion and neonatal transport (Christoffel, 2009).

Over time, more and more specialized centers have emerged and new technologies have been created that have ensured greater survival, as well as reduction of sequelae related to inadequate care.

In the 1990s, the importance of the insertion of family care was considered. The permanence of parents began to be valued in neonatal ICUs, a practice considered to date, being widely used to strengthen the bond between parents and newborns, favoring the success of treatment. These evidences caused the current models of neonatal intensive care incubator (Rodrigues, 2010).

According to the Ministry of Health, in Brazil, in 2010 there were 2,857,011 live births. Of this total, 201,929 were pre-terms with gestational age between 22 and 26 weeks, with the majority (84.1%) neonates aged between 32 and 36 weeks (Brasil, 2010).

The main population assisted in the NICU is characterized by preterm newborns (PTNB) who, according to the World Health Organization (WHO), are those with gestational age less than 37 weeks. It is a broad and heterogeneous group, because it includes children from the viability limit until near the end, presenting very variable physiological and pathological characteristics (Goulart et al, 2004).

A specificity of premature newborns is the fact of the occurrence of high rates of morbidity and mortality, in addition to the occurrence of sequelae that are often disabling or long-term, and may be due to their prematurity, inadequate treatment or lack of a technology that favors the care of premature newborns.

The modernization of the NEO ICU, with the use of state-of-the-art technologies, in addition to the standardization of nursing care (SAE), contributes to the reduction of iatrogenies that occurred in neonatal ICU.

Among the duties of the neonatologist nurse, we can mention: promotion of the adaptation of the NB to the external environment (thermoregulation, respiratory contribution and comfortable environment); Monitor the clinical picture, provide adequate nutritional support, help control infections, guide family members, standardize nursing care to newborns and mother, develop multidisciplinary activities, be an educator, establish THE and train the entire nursing team of the NEO ICU (Birindiba, 2016 p.15 apud Almeida, 2012).

It is necessary for nurses to always be aware of their duties and to continuously seek training to perform their function in the best possible way.

For the proper performance of their activities it is necessary that nurses have scientific knowledge, technical skills and the ability to perform careful evaluations of patients under their care, and it is necessary that this professional is in a constant process of theoretical-practical training, knowing the new technologies and applying them to improve the health care process (Duarte, 2007).

### **Intravenous erapia**

Intravenous therapy began on rebirth after the discovery of blood circulation.

Until the year 1400, no one knew the blood circulation, between 1400 and 1600, scientists of the time were unaware of important parts of the circulatory system. Only in 1616 did William Harvey discover the circulatory system and the difference between arteries and veins, and found that these structures contained blood inside them (Phillips, 2001).

"During the Second World War, nurses assumed functions such as: intravenous infusion, sutures, blood collection and vital signs verification (Phillips, 2001)" It is understood that at this time there was a need for the practice of intravenous solutions administration, where the pioneer was nurse Ada Plumer of the Massachusetts general hospital, first to minister intravenous solutions, in this period, the replacement of needles by catheters also arises; in 1980, the first peripherally inserted central catheters (PICC) emerged, which from 1990 on, began to be passed by a nurse in the USA. In Brazil, the practice emerged in 2000 as a new specialty in nursing, called intravenous therapy or vascular access; with the advancement of medicine this therapy has become increasingly necessary within Brazilian institutions and in the world.

Until 1920 vascular access was always obtained by means of a needle; in 1929 a German physician named Forssman anesthetized his own arm and inserted a urethral catheter into his antecubital vein, x-rayconfirming the catheter position in his right atrium, proving that a catheter could be safely inserted into a human heart.

"The use of PICC expanded from the 1980s onwards, with the improvement of the catheter, its initial use within UTIs-Neo and the subsequent dissemination to several hospital sectors, as well as home sectors" (Phillips, 2001).

"In Brazil, it has been employed since the 1990s in areas such as neonatology, pediatrics, intensive care, oncology and home care" (Vendramin, 2005).

In this sense, PICC has been widely used as an alternative of stable venous access and ensuring a safe and effective therapy for critically ill neonates.

### **Peripherally inserted central catheter (PICC)**

According to Baiocco (2013) the peripherally inserted central catheter (PICC) is a new technology for intravenous therapy administration; being introduced in Brazil from 1990, first in neonatology, due to its diameter and flexibility, in 1995 the use was started in adults.

In 1996, the Brazilian Society of Intensive Care Nurses (SOBETI) was the first scientific entity to qualify and certify nurses for picc insertion.

Because it is a deep access it allows us: infusions of solutions with extremeph and osmolarity, vesicant or irritating drugs, blood products, PVC verification and NPT infusion.

This device has one, two or three lumens, is long (20 to 65 cm long), with caliber ranging from 14 to 24 Gauge or 1 to 6 French(Fr), is flexible and radiopaque, has smooth and homogeneous walls, is made with biostable and biocompatible material, such as silicone, polyurethane and polyethylene; the new technologies applicable result in less thrombogenic catheters with less capacity to promote colonization of bacteria (Baiocco, 2013).

The introduction of the catheter can be done at the bedside by qualified nurses; it is inserted by peripheral vein (preferential basilica, cephalic and median cubital) and is palpable, calibrosa and non-sinuuous, which progresses through an introductory needle, with the help of blood flow, to the distal middle third of the superior or inferior vena cava.

Before insertion, nurses should consider some factors such as caliber and size of the appropriate catheter, venous puncture site, material required for maximum barrier paramentation, clinical conditions of neonates, such



as good peripheral, normothermic, hydrated perfusion, with oxygen saturation above 90%.

The PICC should be considered as a first choice access, and its indication needs to be discussed with the members of the multidisciplinary team, in order to ensure success in therapy and care actions.

"Among the advantages related to the use of PICC as a care tool for neonates in the Intensive Care Unit (ICU-Neo), the following stand out: the decrease in the frequency of venous punctures, the easy central venous access with the possibility of bedside insertion, the lower risk of complications related to insertion, when compared to other central venous accesses, the reduction of customer and team stress and low costs for implantation (Camargo et al., 2008)"

Therefore, the role of nurses working in UTINEO requires vigilance, skill, respect, updating and constant improvement, in view of the vulnerability of this clientele.

#### **Indications of picc in neonatology:**

As they report (Tamez & Silva *et al.*, 2002), the indications for long-term venous access through PICC, with minimal handling and stress for the newborn, especially the low birth weight premature infant, include the need to: Schedule of intravenous therapy above seven days, antibiotic therapy, venous hydration and parenteral nutrition (NP), infusions of: hypertonic solutions, vesicant and irritating solutions or with extremes of pH and osmolarity, antineoplastic drugs, vasoactive drugs and blood components (for catheters above 4 Fr).

#### **Contraindication of picc in neonatology:**

The contraindications in the use of PICC as described by Feitosa, Antunes and Arantes (2002), Sadeck (2007), Teresa Neto (2009), Rodrigues and Magalhães (2008) are: Manage large volumes "in bolus" and under pressure, difficult peripheral venous access by repeated punctures with hematoma and thrombus formation, insertion site with skin lesions, swollen (relative) RN, when you have difficulty identifying a vein of adequate caliber, previous Venopuncture or venous dissection, orthopedic problems, negative response of the vein to the procedure, refusal of parents, dermatological problem,

extremely small nb, hemorrhagic diathesis and disseminated intravascular coagulation.

#### **Cuidados in catheter maintenance:**

Daily assessment of the access site: permeability, signs of infection, catheter fixation, it is contraindicated to use syringes smaller than 10 ml, as they may rupture the catheter due to the pressure used.

#### **Thenalysis of data**

It is a detailed study on something, which can be applied in different areas of knowledge as a way to observe a given theme, and analyze the data of a problem and identify them.

#### **Anddescriptive statistic:**

"Descriptive statistics consists in the collection, analysis and interpretation of numerical data through the creation of appropriate instruments: tables, graphs and numerical indicators" (Reis, 1996).

In data interpretation we should use a more appropriate method depending on its nature which may be a verbal, numerical summary or use graphical methods to describe its characteristics.

"The data are the final result of the processes of observation and experimentation" (Vairinhos, 1996).

#### **Qualitivedata:**

We can describe qualitative data such as the representation of information that identifies some quality, category or characteristic. Example: gender, age...

#### **Quantitative data:**

We can describe quantitative data such as the representation of information resulting from characteristics with the possibility of being measured, which may be of a discrete (discontinuous) or continuous nature. Example: voting intention survey, seeks to estimate through the sample the total number of voters who would vote for each candidate (Reis,1996).

#### **Data analysis tools**

The research was carried out through the electronic search of scientific articles in the database of the Virtual Health Library (VHL) where the descriptors: Nursing were used. Intensive care. Neonatal ICU. Picc.

According to Severino (2007) An exploratory research was carried out that seeks to raise information about a given object, thus delimiting a work field, mapping the conditions of manifestation of this object.

The publications were initially evaluated by title, year and abstract, to make sure that they would meet the inclusion criteria. After were read in full.

In view of the above, 117 articles were excluded because they did not address the theme pertinent to the objective of this research or because they were in a foreign language.

The results of the selected publications are shown in **Chart 1**, as well as the main aspects analyzed.

*Frame. Analysis of the articles.*

Quantitative analysis of the articles found in the databases			
- 1st Stage			
DESCRIPTORS	VHL database		
	TOTAL	LILACS	SCIELO
NURSING	65.209	32.177	33.032
INTENSIVE TERPIA	11.236	7.466	3.770
NEONATAL ICU	1.383	1.124	259
PICC	299	246	53
TOTAL	78.127	41.013	37.144

Due to the large number of articles found, the descriptors were crossed in double refinement using only the filters, through the Lilacs, Scielo and Medline database, which resulted in the table below.

Quantitative analysis of the articles found in the databases			
- 2nd stage			
DESCRIPTORS	VHL database		
	TOTAL	LILACS	SCIELO
NURSING AND INTENSIVE CARE	3.537	1.941	1.596
NEONATAL ICU AND PICC	30	25	05
TOTAL	3.567	1.966	1.601

**A picture.** Analysis of the articles.

**Source:** Own Elaboration.

In all, 142 articles were found, of which 15 articles were analyzed, abstracts were read and those that fit the subject were selected. For the research, 10 articles were used that is arranged in the tables below.

*Frame. Quantitative analysis of articles.*

Quantitative analysis of the articles found in the databases			
- 3rd stage			
DATA	VHL database		
	TOTAL	LILACS	SCIELO
FOUND	142	133	09
ANALYZED	15	20	04
USED	10	07	03

**Source:** Own Development

*Frame. Representation of the main aspects analyzed in the publications.*

Authorship	Article Name	Sample study type	Goal	Results and Conclusions
Freitas & Nunes (2009)	The nurse in the praxis of peripherally inserted central catheter in neonates	Descriptive non-experimental study, with longitudinal design and prospective data collection on the practices of insertion, maintenance, picc removal and related complications.	Describe some variables related to the procedure of insertion, maintenance and removal of the peripherally inserted central catheter in neonates hospitalized in the ICU.	It is concluded, therefore, that picc is a technological advance in NICUs, providing advantages for the patient. It meets the needs of intravenous therapy, allows greater probability of remaining implanted until the end of treatment, reduces the stress of successive punctures, preserves the catheterized vessel.
Baggio, Bazzi & Bilibio	PERIPHERALLY INSERTED CENTRAL CATHETER: description of use in neonatal and pediatric ICU	Descriptive, retrospective, documentary survey	Describe the use of PICC in UTINEO PICU, regarding insertion, maintenance and removal, and identify the profile of children who received PICC	For better performance in catheter maintenance, training and continuing education of professionals are required, strategies aimed at qualifying care
Hills Teixeira, Barbosa & Barichello	Occurrence of complications related to the use of PICC in newborns	Retrospective, descriptive study with quantitative approach, in a large, public teaching hospital that serves high complexity patients in the city of Uberaba-MG	Identify the occurrence of picc-associated complications in newborns admitted to the neonatal intensive care unit	The results suggest that there should be investment in training and continuing education programs, establishment of care protocol, and conducting longitudinal studies that allow a better follow-up of the occurrence of complications related to the use of this type of catheter
Motta et al	Peripherally inserted central catheter: the role of nursing in its use in neonatology	Documentary research	Check the use of peripherally inserted central catheter in a neonatal intensive care unit (ICU)	In this study it was verified that the use of PICC is really important, because it is possible to observe the numerous benefits that this procedure brings to the newborn, especially with regard to the decrease in the number of punctures and, consequently, reduction of stress and pain, because this device, for the most part, remains the necessary time for treatment
Beautiful et al	Knowledge of	Descriptive, cross-	To analyze the	It is concluded that the

	neonatology nurses about peripherally inserted central venous catheter	sectional study with quantitative approach.	knowledge and practice of nurses about the use of PICC in newborns.	peripherally inserted central catheter is a technological advance in the NICU, providing several advantages to the newborn, especially those at high risk. However, despite the benefits of this technique, a large portion of the nurses surveyed did not have a license to insert the PICC and only two neonatal units used this technique in daily practice.
Teles	Insertion and maintenance of picc in icu: the need for peculiar nursing care	Bibliographic review of scientific articles, nursing journals and specialized protocols. Exploratory-descriptive	Describe nursing interventions based on care related to the implementation and maintenance of picc.	The study demonstrated the extremely important role of the nursing team with regard to practices and interventions with technical-scientific knowledge, during the implantation and maintenance of the PICC device in neonates hospitalized in the NICU.
Duarte et al	Factors associated with infection by the use of peripherally inserted central catheter in a Neonatal Intensive Care Unit	Epidemiological and analytical study, developed in a hospital in Belo Horizonte, Minas Gerais	To analyze the factors associated with infection by the use of peripherally inserted central catheter in newborns hospitalized in an intensive care unit	It is verified that it presents adverse events that may be due to conditions intrinsic to neonates or their management
Swerts et al	Nursing care in the face of complications of peripherally inserted central catheter in neonates	Descriptive observational study with quantitative approach	To evaluate nursing care in the face of complications related to peripherally inserted central catheter in neonates	The results of this study offer support for nursing professionals to be aware of the necessary interventions in the face of PICC complications in neonates
Brandon	The main complications regarding the peripherally inserted central catheter that result in discontinuation of treatment in	Exploratory bibliographic research	Identify the main complications regarding PICC that result in discontinuation of treatment in newborns and their respective	Given the complications resulting from the use of PICC, it is understood that to mitigate them, more investment in continuing education is needed for nursing professionals who manipulate this catheter

	newborns and their respective interventions		interventions	
Eaves	Prevention of primary infection of the bloodstream related to peripherally inserted central catheter	Exploratory bibliographic research	Check the implementation of SAE in the assistance of enf. to neonates using PICC in the literature and describe good picc-related prevention practices in NICU	For better performance in catheter maintenance and for measures to prevent infection from infection, training, updating on THE and continuing education of professionals are required.

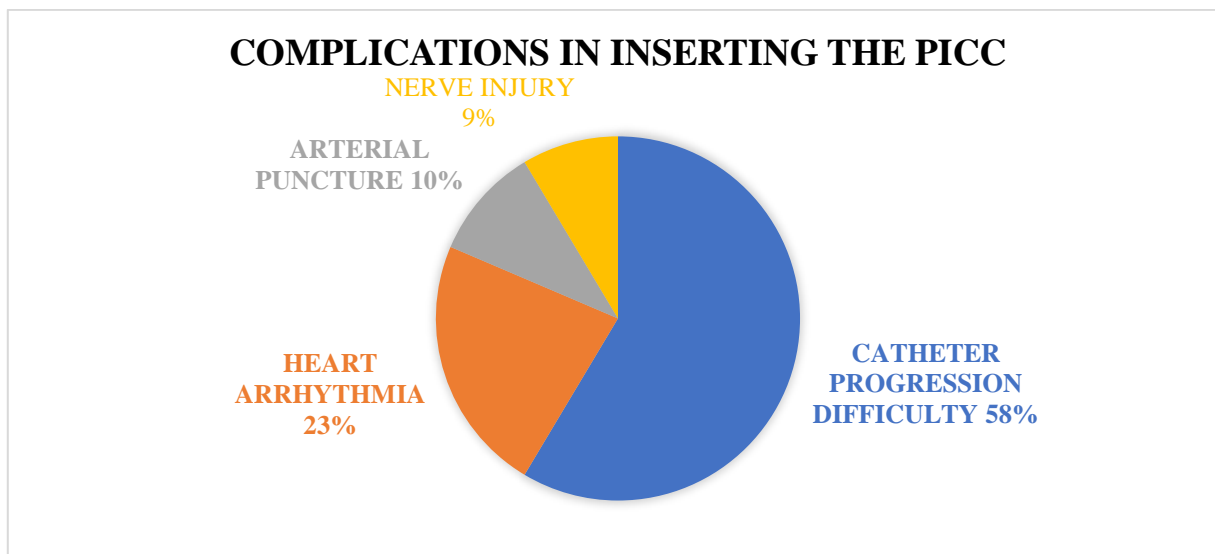
Source: Own Elaboration.

**Comcomplications related to picc:**

The use of the PeripheralLy Inserted Central Catheter (PICC) has been increasing even with patients inside and outside the hospital. The complications are directly focused on the technique of the care provided, at

the time of insertion and also for the entire period of catheter maintenance. Complications: First moment in insertion and the second moment in post-insertion can be divided into 2 types.

**Comcomplications in picc insertion**



**Difficulty in Catheter Progression**

The complication, but common that occurs at the time of arterial puncture, the most common causes of difficulty in catheter progression are associated with: inadequate positioning of the patient, poor catheter positioning, venospasm, inadequate catheter caliber, sclerosis, previous vein dissection, valve closure, venous bifurcation and marked venous angulation, several puncture attempts. Choosing the ideal vessel through ultrasound is a great ally for a correct puncture.

**Cardiac Arrhythmia**

Cardiac arrhythmia is caused when the catheter is displaced to the right atrium or right ventricle, when located within these structures it can cause myocardial irritation, erosion, perforation, cardiac tamponade, and subendocardial abscess. Using the appropriate patient measurement technique for proper positioning of the catheter tip. Stabilizing the catheter is of paramount importance so that it does not migrate into the cardiac chambers.

The signs and symptoms of cardiac arrhythmia caused by poor catheter positioning are: irregular pulse,

patient with palpitation and visualization of arrhythmias on the electrocardiogram or on the monitor tracing. When this occurs, it is recommended to bring the catheter and perform chest X-ray.

### Arterial Puncture

It is an uncommon mechanical complication due to the inclusion of the ultrasound-guided venous puncture technique. This arterial puncture occurs when at the wrong choice of the vessel. An indicator of arterial puncture is pulsatile blood flow and a blood reflux can also be observed to the equipment; blood staining is not a reliable indicator.

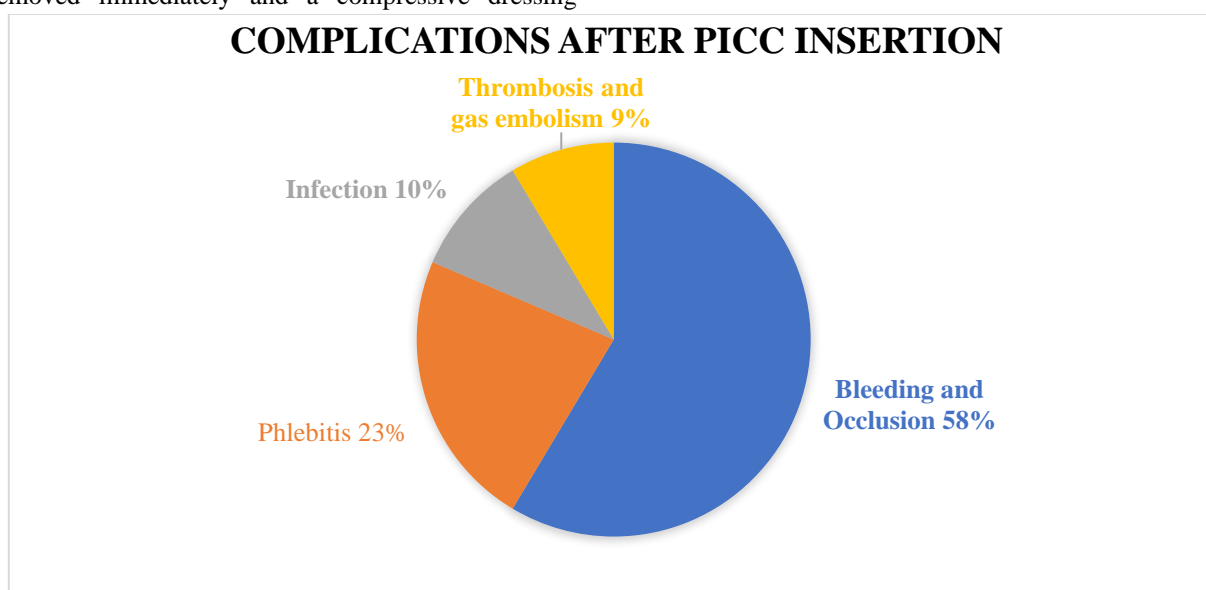
If the arterial puncture occurs, the catheter should be removed immediately and a compressive dressing

should be performed. Observe the arterial pulses of the limb, hematoma formation, bleeding or compartment syndrome.

### Nerve Injury

Puncture of a nerve is an unusual event during puncture of the PICC. The patient may present with tingling, numbness, and loss of strength in the punctured limb. When these symptoms occur, it is recommended for progression, remove the needle immediately, and evaluate the hand and arm for mobility. The use of ultrasound is indicated to guide the puncture thus avoiding this type of complication.

### Complications in post-picc insertion



### Phlebitis

It is a process that develops inside the wall of the blood vessel, in which the endothelial cells become inflamed and rough, favoring the adhesion of platelets. Phlebitis occurs due to mechanical, chemical or infectious factors.

Mechanical phlebitis occurs due to trauma during insertion, removal or movement of the PICC device inside the vessel, is evidenced 48 to 72 hours after insertion or removal. It is the most evidenced complication with PICC (Jesus, Secoli, 2008). Chemical phlebitis occurs due to the infusion of incorrectly diluted irritant medications or medications or the mixture of incompatible drugs, very rapid infusion and particles in the injected solution, with an aggression in the vein wall. (Jesus, S ecoli, 2008). Infectious phlebitis is inflammation of the wall inside a vein associated with infection by microorganisms. Some factors may contribute to this complication developing, such as inadequate aseptic technique during the catheter

insertion and maintenance procedure; failure to detect device integrity breaks and failure to evaluate the insertion site are determining factors (Jesus, Secoli, 2008).

Some factors reduce the occurrence of phlebitis between them include insertion by the basilica vein, catheter positioned with the tip in the superior vena cava, little movement during the introduction of the device, adequate fixation of picc to avoid retraction in the vein (Jesus & Secoli, 2007).

### Infection

The risk of infection is associated with the site of access, the type of solution infused, the experience of the professional responsible for the procedure and the length of catheter permanence.

Local infection occurs due to microbial contamination of the device or infusion. Prevention occurs through aseptic techniques during catheter maintenance; this includes correct hand washing, care in the preparation

of intravenous drugs and disinfection of connectors and dânuilas with 70% alcohol.

In local infections we found the following signs and symptoms: Local edema hyperemia, presence of purulent exudato (Baiocco, 2013).

### Thrombosis

Deep vein thrombosis (DVT) is a well-known complication in PICC users. It can be painful, requires clotting therapy and catheter removal, which increases the patient's time in the hospital, deep vein thrombosis occurs in the second week of catheter use, and most cases are asymptomatic. Thrombosis is caused by fibrin and platelet adhesion that end up clogging the catheter into the lumen of the blood vessel. Traumas to venous endothelial tissue, interruption of the therapist for a long time, blood reflux through the catheter, slow rate of infusion and coagulopathies caused by diseases such as diabetes and cancer are factors that cause the formation of clots (Aiccous B, 2013).

PICC care protocols should address a flowchart for early diagnosis of upper extremity thrombosis in order to reduce the risk of complications and detect early central venous thrombosis (DVT). Postthrombotic syndrome can cause asymptomatic pulmonary embolism in one third of cases or symptomatic in 9% of cases (Baiocco, 2013).

Signs and symptoms of deep vein thrombosis in the upper extremities are arm edemas, pain, and leakage at the insertion site.

### Gas Embolism

Gas embolism in picc patients is rare is lethal, the catheter insertion site is below the heart level, which helps maintain adequate pressure within the system. The causes of this complication: in the presence of air in the equipment, disconnections in the infusion system, inadequate technique in the performance of dressing changes and puncture in central accesses.

Signs and symptoms of gas embolism include hypoxia, mental confusion, dyspnea, aquicardia, hypotension, and chest pain.

### Bleeding and Occlusion

Bleeding occurs within the first 24 hours after catheter insertion, coverage is made with compressive gauze. Occlusion results from partial or complete obstruction of the catheter, which hinders or prevents blood aspiration, causing the loss of its permeability. There are two types of obstruction: mechanics and thrombotics (Baiocco, 2013).

Thrombotic occlusion is originated by the adhesion of platelets and fibrins that occum the catheter

and lumen of the vessel. Some factors contribute to the formation of a thrombus, such as traumas to the endothelial cells of the venous wall; some drugs such as phenytoin and diazepam may form crystals inside the catheter, obstructing it; discontinuation of prolonged therapy; catheter blood reflux; decreased infusion velocity, and states of hypercoagulopathies caused primarily by cancer or diabetes (Jesus & Secoli, 2008).

Mechanical occlusion is caused by bending or compression of your lumen and usually results from the migration of the device to a lower lumen vessel.

## IV. DISCUSSION

In the present study we found that the use of PICC in the neonatal icu is extremely important, due to the various benefits that this procedure provides to the neonate, mainly reducing the number of peripheral punctures, pain and stress, besides establishing a safe venous access for infusion of prescribed therapy.

During data analysis, we observed the need to establish a constant training routine of nurses so that there is a decrease in iatrogenies related to the management of PICC and complications during its insertion. Among the articles used 40% address the importance of nurses being qualified and trained to perform the procedure, 20% verified the presence of adverse events resulting from conditions intrinsic to neonates or their management, 10% address ed the importance of nursing qualification for the insertion of picc, 20% emphasizes the importance of reducing the number of punctures, of stress and pain, because most of this device remains for as long as necessary for treatment, 10% detected that nurses in the sector were not qualified for such a procedure.

## V. CONCLUSION

In view of what was exposed and explored during the research trajectory, we realized that it is necessary to invest in training and continuing education programs, as well as the establishment of protocols and care that allow better monitoring of the occurrence of complications related to the insertion and handling of picc. Nurses must be qualified to insert the PICC because the use of the device requires knowledge, dexterity and ability to handle it, thus reducing the occurrences that compromise its permanence.

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# Emotional Education from the Perspective of care for Yourself

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Received: 01 Jul 2022,

Received in revised form: 31 Jul 2022,

Accepted: 05 Aug 2022,

Available online: 12 Aug 2022

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**Keywords**— *emotional education, self-care, educational processes*

**Abstract**— *We seek to present the development of education from theoretical reflections on emotional education from the perspective of taking care of oneself, in contemporary times. We discuss the conception of some authors and their contributions to the promotion of an education that contemplates the integrality of the students. At the end of this study, we infer that promoting an educational process based on emotional education requires that the various actors participating in this process are open to breaking historically consolidated paradigms, focusing on student learning, creating environments that favor the development of socio-emotional skills, for through meaningful connections between what is learned and the social/world context in which they live. We understand, therefore, that there is a possibility of a synergy between education and emotional development, from a teaching-learning process where students and teachers are engaged in an emancipatory education proposal.*

## I. INTRODUCTION

It's just two sides of the same journey. The train that arrives is the same train that leaves. The meeting time is also farewell. The platform of this station. It's the life of this place of mine

(Milton Nascimento)

We invite you on a trip. Our starting point may be different for each of us, but we propose as the point of arrival the station of our emotional education, remembering that the stations are composed of embarkation and disembarkation, making a continuous process.

Emotional education has been discussed over time by several areas of knowledge, such as psychology, philosophy, anthropology, geography, among others. Here, we will discuss this topic from the perspective of taking care of the self as a path to be followed, and not a trail.

The figurative image of walking on rails reminds us of the need to be engaged in cylinders with no possibility of changing the route, completely plastered and, at any unexpected movement, disaster can occur. Our investigation on this theme sought to follow the figurative

language of a trail in which changes in the path are possible, whether to avoid obstacles, or to admire the landscape, but always with a focus on reaching the point of arrival, which is the goal of the study.

Our perspective of taking care of the self starts by relying on Foucault (2010), in his book *The Hermeneutics of the Subject*, in which he presents the concept of taking care of the self as a way of life: "Occupying oneself is not, therefore, a simple momentary preparation for life; it's a way of life" (p. 446). This author, in his last writings, presented in-depth studies of the first two centuries of our history, a period he called the golden age of self-care. It is an exploration of the thoughts of the Stoics Seneca, Marcus Aurelius, Epictetus, the Epicureans and the Cynics, in relation to life as an art of living.

Following the trail of our studies, we found relevant topics to add to the baggage of our trip. We are talking about the concept of resilience, in the integral approach to life, presented by Ken Wilber (2007), Achor (2012), when discussing *The Harvard way of being happy*, and Seligman (2012), with the advancement of happiness studies, presenting the concept of well-being. Many others, regardless of their popularity or not in academic research,

bring relevant contributions to educational practice and collaborated in this journey of knowledge about emotional education.

In order to better appreciate our trip, we made some brief stops to discuss specific and necessary topics for the development of emotional education, such as: self-knowledge as a practice of taking care of oneself; gratitude as pedagogy in the practice of taking care of oneself; forgiveness as a cure in the practice of taking care of oneself and dreams and projects as a practice of taking care of oneself.

## II. EMOTIONAL EDUCATION

Education is an act of love, therefore, an act of courage. You can not fear the debate. The analysis of reality. It cannot escape the creative discussion, under penalty of being a farce.

Paulo Freire

We are faced with a society ruled by profit, in which the accumulation of objects appears to be synonymous with individual success. In this context, the challenge of educating for existence sometimes seems impossible. Believing that through the educational process the subjects involved are able to build themselves, cultivate and form themselves in their life course is to rely on a paradigm that conceives education in its entirety.

Therefore, it is necessary for education to see the human being in its entirety, considering all other dimensions besides cognition. However, to account for this perspective presented here, we need to bring the theme of EMOTION into the formation process. Therefore, in contemporary times, it is necessary to think about formative processes that have life at their core, that think of education as an art of living, that allow the configuration of dynamics of resistance to the centrality of economic power in the proposition of educational goals (Dias, 2011).

However, there is a gap in this relationship between education and economic power that presupposes the possibility of developing an emotional education based on an integral human education. This understanding is shared by several authors who study education from the perspective of human formation (Larrosa, 2016; Gallo, 2008; Freitas, 2010a, 2010b, 2010c; Foucault, 2010; Dias, 2011; Montenegro, 2017). Delors draws our attention to the important role that education plays in developing people and societies on an ongoing basis:

...not as a miraculous remedy, even less as an “open sesame” of a world that had fulfilled all its ideals, but as a path – certainly, among other

paths, although more effective – at the service of a development more harmonious and authentic human being, in order to contribute to the reduction of poverty, social exclusion, misunderstandings, oppressions, wars... (2003, p. 11)

After all, “education is an act of love” (Freire, 1987, p. 79), and as every love process is based on the perspective of (re)construction and not on destruction, education can be a way to (re)construction of the humanization of women and men. Education experienced not as an accumulation of content, but as a means of providing opportunities for the development of resilience, gives rise to the ability to psychologically recover in the participants of the learning process, despite the adversities, violence and catastrophes that are part of life (Pinheiro, 2004).

Considering that resilience “comes from the meaning that is attributed to human existence, that is, from the ability to form affective and professional bonds and also from the presence of a life project” (Pinheiro, 2004, p. 67), we consider that the premise of education for resilience takes place through an integral human education.

It is an education that does not consider the area of knowledge as the main element to be developed in the human being, being just a piece of the immense mosaic of which we are constituted: a piece of the mosaic cannot be considered the mosaic itself, however, we cannot deny that it is also a mosaic. Likewise, the area of knowledge is not the human being as a whole, but is part of the human constitution. Therefore, this area needs to be valued, but not in a restricted way, because there are other dimensions of the human being that must be considered and highlighted.

We are able to admire the beauty of the mosaic by appreciating its entire image, and, in this sense, we infer the possibility of contemplating the human fullness from an education for existence, an education that considers the human in all its integrality.

But this feat is not possible through an educational process that values one area of knowledge to the detriment of others, because the area of knowledge exalted in isolation does not say about the human being as a whole.

We present one of the possibilities of developing an integral education, from the point of view of Ken Wilber (2007), thinking about an education that considers three principles of integral thinking presented by this author:

Principle 1: Nonexclusion “Everyone is right”: non-exclusion is being able to accept valid truth statements.

Principle 2: Enfoldment – “Some are more right than others”: everyone can be right, although some views are more appropriate than others. None are entirely wrong; some are simply more inclusive, more comprehensive, more holistic, more integrative, more detailed, more transcendent-and-inclusive, infinitely.

Principle 3: Act/Do (Enactment) – “If you want to know this, do that”: Most “paradigm clashes” are generally considered to be “irreconcilable”, i.e. there is no way to integrate two paradigms, but this it happens only because people focus on phenomena and not on practices (methods). (and fully compatible) experiences revealed by diverse practices.

The vision of the integral human being that the aforementioned author brings us can contribute to an educational process that aims at reintegration with our own being, as it is a practical way of self-knowledge and knowledge of the other. It is a way of dealing with the educational process of emotions, not as an appendix to the curriculum or an extra moment in our lives, but incorporated into existence itself.

The possibility of an education through self-knowledge and recognition of the other, having as a means the ideas of integrality proposed by Wilber, seems to be the presupposition of the feasibility of reconstituting the humanity of the other from the processes of resilience, in the face of the adversities experienced in education. contemporary.

The idea of integrality proposed by Wilber is consolidated in the Integral Map, which consists of a practical system that can be applied to any field of human activity. A comprehensive map of the person and the world, in which the person can locate himself.

This map takes into account all known systems and models of human development – from the shamans and sages of antiquity to the current great discoveries of cognitive science – and breaks down their main components into five simple factors: factors that are essential or key elements that they unlock and drive human evolution (Wilber, 2007, p. 17).

These five factors proposed by the author are called quadrants, levels, lines, states and types and trace the paths of the Integral Map, leading the subject to understand himself with his own life and perception.

Consistent with this vision, Delors calls attention to giving a new value to the ethical and cultural dimension of education, having self-knowledge as a movement to understand the other and “understand the world in its chaotic march towards a certain unity. But first, it is

necessary to start by getting to know yourself, in a kind of inner journey guided by knowledge, meditation and the exercise of self-criticism” (2003, p. 16).

In this sense, we are talking about an education that considers values and respect for life, that allows constant reflections on attitudes and responsibilities, that develops actions that stimulate the elevation of self-esteem through self-knowledge, bringing personal security and empathy for others. An education that has “the mission of making everyone, without exception, bring to fruition their talents and creative potential, which implies, on the part of each, the ability to take responsibility for the realization of their personal project” (Delors, 2003, p. 16).

It may seem utopian to talk about such an education, but what would education be without utopia? Is it not possible for education to pay attention to the active power that creates reality, and then to create the possibility of idealizing the new and allowing its emancipatory visualization? After all, this is the double task of utopia.

Utopia is the exploration of new possibilities and human wills, through the opposition of imagination to the need for what exists, just because it exists, in the name of something radically better that humanity has the right to desire and because it is worth fighting for. Utopia is thus doubly relative. On the one hand, it is a call for attention to what does not exist as a (counter) an integral, but silent, part of what does exist. It belongs to the time by the way it separates itself from it. On the other hand, utopia is always unevenly utopian, insofar as the imagination of the new is partly composed of new combinations and new scales of what exists (Santos, 2000, p. 323).

It is urgent and necessary to think about an education that allows the human being to develop the ability to find alternatives for solving problems, such as self-control in the face of frustrations, in order to come out renewed; that allows discovering internal sources of satisfaction and the acceptance of individual differences; that allows human beings to be strong, but sensitive, to reinvent their life goals after losses, building strategies to establish and achieve their goals, and that, instead of leaving weakened in the face of problems, they feel more competent to face new ones. challenges inherent in life. That is, an education for resilience, which can be produced from social and intrapsychic processes. After all, you are not born resilient, nor do you acquire resilience naturally in development: it depends on certain qualities of the subject's interactive process with other human beings, responsible for the construction of the human psychic system (Melillo, 2005).

In short, it is necessary to think about an education that has as its first objective to enable the participants (all the actors involved in the educational process) to develop their potential and creativity in an autonomous and self-responsible way in the construction of their life project.

From this perspective, education presents new values: the ethical dimension, the art and the cultural dimension. Education itself denotes an ethical process, related to the lives of individuals, because ethics does not depend on a concept of human nature, but on people's practices and actions.

Thus, the following will discuss the practice of taking care of oneself as an educational praxis for human formation.

### III. PRACTICE OF TAKING CARE OF YOURSELF

We need to resolve our secret monsters, our secret wounds, our hidden insanity. We can never forget that dreams, motivation, the desire to be free help us to overcome these monsters, defeat them and use them as servants of our intelligence. Don't be afraid of pain, be afraid of not facing it, criticizing it, using it.

Michel Foucault.

Taking care of yourself is, in its first instance, knowing yourself. However, taking care of oneself was in historical moments in an inferior condition when knowing oneself. We recall that the concept of knowing oneself as the first instance of taking care of oneself was like this in the text "Alcibiades I" and "The Symposium" by Plato. In it, Alcibiades is provoked by Socrates when he asks him how he could take care of himself without knowing anything about himself or his opponents. How could he govern others if he could not govern himself?

In Hellenism and its schools with the Cynics, Stoics and Epicureans, taking care of oneself is detached from the first condition of knowing oneself and becomes an unconditional principle, coextensive with one's own life, an essential practice for the human, regardless of age or generation, a way of life, a continuous practice, an art of living. This is a big change, because for Plato knowledge would lead us to the Truth, and there we would

find freedom, while taking care of oneself in Hellenism is the conductor itself, and the discovery leads us to a new self from a new connection. I really can. In this case, the relationship "I and truth" becomes horizontal and no longer vertical (Trindade, 2016).

But how to develop self-knowledge as a practice of taking care of oneself living in a troubled world and in the face of so many demands, little time, without security... a liquid world, as Zygmunt Bauman (2001) stated. The concept of liquid society developed by Bauman concerns economic and social relations, which in contemporary times are fragile and malleable. Competitive individualism replaces the idea of the collective, and relations of solidarity in which rewards were not sought begin to connote exchanges of interests.

In this study, we do not propose magical and sudden solutions to resolve this scenario, not least because it is a scientific research, in which "the movement of the passionate researcher has a growing and spiraling meaning that always leads him to seek other perspectives" (Araújo, 2008). New perspectives that lead you to know more and more about the researched phenomenon (allowing it to stop being "unknown"), through an increasing theoretical deepening.

The unknown has the power to cause us fear, to frighten us. Not knowing is not knowing and, in turn, not knowing is not being able. Recalling Foucault (2012), knowledge and power are intertwined, because it is not possible to establish a power without having developed a knowledge. Thus, it is through knowledge that power relations are constituted, that is, where there is knowledge, there is power.

From this perspective, it is up to us to reflect on knowing oneself, knowing oneself. This practice is not common to us, despite being highly acclaimed by several areas of knowledge, highlighting the need for its practice. Not knowing oneself is not being able to do it, and not being able to do it is not being free, it is dependence, it is constantly experiencing the unexpected. This is because, for Foucault (2012), it is only possible to find happiness when we have freedom from the constraints that come externally to the subject and from the subject itself.

The importance of self-knowledge has been enunciated from antiquity to the present times, such as the Platonic-Socratic philosophy with the "know thyself", and even Spinoza, Freud, among others, who bring self-knowledge as an achievement. through a continuous process in the realization of freedom.

According to Zygmunt Bauman, we are currently experiencing "liquid times", which are times full of uncertainties. However, these times offer infinite

possibilities for experiences and knowledge, as they are times when relationships are liquid and, therefore, insecure and temporary, but it is precisely for this reason that we have the possibility of experiencing (quantitatively) more relationships than in earlier times. previous.

The concept of liquid times developed by the author is a metaphor for the possibility of the liquid that can take different forms according to the reservoir that holds it, not clinging to a single configuration. However, although the liquid has no shape of its own, it has permanent characteristics. The conflict between the characteristics that do not change, but that are inserted in a constant change, is what describes the current society. In this context, self-knowledge allows us to know what is in fact constant in us, what is permanent and how we can experience the changes presented by modernity. Thus, the “know thyself” presents itself as self-knowledge and knowledge of the world, of the truth.

Another issue that we need to highlight concerns the temporality of self-knowledge. There is an erroneous idea that self-knowledge takes place in a time and space, as if we were to read a book and in the end we already know everything that is contained in its pages. Not quite. Socrates warns us that self-knowledge is a daily practice, it is a condition of life and we need to decide to live life in self-knowledge. That's because we are mutable beings, and we need to know the being we were yesterday, what we are today and be open to know how we will be tomorrow.

It must be remembered that in this mutation there is something in us that is constant, which is our essence, that

which does not change. This essence for Foucault is our truth, and when we know our truth we can be happy. For him, we need to have the courage of the truth, of our truth, and “taking care of oneself is to equip oneself with these truths” (Foucault, 2010, p. 269). This essence was called by the philosopher Marco Aurelio<sup>1</sup> the Interior Garden (or Interior City), and it is there that our true freedom is found; it is the space for our interiority, for our exercise of virtues, knowledge and discernment.

Self-knowledge allows us to develop the practice of self-care, because by getting to know each other better, it is possible to identify our weaknesses and potential, thus developing possible actions to equalize our existence. Self-care is taking care of yourself. Like any practice, we need exercises to be able to perform it, and taking care of yourself is no different. Thus, we will walk a little through the perspectives of authors who presented some techniques of self-knowledge and through the writings of Foucault himself, with the exercises of caring for the self. We purposely did not follow a single line of practical exercises, as we recognize that we are different both as people from each other and in the person between the stages of life. We also did not focus only on authors who are part of the academic classics, but on those who have contributed to different pedagogical practices.

We found in Fritzen (2013) the process of giving and receiving feedback through the scheme presented by Joseph Luft and Harry Ingham, called Johari Window, as shown in Figure 1.



Fig.1 - Johari Window/ Source: Prepared by the researcher

It is a process capable of contributing to self-knowledge, identifying our behaviors and allowing us to devise strategies to overcome difficulties in intra and interpersonal relationships.

The analogy with a window leads us to perceive the possibilities of opening communication with ourselves and with others. A window with four parts, that is, a quadrant,

where we locate in the left vertical column our behaviors known to us, and in the right column our behaviors that we do not know, that is, when we act and do not perceive. Looking horizontally, on the top row are our behaviors that are known to others, and on the bottom row, those that others are not. We can exemplify as follows:

I. I OPEN – these are behaviors that we have and that are already known to us, and are also known by those who live with us (what I know about myself and everyone knows too).

II. I BLIND – these are our behaviors that we are not aware of, but those who live with us understand (what I don't know about myself, but everyone knows).

III. SECRET ME – these are behaviors that we have, but that we don't let others know (what I know about myself that I don't want anyone to know).

IV. UNKNOWN ME - these are behaviors that we have involuntarily, and neither we know how we are going to act nor the other knows how we will act. It usually occurs in the face of an unexpected situation and strong emotions, such as, for example, the reaction to a robbery (what I don't know about myself and no one knows).

Identifying our behaviors in these quadrants is a process of self-knowledge and deepening the knowledge of our personality, allowing us to clearly find an ethical way of living with ourselves and with others.

Among so many strategies of giving and receiving feedback presented by the author, we highlight here a posture that is in line with all the other authors that we will bring to this discussion. It is about our readiness to listen, understanding all the complexity of hearing that is distinguished from the bodily resource of hearing or listening, because, as Fritzen, 2013 well points out: "Hearing takes place through the ear, while hearing implies a process intellectual and emotional intelligence that integrates physical, emotional and intellectual data in the search for meaning and understanding" (p. 26).

Going through other authors and self-knowledge techniques, we quote Davis (2012), who presents a holistic view of being, denoting that we are integrated with the whole external to us and stating that, according to our internal change, the external changes. So, the process of self-knowledge and the perspective of personal improvement are fundamental for the lifestyle we aim for. For this author, cause and effect are intertwined. To change an effect in our lives, we need to become the cause of it, so it is necessary to know ourselves and recognize our power to cause effects in our existence.

We dare here to idealize women and men, recognizing their potency in life and together engendering resistance to subjective power, this because, as presented by Foucault (2010), we recognize the politics of subjectivation that power exerts over our bodies, over our lives, called the biopolitics of power by the author. Therefore, it is necessary to find ways to identify our power in life and also to take this possibility to our companions, so that we

can organize ourselves in resistance, as Pelbart (2003) defends: "Everything cracks and cracks like the equipment of a wrecked sailboat. . [...] Next to power, there is always potency. Alongside domination, there is always insubordination" (pp. 42-43).

Among the exercises presented by Davis (2012), we will bring here the reflective questions proposed by this author, which act as conductors to our interior, seeking to connect with ourselves, enabling the relationship "I and truth", as mentioned above regarding the practice. of caring for oneself (Foucault, 2010).

Here are some questions proposed by Davis (2012) for us to ask ourselves, for the purpose of making things clear in our minds and helping us to be honest with ourselves in our rebirth with life. The proposal is to respond with sincerity, and if changes are needed, start with a positive attitude.

- ✓ What is my weakest point?
- ✓ What is my biggest weakness?
- ✓ What is my biggest fear?
- ✓ What is my biggest hope or secret dream?
- ✓ What was my biggest mistake?
- ✓ What was my most noble deed?
- ✓ Do I really want to serve others?
- ✓ Do I really forgive others and wish them well?
- ✓ What would I most like to erase from memory?
- ✓ If given the opportunity, what would I try to do better?
- ✓ Do I always tell the truth? Am I honest with myself?
- ✓ Am I practical and realistic, or do I daydream?
- ✓ Am I really what I appear to others? What's the truth?
- ✓ Who do I love most of all?
- ✓ Hate someone? Because?
- ✓ Am I afraid of someone? Because?
- ✓ Who has been the biggest influence in my life?
- ✓ What are my main goals? Because?
- ✓ How can I achieve them more efficiently?
- ✓ If I have failed in the past, why?
- ✓ Am I ready to leave this world without regret? Why yes or why not?
- ✓ Do I really use my time, energy, talents, mental powers and money properly? If not, why not?
- ✓ Am I serious about living a creative existence, or am I just kidding around?
- ✓ Am I really the person I want to be, and am I really and truly doing the best I can with my life?

Asking reflective questions is a practice known since the beginning, presented by Socrates in his way of educating through maieutics, in which the role of the teacher (teacher

or professor) is to ask questions that lead the disciple (student) to discover the truth about something, in this case, about oneself.

In our journey regarding the practice of self-care and self-care, we found two authors of positive psychology who contributed a lot to the construction of our intervention. One of them is Achor, in his work *The Harvard Way of Being Happy* (2012), where he presents scientific studies on the subject, as well as his research carried out with 1,600 Harvard students. We also emphasize that Harvard University carried out a Study of Adult Development (Study of Adult Development), which lasted 75 years, beginning in 1938, investigating 268 Harvard-educated men and 456 young people from disadvantaged social classes. , non-delinquents living in poor Boston neighborhoods, accompanying them throughout their lives, monitoring their mental, physical and emotional state. This study was continued with the children of the original participants.

Returning to the research developed by Achor, with Harvard students, with happiness as an object, the author points out as a result seven principles that contribute to our process of self-knowledge and self-care. Are they:

Principle 1: The benefit of happiness: here the author shows us scientific research that proves the prerogatives that the feeling of happiness brings to the subject, inverting the logic that it is necessary to be successful to be happy, because it is the feeling of happiness that brings the success. He states that "...we were led to believe that happiness revolved around success... we are learning that what actually happens is the opposite... Happiness is the center, and success revolves around it. her" (Achor, 2012, p. 43).

Principle 2: The fulcrum and lever: This principle deals with the way we see things and situations. The same thing can be seen from different angles and this makes all the difference in our lives, because, "although of course it is not possible to change reality by willpower alone, we can use our brain to change the way we process the world, which, in turn, changes the way we react to it" (Achor, 2012, p. 72).

Principle 3: The tetris effect: with this principle we can understand that we need to be aware of "the way our brain is programmed to work in the real world" (Achor, 2012, p. 98), not letting ourselves be an effect, as well presented by Davis. (2012).

Principle 4: Find Opportunity in Adversity: This principle concerns the different ways people face adversity. Some will give up, disheartened, while others will gather their strength, capitalize on their strengths and move on (Achor, 2012, p. 128).

Principle 5: Find Opportunities in Adversity: as a continuation of the previous principle, the author warns that opportunities are not always great, but they are always opportunities, since "small successes can add up and turn into great achievements. Just trace the first circle in the sand" (Achor, 2012, p. 155).

Principle 6: The 20-second rule: "why is it so difficult to change our behavior and how can we make it easier?" (Achor, 2012, p. 160). The importance of time in our lives and the formation of habit and changes in habits already crystallized are the themes addressed in this principle.

Principle 7: Social investment: the importance of having a social network does not concern the number of friends on social networks, but the quality of our relationships. Non-selfishness, the humility to ask for help when needed and help whenever possible, that's having high quality connections. "And in everyday life, both at work and at home, our social support network can make the difference between succumbing to the cult of mediocrity and reaching our full potential" (Achor, 2012, p. 208).

Following the line of positive psychology, in our journey in the practice of taking care of the self, we mentioned the second author of positive psychology, Martin Seligman. In his work *Florescer* (2012) the author, starting from the theory of "authentic happiness" (Seligman, 2010), coined by him, advances in research and presents "the dissolution of the monism of "happiness" in more feasible terms. To do this well, it takes much more than a mere exercise in semantics. Understanding happiness requires a theory" (Seligman, 2012, p. 13). And so the concept of Well-Being is exposed.

The welfare theory has five elements, each of which has three properties.

*Table.1 - Elements and properties of the theory of well-being*

Elements	Properties
1 positive emotion	1 Contributes to the formation of well-being.
2 Engagement	2 Many people seek for its own sake, and not just to get some of the other elements.
3 sense	3 It is defined and measured independently of the other elements (exclusivity).
4 Achievement	
5 positive relationships	

Source: Prepared by the researcher

Briefly, we describe what each of these elements means:

Positive emotion: Pleasant life. This element is inherited from authentic happiness, previously presented by the author.

Engagement: How long we are absorbed in an activity, having the feeling that time has stopped.

To belong and serve something believed to be greater than the self.

Fulfillment: In its momentary form, it is “fulfilling life” in its expanded form. It is not doing for the sake of doing, but doing it with meaning; even when you lose, you win.

Positive Relationships: Positive things are not lonely, and other people are the best antidote to the bad times in life.

We could write hundreds of pages on theorists who present practical exercises for self-knowledge and self-care, which we can apply as a practice of taking care of ourselves, but we chose to quickly introduce these authors, who contributed a lot at the time of the construction of our intervention.

We will now return to the view of the practice of caring for the self presented by Michel Foucault, which was the cornerstone of our studies. However, it is worth clarifying that our objective here is not to analyze the author's concept, but rather to describe his conception, since we cannot disregard the complexity of his works and the connections between them, which would require a systematic investigation of all his production, which would require a specific thesis work.

Here, we will bring important points for further clarification on the idea of taking care of oneself from the perspective of a teaching practice, with the teacher and the teacher being a professional who takes care of the other, experiencing a process of human formation.

In the last decade, Michel Foucault's thinking has stood out in the Brazilian educational field, and the use of the notion of self-care in contemporary educational theorization has “privileged reflection on governmentality and the processes of ethical subjectivation” (Silva, 2012, p. 8). Among the authors who treat the notion of self-care as an ethical subjectivation, Nadja Hermann has been focusing on the writings of the last Foucault, “justifying its use because it offers an aestheticizing perspective of ethics” (Silva, 2012, p. 103). ). Foucault argues that art is not only related to objects, but to the lives of individuals, and that ethics, therefore, does not depend on a concept of human nature, but on practices that people do. Thus, ethics, as explained by Hermann (2005):

it is centered on a problem of personal choice, of the aesthetics of existence. The stylized construction of the ethical subject does not take place through categorical moral rules, but

according to an art of living that starts from the choice of practices and ideal formulas that are already socially known. The most important decision is the one that individuals make in relation to themselves and others, the aestheticization of ethics, as a process of creation and construction of unique techniques, in which the subject manages his own freedom (p. 62).

It is considering the practical dimension of our existence that we make use of the writings of the last Foucault, who, in the Course given at the Collège de France, presented modes of experiences that transform the being itself: the experiences of asceticism (*áskesis*) as an exercise of the self on itself and as a practice of truth, a way of linking the subject to the truth. Among these practices is the use of meditation, the *meléte*, as a game of thought on the subject, an exercise in thought, an exercise “in thought” (Foucault, 2010, p. 318): “It is an exercise through which the subject puts himself, by thought, in a given situation. Displacement of the subject in relation to what he is as a result of thought” (Foucault, 2010, p. 320).

Thus, Michel Foucault, in his course *The Hermeneutics of the Subject*, in 1981-1982, rescues the concept of self-care presented by ancient Greek philosophers (*epimeleia heautou*), highlighting three fundamental attributes.

First, he explains that taking care of oneself is a theme of general attitude, “the *epimeleia heautou* is an attitude – towards oneself, towards others, towards the world” (Foucault, 2010, p. 11).

The second attribute is looking at oneself, taking the focus off the world, on others and focusing on oneself. “Caring for oneself implies a certain way of being attentive to what one thinks and what goes on in one's thoughts” (Foucault, 2010, p. 12).

The third deals with practices of oneself towards oneself, actions that we exercise to assume ourselves, modify ourselves, purify ourselves, transform ourselves, transfigure ourselves. “These are, for example, meditation techniques; those of memorization of the past; the examination of conscience; those of verification of representations insofar as they are presented to the spirit” (Foucault, 2010, p. 12).

Michel Foucault portrays the details of the practical exercises used by philosophers of the first ages, and among these we highlight the practice of meditation as a philosophical or spiritual practice of antiquity, an exercise in the empowerment of a thought until it makes us a truth, which can be rewrite whenever necessary, recording this truth in the spirit to be remembered whenever necessary (Foucault, 2010).



We infer that the exercise of meditation in its formative and spiritual sense can, at present, bring a positive legacy to a pedagogical praxis, as we recognize that this practice has a strong influence on the way we relate to ourselves and others. When we consider that these relationships are fundamental in the process of human formation, we can understand the role of meditation in the processes of formation.

Foucault shows us that the rule of silence permeates the educational process of antiquity, and in it listening is fundamental, along with the exercise of writing what is heard. It also describes the exercise of memory, which must be carried out while the master speaks, as this must not be interrupted and one must not write during his words, as one must pay full attention to everything that is heard, with an open mind to the memorization.

Being a good listener (*akoustikoi*) and knowing how to shut up are difficult learnings to develop in contemporary times, but indispensable for antiquity. We can infer that taking care of oneself is an exercise in solitude and not in solitude, as it is an option to be alone in the perspective of providing moments of reflection for self-knowledge and personal growth. But it is also a social exercise, in that, taking a more ethical attitude towards oneself, one takes an ethical attitude towards the other.

Another practical exercise presented by Foucault (2010) is the writing of the self as a cartography of the subject himself, a device of self-knowledge. There is no doubt that, among all the self-care practices presented in antiquity (*epimeleia heautou*), writing – writing for oneself and for the other – only played its important role late.

It is necessary to read, said Seneca, but also to write. It is Epictetus, who, however, only taught oral teaching, insists repeatedly on the role of writing as a personal exercise: one must 'meditate' (*meletan*), write (*graphein*), train; may death snatch me while I think, write, read (Foucault, 2009, p. 133).

There are two forms that Foucault (2009) presents as a practice of self-writing: the *hypomnemata* and correspondence.

The *hypomnemata* consisted of having a personal notebook that you write about yourself, putting important quotes you have read, parts of works or your own understanding, situations you have witnessed, debates you have participated or attended. "Their use as a book of life, a guide to conduct... they were thus offered, like an accumulated treasure, for re-reading and further meditation. They also formed a raw material for writing more systematic treatises" (Foucault, 2009, p. 134).

It is not a notebook to aid memory, nor understood as an intimate diary. Despite being personal, it is not a confession of oneself: "hypomnemata is an important vehicle for this subjectivation of discourse... (Foucault, 2009, p. 135).

The important thing in this practice is to reflect on what happens to us, to learn from the messages, events and knowledge that come to us. It is reading a book and writing something about what touches us, because if we read without the exercise of reflection on what we read, we only accumulate information, but do not transform it into knowledge. Everything around us teaches us, but we need time for reflection to learn, and writing about oneself and what touches us is a strategy presented by ancient philosophers that we believe is possible to incorporate into our contemporary pedagogical processes.

Correspondence is another form of self-writing. The letter to another is also a personal exercise. The texts of the notebook, which constitute an exercise in personal writing, can be used as raw material for the letters, as the correspondence sent to another brings virtues to those who receive it through its reading and rereading, as well as to those who send it, through writing itself. "This dual function makes the correspondence very close to the *hypomnemata* and its form is often very close to them" (Foucault, 2009, p. 137).

When writing to a friend or a teacher, we are putting ourselves in words, describing how we are, our thoughts, our life. And when we are writing to someone in consolation, advising, we are contributing first hand to ourselves, because "Writing that helps the recipient, arms the writer – and eventually the third parties who read it" (Foucault, 2009, p. 138). The opposite is also possible, as it happens that the feeling placed by the writer for the addressee is returned to him in the form of 'equitable advice', because, "as he progresses, the one who is guided becomes more and more able, in turn, to give advice" (*idem*).

The letters as a method of "writing the self" are a process of formation of the self, configuring themselves in a possible device of constituting an aesthetics of existence. The practice of taking care of oneself through correspondence is the writing of oneself as a process of perception and movement of thought, as an exercise of reflection and analysis of the acts of positivization that constitute us. This is because, as we saw earlier, the writing of oneself has a double function that allows the personal exercise of writing and reading what one writes, that is, the gesture of writing acts through the very gesture of writing on the one who sends it. : as well as through

reading and re-reading, it acts on the one who receives it (Foucault, 2009).

Writing collaborates with “the arts of oneself... as an element of training oneself... it is the operator of the transformation of truth into ethos” (Foucault, 2010, p. 147). For this reason, we infer that it presents itself as a process of enchantment for practitioners who, in the face of uncertain and unstable times in which we live, represents a penumbra in relation to the construction of our humanity, allowing us to live the experience of trying to know ourselves, discover ourselves, to recognize the importance of having and respecting the time to build and rebuild in the very process of your experience.

#### IV. GRATITUDE AS A PRACTICE OF TAKING CARE OF YOURSELF

Gratitude is a second pleasure,  
which extends a first one, as an echo of  
joy to the joy felt, as one more happiness  
for one more happiness.

André Comte-Sponville

Let's talk a little about gratitude from Martin Seligman (2012), Howells (2012) and the document *Innovating Pedagogy* (2021). We can have gratitude as a practice of taking care of oneself, a pedagogical praxis, and not just as an emotion, being it an approach that actively involves all the actors involved in the teaching and learning process, in the perspective of a spiral cycle in which there is the recognition of receiving something or an action consciously, and it awakens the desire to reciprocate in some way.

In his book *Flourish*, published in 2011, Martin Seligman presents gratitude for a practical vision with scientifically proven activities through his research on this topic. The author alerts us to the fact that we think too much about the things that go wrong in our lives, and too little (or at least not enough) about the things that go right.

We know that it is necessary to recognize what went wrong in order to learn from those mistakes. But sometimes we spend more time with our thoughts stuck on what went wrong, afraid that it will happen again, which, according to Seligman (2011), leaves us predisposed to anxiety and depression, or at the very least in a depressive state, what we popularly call low mood.

A good way to avoid this low mood is to try to experience more intensely the emotions we feel when something very good happens in our lives. The most interesting thing is that even if these emotions have been experienced in the past, we can relive them. And, by doing so, we can awaken in us a feeling of gratitude for the things, people and

situations that made possible and/or contributed to the good that happened in our lives.

The author also states that the feeling of gratitude is responsible for making our lives happier and more satisfying. This was proven through research carried out by the Positive Psychology group, in the search to identify which feeling was closest to the much-desired genuine happiness.

Gratitude can make your life happier and more fulfilling. When we feel gratitude, we benefit from the pleasant memory of a positive event in our life. Likewise, when we express our gratitude to others, we strengthen our relationship with them. But sometimes we express our gratitude so casually and quickly that it becomes almost meaningless (Seligman, 2011, p. 22).

In 2012, Kerry Howells of the University of Tasmania, in her decades of research into gratitude in education, revealed that student learning is influenced by practicing gratitude as well as the gratitude expressed by their teachers and school leaders. This teacher released the results of her research in the book “*Gratitude in education: a radical view*”, not yet translated into Portuguese.

Another introduction of Gratitude as pedagogy occurred through the Institute of Educational Technology at the Open University, in the United Kingdom, which annually publishes a document called “*Innovating Pedagogy*”, presenting the educational trends that will guide educational institutions in the coming years. In 2021 he presents “*Gratitude as Pedagogy*”. *Gratitude as Pedagogy!*

This document presents pedagogical practices that can be worked on in the classroom in a systematic way, considering the theme of gratitude. One of the activities presented is the writing of moments of good events that are happening or that have already happened in the student's daily life. connection between school and community, enabling focus and understanding of the concepts being learned.

According to what is presented in this document, the fact of expressing gratitude to someone or something, during a pedagogical activity, makes students and teachers improve their well-being and calm in the midst of stress. It was also possible to identify that gratitude in education has been used to increase inclusion and diversity in teaching and learning, building resilience of the entire school community involved in this practice as a pedagogical activity.

And in this path of the search for self-knowledge and self-care, we could not leave out the practice of gratitude as a pedagogical practice, aiming at a better well-being in all

subjects participating in the teaching-learning process. A practical way to approach gratitude in learning can be asking students to reflect on a particular topic that has been worked on in the classroom, or activity that has taken place. Reflection should follow the following elements: thoughts, words, emotions, inner speech and physical state. Ask students to use two different angles: first, look at these elements in the opposite direction to gratitude, which is often complaining, dissatisfaction, and entitlement, and then look at the elements again from the point of view of gratitude. . While reflecting, students are asked to take notes.

This reflection activity provides awareness of the negative feeling that leads us to have certain attitudes and behaviors in relation to certain themes and/or pedagogical activities. The idea is to analyze negative attitudes and propose to replace them with elements of gratitude, bringing a state of awareness, presence and appreciation among students and teachers (Kukulka-Hulme et al., 2021).

We found several other ways to stimulate the feeling of gratitude in the educational process. As an example, we can mention the Revista Construir Notícias, which in its May/June 2017 edition (Nº 94) had as its main theme “Gratitude transforms your classroom”, bringing different pedagogical works in the classroom with a focus on practice. of gratitude. Here, we would like to highlight the article by Professor Marcia Luz, who presented the Jornada da Baleia da Gratidão as a practice, at a time when world society was experiencing the game with the name Blue Whale, which led young people to cause their own death.

Following the same logic as the aforementioned game, the gratitude journey presents 50 challenges that must be carried out one a day, during the 50 days, involving family, friends and work/school colleagues. When performing the tasks, the student must share on social networks with the hashtag #whalinggratitude, and then must level up, moving on to the next activity.

Recalling Seligman (2011), and as we mentioned earlier, “when we express our gratitude to others, we strengthen our relationship with them”, and this makes us reach the feeling of happiness and well-being with greater speed and intensity. Certainly because we were able to experience the Alterity referred to by Levinas (2005): by recognizing the other as my mirror, I am happy to see that I have made him happy.

For Howells (2012), it is necessary to bring gratitude into schools, as a pedagogical praxis, because students grow and develop where they feel valued and confident, and schools in contemporary times, as well as the world of work, stimulate competitiveness. , which can cause

resentment, the feeling of being a victim, envy or insecurity.

This author causes a major paradigm shift in the understanding of the educational process. For her, the teaching-learning process must present itself as a healthy flow of giving and receiving, that is, the teacher gives a gift to the student, which is education, and the student, in turn, , awakens the desire to give back to the teacher. However, what we see today is far from this healthy flow of give and take, and our schools experience the paradigm of exchange, in which students do not see education as a gift or privilege, but as a right or expectation.

This book does not present gratitude as the answer to how we can educate better citizens, nor as a panacea to cure all of society's ills. However, it does present a strong case for why we can consider gratitude as an important educational practice today, and why it can play a role as a powerful antidote to the exchange paradigm (Howells, 2012, p. 8).

Also, regarding gratitude as pedagogical practices, we emphasize the research carried out by Martin Seligman Professor at the University of Pennsylvania, Psychologist, Former President of the American Psychological Association, who presents the exercise of gratitude as a didactic activity called “The visit of gratitude ”, This activity was carried out in our intervention, following the guidelines of the author who suggests that we ask (in our case, the students) to close their eyes and bring to mind the image of a person who is still alive and with whom they have no contact for some time now, someone who has contributed positively to the life of the viewer, or, as Seligman (2011) teaches: “Someone you have never adequately thanked” (p. 22).

After performing the visualization, they are asked to open their eyes and write a letter of gratitude to that person. Afterwards, the orientation is to arrange to visit her and deliver the letter in person. At that time, you should read the letter without haste, observe her reaction and your own, and then discuss the contents of the letter.

As gratitude is an apparently new topic as a pedagogical practice, but of great relevance, we recognize that we could not leave it out of this study, but we consider it worthy of future specific investigations.

## V. BRIEF FINAL REMARKS

At the end of our reflections on emotional education in contemporary society, we inferred the need for the educational process to contemplate the integrality of students. For a better understanding, we present some

authors who brought practical contributions in the development of an education in this perspective. However, we cannot fail to boast that the development of a training process in this context requires a pedagogical innovation that considers the student as the protagonist of his/her knowledge, and his/her learning as a sine qua non factor for the educational act.

We understand that the educational process that includes emotional education is a paradigm shift where the school's view will no longer be focused on the institution's needs, but on the students' needs, seeking to have an environment that favors the development of socio-emotional skills, to who can make meaningful connections between what they are learning and the social/world context in which they live. Thus, we hear that student-centered learning, considering their socio-emotional skills, presents itself as a necessary issue for education on the world stage.

This scenario leads us to the possibility of there being a synergy between education and emotional development, contributing to a teaching-learning process in which students and teachers are engaged in a deep and transforming learning process; a personalized and fun learning, in which education is not limited by time or space, but which always presents emancipatory proposals.

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## Pedagogical models focused on the integration of ICT in basic education: A systematic review

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Received: 12 Jul 2022,

Received in revised form: 01 Aug 2022,

Accepted: 07 Aug 2022,

Available online: 12 Aug 2022

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**Keywords—** Pedagogical model, Digital Information and Communication Technologies, Basic Education.

**Abstract—** A pedagogical model is a system of theoretical premises that organize a curricular approach, being incorporated into teaching practice and the interactions between teacher, student, and learning object. In teaching practice, their interaction with students should be based on activities that seek to contextualize with reality. On the other hand, pedagogical practices, based on the implementation of Digital Information and Communication Technologies, improve the performance of teachers who develop skills to plan modern and technology-integrated learning processes. This article presents a systematic review of works published in the period 2018-2022 that dealt with the use of pedagogical models based on the integration of TDIC in basic education. From the 10 works identified, it was possible to conclude that a pedagogical model must use the technological approach to meet the needs of the teacher and their students. The research contributed to finding the main and most recent studies on the subject. In this way, the article serves as a summary of publications on pedagogical models in TDIC carried out in the period 2018-2022.

### I. INTRODUCTION

Teaching strategies in an educational environment are fundamental tools to develop students' cognition, metacognition, and emotional processes. The use of these strategies allows students to understand and build knowledge with autonomy and responsibility that meets their particularities. Therefore, the teacher has a fundamental role for students to be able to engage in their learning. This occurs mainly when the educator structures the activities and the pedagogical environment dynamically, with the participation of all subjects [15].

Camargo and Daros [18] argue that pedagogical activities should be reality-oriented and develop useful

skills for the student's personal and professional fulfillment. For the authors (CAMARGO & DAROS, 2018), students must learn cognitive strategies and skills inherent to each application of knowledge. In this way, they obtain the ability to build knowledge applicable to their realities. Therefore, Camargo and Daros [18] also indicate the need to develop digital skills, as these become an increasing need in our society.

In turn, digital skills enable the implementation of Digital Information and Communication Technologies (TDIC) as contributing instruments for this learning process [17]. For Bacich and Moran [3], education must be reformulated by analyzing the contributions, risks, and changes arising from the interaction with digital culture,

the interaction of TDIC, resources, interfaces, and media languages to teaching practice. Thus, exploring the potential of integration between professional, cultural, and educational spaces for the creation of authentic contexts based on technology.

It is worth noting that the pedagogical practices, adopted from the implementation of TDICs in teaching, improve the involvement of students, who develop skills to plan processes and procedures related to their learning [21]. Consequently, the interaction between students, teachers, and the school environment is modified by the inclusion of technological resources, creating conditions for the teaching and learning process to occur mutually between educator and student [21].

An important tool that helps in the development and execution of pedagogical strategies is the Pedagogical Model (PM). Behar [4] defines PM as a system of theoretical premises that represent, explain and guide a curricular approach and are incorporated in teaching practice and the interactions between teacher, student, and learning object. In this social relationship, the subject will act according to the defined model.

The use of Pedagogical Models for the integration of TDIC can help students develop the technical knowledge necessary to use these technologies. To integrate with the TDICs, the MP must place the student at the center of the learning process, enabling interaction with the world, and the construction and development of knowledge from the possibilities offered. [22]

This article aims to carry out a systematic review on the application of pedagogical models focused on the integration of TDIC in Brazilian basic education.

This article is divided into four sections. The first section, Introduction, is dedicated to presenting initial concepts about the researched topic. The second section, Methodological Procedures, presents the research techniques and methods for the development of this research. In the third section, Results, and Discussions, data analysis and interpretation are performed. Finally, the conclusion is presented.

## II. METHODOLOGICAL PROCEDURES

To carry out this research, technical procedures that have the classification of the systematic review were

adopted. This type of review identifies and minimizes bias through a transparent, explicit, and systematic methodology. In this sense, Khan et al [13] present five main steps for carrying out a systematic review:

Table 01. Systematic Review Steps

Stage	Description
1	Develop guiding questions
2	Identify relevant work
3	Analyze the quality of studies
4	Summarize the evidence
5	Interpret the findings

In step 1, the guiding questions must be elaborated, that is, problems that the systematic review seeks to solve. Subsequently, it is necessary to identify relevant works already carried out on the subject. The third step is to individually and thoroughly analyze the quality of the studies found to prepare a summary of the evidence of each one, according to step 4. Finally, the findings must be interpreted, characterized by the results of the systematic review carried out [13].

The guiding question for the present research is to "identify the most recent works that present pedagogical models that integrate TDIC in basic education".

To obtain the portfolio of articles to be analyzed in this research, systematic search criteria were used, based on Khan et al [13]. Therefore, the following keywords were used: "Pedagogical Model "; "Digital Technologies" or "Digital Technology" or "ICT" or "Information and Communication Technologies" or "TDIC" or "Digital Information and Communication Technologies"; and "Basic Education". The databases used were IEEE Xplore, Scopus, and Springer.

In this bias, filters were applied to delimit the search. The search was for publications related to the years 2018 to 2022, intending to emphasize the most recent studies on the subject. The types of publications filtered were conference documents, articles, dissertations, and theses. In addition, it was necessary to use documents with free access and complete availability of the text. The search results in the databases were 5 publications in IEEE Xplore, 7 publications in Scopus, and 326 in Springer, totaling 338 studies. Table 02 presents the results found:

Table 02. Systematic Search Results

Specifications		Database results			Total
		IEEE Xplore	Scopus	Springer	
String	("Pedagogical Model") AND ("Digital Technologies" OR "Digital Technology" OR "ICT" OR "Information and Communication Technologies" OR "TDIC" OR "Digital Information and Communication Technologies") AND ("Basic Education ")	5	7	326	338
Publication Type	Conference articles Magazine articles Dissertations and Theses				
Publication date	2018 to 2022				
Other filters	Open access Full text available				

Donato [9] explains that in a systematic review it is essential to define the studies that will be selected and those that will be excluded. For this, it establishes 5 steps, starting with the analysis of the relevance, later reading the titles and abstracts to remove studies that are not related to the topic, exclusion of duplicate works, reading the introduction and conclusion, and finally, the complete reading.

The following section, Results, and Discussion will present the filtering process applied in the present research.

**III. RESULTS AND DISCUSSION**

This section presents the results found and discusses what was discovered. The results were subjected to five exclusion criteria, as shown in the table below:

Table 03. Exclusion Criteria

Specifications	Results in databases			Total
	IEEE Xplore	Scopus	Springer	
filters				

1	Analysis of relevance	5	7	326	338
2	Reading the title and abstract	5	7	154	166
3	Deleting duplicate jobs	5	5	72	82
4	Introduction and conclusion reading	1	0	21	22
5	full reading	1	0	9	10

Source: authors

When reading the titles and abstracts, results that did not have objectives aligned with the study theme and duplicated results were excluded, leaving 82 works. The introduction and conclusion were read, classifying 10 relevant works for a complete reading.

**Description of publications found**

The second study analyzed, by Ilomäki and Lakkala [11], aimed to create a model that describes the main elements to improve schools using digital technology,

helping to reveal the differences between schools, and identifying their best practices and challenges. The applied model was based on six main elements that describe an innovative digital school: school visions, leadership, teaching practices, pedagogical practices, school-level knowledge practices, and digital resources. The application took place in three basic education schools and the results indicate essential differences between the schools and their best practices and points of improvement.

Kaminski et. al. (2019) built their research around the existing framework of the Writer's Workshop <sup>1</sup>to create a new framework to support learning that takes place in a makerspace environment. This article provides academics and practitioners with a guide to teaching and learning that can be customized to suit different aspects of STEAM content <sup>2</sup>to the unique circumstances of the school environment, and can be used in an everyday context and as a large-scale interdisciplinary STEAM initiative.

Avsec and Sajdera [2] use a pedagogical model for " *engineering thinking* ", which is a variation of " *design thinking* <sup>3</sup>", but more focused on engineering concepts. They tested this pedagogical model with 154 preschool teachers from Slovenia and Poland. According to the authors, they were looking for a tool to improve the creative potential of teachers, as well as their attitudes regarding the use of technology at school. According to Avsec and Sajdera [2], the pedagogical model was effective in deconstructing paradigms regarding the use of technology in preschool. The authors indicate that pedagogical models based on *engineering thinking* are positive especially in preschool and early grades.

The article by Kadioğlu-Akbulut et al [12] aims to develop a valid and reliable *ICT-TPACK-Science Scale* based on the transformative model, taking into account recent improvements in educational technologies specific to science teaching. The *ICT-TPACK-Science Scale* is a reliable and valid instrument to measure the TPACK of science teachers in training. This study included 722 science professors from 12 universities in Turkey. This has resulted in a scale that can be used to examine and support the development of TPACK. The scale is administered

<sup>1</sup>The process-oriented framework allows students autonomy and choice while providing a framework to meet specific literacy standards as they engage in the creative act of writing, allowing students to take turns with activities such as giving and taking peer feedback, talking to the teacher, and reviewing (KAMINSKI ET.AL., 2019).

<sup>2</sup>Application of specific knowledge of Science, Technology, Engineering, Arts, and Mathematics (KAMINSKI ET.AL., 2019).

<sup>3</sup>Process of generating ideas in a multidisciplinary group with a focus on problem-solving [5].

periodically in teacher training institutions to design and implement support strategies.

Falloon [10], in his article, presents an expanded conceptual framework of the teacher's digital competence. The research goes beyond technical conceptualizations to advocate for a more holistic and broad understanding, recognizing the need to expand teacher-in-training's understanding of the kind of competencies needed to function productively, safely, and ethically in diverse environments, including the digital one. The result is a comprehensive digital competency framework for teachers that will help build pedagogical models and take advantage of digital resources.

Another article analyzed was by Kamaludin et al [1]. The study developed a model to examine the factors that influence the behavioral intention of teachers and the actual use of the blended learning modality based on the Unified Theory of Acceptance and Use of Technology and the Technological, Pedagogical and Content Knowledge model. The survey was applied through questionnaires with 544 academic staff at universities, colleges, and polytechnic centers. The main result found was that the expectation of performance, effort, and social influence significantly impact the behavioral intention of teachers to use a hybrid learning modality for teaching.

In a study on digital pedagogical models, Brink, Kilbrink, and Gericke [6] seek to investigate teachers' experiences with these models. This study carried out 12 semi-structured interviews with technology teachers. The results show that technology teachers teach with different goals and purposes, whether improving and integrating other disciplines, visualizing technology for students, enabling digital modeling, and preparing students for the future. As technologies evolve rapidly, there is no single way to experience teaching digital pedagogical models, as these can also change over time.

In the article by Çam and Koç [7], they analyzed the impressions of teachers in training on the practices of Technological Knowledge of Pedagogical Content (TPACK) in higher education. The research was carried out using the case study method and with it, 7 educators in training received training and were asked to carry out practices. According to the survey results, the teachers in training showed a positive attitude towards the courses carried out according to the TPACK. The TPACK practical activities caught the attention of teachers during training, who actively participated in the practical activities. Finally, they reported that traditional teaching methods had lost attention and wanted novelties that they could use when they became teachers.



Foulger et al [5] present a form called IT2 (Teach with Technology) Survey. They demonstrate the tool as an effective instrument to examine factors associated with contextual knowledge and their influence on technology integration. For the authors, the form is considered part of a pedagogical model based on contextual learning.

In the last study analyzed, Jong et al [8] present an informed account of the Go-Lab, an ecosystem that supports teachers in creating Inquiry Learning Spaces (ILSs). Within the Go-Lab ecosystem, teachers can combine these online labs with multimedia material and learning apps, which are small apps that assist students in their inquiry-based learning process. For the article, data on the design process and structure of 2,414 ILSs were analyzed and the results found show that about 20% of implemented ILSs came from the Go-Lab sharing platform. This means that most originated from an empty ILS that the teacher fills with materials. Another important result is that 51.12% of the implemented ILS were created by a single teacher and 48.33% were created in teamwork.

#### IV. CONCLUSION

The objective of this research was to search for recent studies that addressed the themes Pedagogical Model, Digital Information and Communication Technologies, and Basic Education. For this search, the technical procedure of systematic review was adopted.

After applying filters and exclusion criteria, 10 articles published in the period from 2018 to 2022 were analyzed in full. The findings show that several pedagogical models were tested by teachers at the most diverse levels of education. In applied research, it was observed that teachers or teachers in training are more adept at using Information and Communication Technologies in the classroom. From the reading of the publications found, it was possible to verify that the pedagogical models that include TDICs gained strength compared to traditional methods, which has a positive impact on student performance.

One can observe the need for the pedagogical models adopted by teachers to seek to contemplate innovative strategies to adapt to current trends and increase the relevance of learning. An innovative MP must utilize the technology approach to meet the growing needs of learners for knowledge acquisition, skills training, and lifelong learning.

In general, this research contributed to finding the main and most recent studies on Pedagogical Models linked to Digital Information and Communication Technologies.

#### ACKNOWLEDGEMENTS

Acknowledgments: This work was carried out with the support of the Fundação de Amparo à Pesquisa e Inovação do Estado de Santa Catarina (FAPESC), through resources from the Public Call Notice FAPESC/CAPES N° 21/2021 – Accreditation of Higher Education Institutions with emerging stricto sensu graduate programs and being consolidated in priority areas in the state of Santa Catarina, Termo de Grant CP 21/2021 FAPESC.

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## Technologies and teacher training: An experience during the Covid pandemic

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Received: 10 Jul 2022,

Received in revised form: 01 Aug 2022,

Accepted: 06 Aug 2022,

Available online: 12 Aug 2022

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**Keywords**— *Teacher training; technologies;  
remote teaching.*

**Abstract**— *The SARS-COVID-19 pandemic has generated many changes in society. The educational sphere has undergone several adaptations in this context, among them the adoption of emergency remote teaching. Thus, the need arose to rethink teaching practices in the context of the use of technologies. This work proposes to analyze some courses developed for teachers, which focused on technologies and remote teaching and their contributions to everyday teaching practice.*

### I. INTRODUCTION

Today's society is experiencing major changes in various contexts - economic, political, health, and education, among others - as a result of the SARS-COVID-19 pandemic that has affected the world since 2019 and Brazil since 2020. One of the first measures of the face of the new coronavirus was social isolation, which changed human behavior in several areas.

Given the pandemic context, it was observed that the forms of communication and social interaction have changed paradigm: the experiences that previously occurred in person came to exist in the virtual world, remotely and online. In this way, Brazilian education has also adapted to the new reality, starting to be carried out in virtual learning environments.

According to Schneider et al (2020), "the pandemic scenario presented us with an unknown situation, transferring face-to-face teaching and its curriculum to a work mediated by technologies and carried out in a non-face-to-face way". Leite et al (2020) reiterate that "in this crisis of global proportion, educators and families had to

deal with unpredictability, (re)learning to teach with the support of technologies".

Therefore, Emergency Remote Teaching (ERE) - a term used to define the teaching modality in the context of a pandemic - has been gaining more and more space in Brazilian schools, and rethinking pedagogical practices has become essential.

Oliveira et al (2020), discuss this context, stating that technologies became part of everyday school life, so that teaching could take place and, as a consequence, the school had to adapt and review the ways of teaching and learning.

In this sense, thinking about the continuing education of teachers within the scope of the ERE and the use of technologies in the teaching and learning process is not only a formative process but also a reflection on teaching practice, since the adoption of digital technologies as a resource for remote classes occurred quickly and for many teachers, it was a great challenge to adapt and change their work.

Several institutions - including universities, and state and municipal education departments - started to carry out continuing education programs aimed at this historic moment in which the world is experiencing the coronavirus pandemic. Here, the importance of continuing teacher education and the work developed in one of the research laboratories at the Federal University of Santa Catarina are highlighted [13].

## II. CONTINUING EDUCATION OF TEACHERS: AN EMERGING NEED

Teacher training is complex and there are many studies on this topic, whether on the knowledge needed to perform the function or on the skills and abilities that are developed throughout the career.

The initial training process does not cover all the problems and challenges of the school environment, since they appear in everyday life, from a specific reality that is part of a specific context; they are not consequences of an abstract plan, but of a concrete world, composed of subjects and their cultural, social, emotional, intellectual and political characteristics. In this way, the school, which harbors all this diversity, goes through countless situations that require quick, immediate solutions and actions, to contribute to the smooth running of the school routine. Therefore, training beyond graduation is of great importance for teachers to expand their knowledge over the years of their professional careers. [13]

Gasparin (2007) states that "Knowledge, therefore, as a historical and social fact always presupposes continuities, ruptures, re-elaborations, reincorporation, permanence, and advances". In this sense, the pandemic context highlighted the need for a " reinvention" of school routine, ways of teaching, and learning. Teachers and students had to quickly adapt to the reality of the ERE.

In this way, the use of Digital Information and Communication Technologies (TDICs) for the continuity of school activities became the starting point for the planning and execution of remote classes. However, many teachers and students were not used to using technological tools during classes, and learning to use them was a challenge for many. [6]

Because of this, the relevance of the instrumentalization of teachers at this atypical moment is highlighted so that the teaching offered continues to be of quality and interactive, achieving the learning objectives. According to Santos et al (2019), the methodology influences the teaching and learning process and, therefore, teacher training needs to be thought of in terms of the applicability of teaching methodologies. To meet the need

for teacher training, many teacher training courses were developed during the pandemic period, focused on the ERE.

It is also worth mentioning that it is necessary to plan with defined objectives so that the use of technologies contributes to the learning process. The teacher needs to be clear about why each technology is used, considering the specificities of their students.

Thus, the continuing education of teachers should not be limited to the acquisition of technical and instrumental knowledge but must provoke reflection in the teacher on the context in which he works, as well as on his practice and his students.

Next, a proposal for teacher training carried out in 2021 is presented, as well as data about the evaluations of the courses offered.

### RExLab and courses for teachers: TDICs in the spotlight

The research group of the Remote Experimentation Laboratory (RExLab), at the Federal University of Santa Catarina, understanding the need for continuing education for teachers in the area of technology uses, organized and offered courses for basic education teachers. [6][13][14]

The courses were taught online, in the InTecEdu virtual learning environment. According to Silva & Bem, (2017) "a virtual learning environment is an educational software accessed via the internet, and its main objective is to support distance education activities".

In this sense, "InTecEdu represents an initiative of the digital inclusion line of action of RExLab, through the integration of technology in the context of Education and develops its projects and activities in Basic Education" [1][6][13][14]. Through the InTecEdu platform, teachers from all Brazilian regions were able to acquire new knowledge about digital tools, and technological resources for remote classes and develop more dynamic classes in the context of the ERE.

In this work, the courses offered in 2021 were highlighted. They are:

- Teacher training for the use of Moodle (module 1) - two editions, with 59 graduates.
- Teacher training for the use of Moodle (module 2) - two editions, with 30 graduates.
- Production of educational videos - two editions, with 43 graduates.
- Maker culture in remote teaching - two editions, with 103 graduates.

- Methodologies and strategies for remote teaching - two editions, with 78 graduates.
- Production of digital content - comics - two editions, with 59 graduates.
- Digital skills for STEAM areas - 55 graduates.
- Gamification - 18 graduates.

In all courses, the emphasis was on the use of TDICs in the ERE. However, it is worth mentioning that the tools and resources explored in the courses are not limited to the use in teaching in a remote format, since today's school is inserted in a society in which technological advancement is constant and the use of technologies in classes can contribute with more interactive, dynamic and meaningful learning.[13][14][15]

### III. MATERIAL AND METHODS

After the completion of each course, the participating teachers were able to evaluate both the course content and the methodology, platform, activities, and workload, among other items. These evaluations present important indications for the work that RExLab develops, both to establish the successes and to raise possibilities for improvement of the courses offered.

Thus, to list the contributions that the courses carried out by RExLab bring to the teachers, as well as the suggestions for improvement, these evaluations answered by the course participants were used as a research source.

From the choice of the research object, it was decided to carry out a content analysis, because it is understood that. The content analysis methodology is intended to classify and categorize any type of content, reducing its characteristics to key elements, so that they are comparable to a series of other elements [2].

Therefore, the research developed can be classified as qualitative, based on content analysis, because "data from research with a qualitative approach needs to be analyzed differently from data from studies with a quantitative approach" [11].

In this sense, considering the assumptions of the content analysis methodology, the research began with a floating reading of the selected documents. As a second step, the corpus of analysis was established, which focused on the difficulties and benefits presented by the course participants in the responses, in addition to self-assessments and suggestions.

The difficulties and benefits concerning the courses were extracted, considering the following aspects: content, the platform used, methodology, workload, and proposed activities. From the collection of these data, we sought to

group the information collected about the courses into two categories - positive aspects and possibilities for improvement. With the categorization established, a table was created with the data, which is presented below.

### IV. RESULTS AND DISCUSSION

The table below presents a compilation of evaluation data. For the courses that were offered in two editions, only the second editions were cut out, considering that the courses were reformulated from the first to the second edition according to the evaluation notes.

Table.1: Course – Moodle 1 – 2<sup>nd</sup> ed.

Course	Positive aspects	Possibilities for improvement
Moodle 1-  2nd ed.	- Knowledge update.	- Provide a list of the tools presented in the closing video with links to facilitate the storage of information.
	- Learning about technologies, new digital resources, and tools, for using moodle.	- They could make a repository, like a Wiki, of tools and tips, and their respective functionalities and advantages.
	- Objective and easy-to-understand course.	- Increase the course workload.
	- Quality material	- Easy download videos.
	- Interaction of the lecturers.	- Longer course availability time.
	- Interesting methodology and practical examples.	
	- Easy-to-handle tools.	
	- Well-organized, easy-to-access, and practical materials.	

Table.2: Course – Moodle 2 – 2<sup>nd</sup> ed.

Course	Positive aspects	Possibilities for improvement
Moodle 2 -	- Provided participants with the knowledge of new teaching tools	- Difficulty in carrying out activities: long videos and content.

<b>2nd ed.</b>	<ul style="list-style-type: none"> <li>- Possibility to put into practice the acquired knowledge</li> <li>- Quality of class materials</li> <li>- Flexible hours to perform asynchronous activities</li> </ul>	<ul style="list-style-type: none"> <li>- Alternate the course with readings and videos</li> <li>- More writing activities.</li> </ul>
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Table.3: Course – Educational Videos.

Course	Positive aspects	Possibilities for improvement
<b>Educational Videos</b>	<ul style="list-style-type: none"> <li>- Possibility to acquire new knowledge and techniques.</li> <li>- Materials and references are available.</li> <li>- Learning new tools.</li> <li>- Learning of pre and post-recording features.</li> <li>- Use of free applications.</li> <li>- Tutorials.</li> </ul>	<ul style="list-style-type: none"> <li>- Longer deadline to finish the course and to do the activities</li> <li>- Greater interaction with the teachers who organize the course.</li> <li>- Show how the recordings of the classes are carried out since the indicated applications are used only for editing.</li> <li>- Improve navigability. Show on the first screen the missing activities to perform, and a better explanation of the exercises.</li> <li>- Higher course workload.</li> <li>- Leave an example of a video that you consider to be of good quality, highlighting what makes that video a good example.</li> </ul>

Table.4: Course – Innovative methodologies

Course	Positive aspects	Possibilities for improvement
<b>Innovative methodologies - 2nd ed.</b>	<ul style="list-style-type: none"> <li>- Learning new resources and technologies.</li> <li>- TPACK model.</li> <li>- Courseware.</li> <li>- Diversity in activities and materials.</li> <li>- Interaction with other professionals.</li> <li>- Excellent opportunity for teachers to update their knowledge of technologies and methodologies.</li> <li>- Dynamics of classes.</li> </ul>	<ul style="list-style-type: none"> <li>- In word search, diagonal words are hard to find.</li> <li>- Understanding of new technological ramifications.</li> <li>- Difficulty finding activities and recording activities already performed.</li> <li>- Longer deadline for carrying out activities.</li> <li>- Do not use the white font (letter) on a gray/light background. The visualization is horrible.</li> <li>- Decrease video advertisements.</li> <li>- Longer term to access the course.</li> <li>- Apostille on the contents.</li> </ul>

Table.5: Course – Gamification.

Course	Positive aspects	Possibilities for improvement
<b>Gamification</b>	<ul style="list-style-type: none"> <li>- Organization of the course.</li> <li>- Use of updated technologies.</li> <li>- Interaction with colleagues.</li> <li>- Exchange of</li> </ul>	<ul style="list-style-type: none"> <li>- Clearer activities; improve their explanation.</li> <li>- More examples of using gamification in Moodle.</li> <li>- More lives.</li> <li>- Longer access to the</li> </ul>

experiences.	<p>course after completion.</p> <ul style="list-style-type: none"> <li>- Access to texts and videos before activities.</li> <li>- Higher workload.</li> <li>- Synchronous encounters.</li> <li>- Exemplify how to implement emblems.</li> </ul>
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	<p>- Finalization with the organization in images/graphs / tables of collectively constructed knowledge</p>	<p>(at the beginning of each LIVE).</p> <ul style="list-style-type: none"> <li>- There was a lack of professionals and, consequently, approaches in the areas of natural sciences. There was a course on pedagogical strategies. From the title of the course, science, engineering, and mathematics approaches were expected.] I suggest discriminating the contents at a later opportunity.</li> <li>- Work a little more on the STEAM approach during the course.</li> <li>- More diversified activities.</li> <li>- Teamwork.</li> </ul>
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Table.6: Course – Digital Skills for STEAM areas.

Course	Positive aspects	Possibilities for improvement
<b>Digital Skills for STEAM areas</b>	<ul style="list-style-type: none"> <li>- Interaction with other professionals from other states.</li> <li>- Lives.</li> <li>- Learning new content.</li> <li>- Tools and apps (canvas, in shot).</li> <li>- Possibility to see lives asynchronously.</li> <li>- Return of activities.</li> </ul>	<ul style="list-style-type: none"> <li>- Platform navigability: improve the organization of documents and activities within the course area, with activities in a logical sequence and with numbering.</li> <li>- Explanation of tasks and activities.</li> <li>- Longer deadline for delivery of activities.</li> <li>- Longer access to the course.</li> <li>- Higher workload.</li> <li>- Provide the contact of the speakers in advance</li> </ul>

Table.7: Course – Maker Culture 2nd ed.

Course	Positive aspects	Possibilities for improvement
<b>Culture maker - 2nd ed.</b>	<ul style="list-style-type: none"> <li>- Provided knowledge about new tools and methodologies.</li> <li>- Possibility of exchanging experiences with other professionals.</li> <li>- Reflection on teaching practice.</li> </ul>	<ul style="list-style-type: none"> <li>- Course navigability and progress bar.</li> <li>- Longer access time to the course.</li> <li>- Improve the organization of activities, perhaps separately from the content.</li> </ul>

	- Accessible language.	
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Table.8: Course – Comics.

Course	Positive aspects	Possibilities for improvement
Comics	<ul style="list-style-type: none"> <li>- Quality content.</li> <li>- Staff service.</li> <li>- HQ platform.</li> </ul>	<ul style="list-style-type: none"> <li>- Better organization of the moodle platform.</li> <li>- The longer term for activities.</li> <li>- More ideas and websites.</li> <li>- More lives.</li> <li>- Make a menu on the course's homepage where it illustrates what remains to be done.</li> <li>- Longer access to the course.</li> <li>- Reduce the number of activities.</li> <li>- Higher workload.</li> </ul>

The courses were organized in a way that promoted different forms of interaction between the professors and the contents covered. Training actions for teachers should promote debates, study groups, congresses, and seminars, among others, so that this training contributes to improving the quality of teaching [5].

Among the positive aspects highlighted by the course, participants are the methodology used in the courses, the diversity of activities, and the dynamics of the content covered, demonstrating that the way the course was planned met the expectations of the professors.

Another relevant point for the teachers participating in the courses was the interaction in the lives and the debates triggered in these moments of learning, which contributed to the reflection on the educational processes. In this sense, it is understood that "technology alone does not change

pedagogical practices, and to maximize the benefits of technological innovation, especially those referring to digital technologies, it is important to change the way education is thought of" [7]. Thus, there is an indication that future courses will continue to provide opportunities for reflections on educational practice.

Teachers also highlighted the usefulness of applications and course content and the possibility of applying what they learned to everyday life. It is of great value that teacher training is directly linked to teaching, to day-to-day school life, because "by putting into practice the acquired knowledge, the subject modifies his immediate reality" [3].

This must be the character of the educational process – to contribute to the development of citizens capable of acting in reality, transforming it. Gasparin (2007) also reiterates that "thus, theoretical knowledge loses its character of being just 'an understanding of what happens, to become an action guide'".

Understanding continuing education as a space for reflection on practice and for exchanging experiences with colleagues in the profession, it can be observed that this objective is consolidated in the courses offered, as indicated by the participants' evaluations. They highlight the importance of interaction and exchange with lecturers and course participants.

Regarding the possibilities for improvement listed by the course participants, it is possible to notice that, in most courses, a longer workload is suggested, as well as more time to carry out the activities and consequent expansion of the period of access to the courses.

From these elements, it can be inferred that, despite the teacher's busy routine, there is a commitment on the part of teachers to their continuing education and, therefore, there is a desire that the workload is greater and that they can dedicate themselves more to the activities of the teacher course.

Because of the evaluations presented, it is worth emphasizing the importance of offering courses to teachers with themes relevant to their daily lives. According to Leite et al, (2020) "it is necessary to guarantee the necessary structures for the educational process, enabling more qualitative and meaningful ways in the teaching and learning process, with the use of technological resources".

## V. CONCLUSION

It is important to understand teacher training as a process that extends throughout their professional careers and is in constant development. Therefore, so that teaching practice does not become routine and repetitive, it is



necessary for the teacher to assume his professional development, reflecting on his actions, since a new practice only develops from a reflective process on the previous practice [4].

In this way, the courses offered by RExLab achieved the objective of promoting the acquisition of new knowledge for teachers. In addition, reflection on teaching practice was also made possible in the courses, through activities and moments of exchange of experiences between lecturers and course participants and between peers.

This work sought to make some considerations about the selected courses, but it does not exhaust the possibilities of study on the subject. There is an increasing need to think about current teacher training, using technologies, and evaluating the actions that have already been developed to bring possibilities for improvement for all those involved in this training process.

### ACKNOWLEDGEMENTS

Acknowledgments: This work was carried out with the support of the Fundação de Amparo à Pesquisa e Inovação do Estado de Santa Catarina (FAPESC), through resources from the Public Call Notice FAPESC/CAPES Nº 21/2021 – Accreditation of Higher Education Institutions with emerging *stricto sensu* graduate programs and being consolidated in priority areas in the state of Santa Catarina, Termo de Grant CP 21/2021 FAPESC.

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# Leadership process in an innovation team at Nokia: An analysis from the Complex Leadership Theory (CLT)

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Received: 09 Jul 2022,

Received in revised form: 02 Aug 2022,

Accepted: 08 Aug 2022,

Available online: 12 Aug 2022

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**Keywords—** Innovation, Innovation Team; Nokia, Complex Leadership Theory.

**Abstract—** This research aims to understand how leadership processes occur in an innovation team of Nokia Networks - Brazil, through the Complex Leadership Theory. By using interpretive research methodology and in-depth interviews, we found in the administrative function: 1) leadership emerges according to the context and develops in a distributed way; 2) the strategic alignment of the team and the contribution of resources are facilitators for innovation. Regarding the adaptive function: 1) collaborative work among project members provides a shared learning environment that generates innovation and team flexibility for changes; 2) there are constant team interactions with other Complex Adaptive Systems for idea generation and new solutions. And in the enabling function: 1) team members are empowered in project development; 2) the feedback contributes to the creation of a transparent and trusting environment; 3) encouraging learning motivates teams to invest time and effort in finding new solutions and achieving project goals.

## I. INTRODUCTION

Rapid technological changes, shortened product lifecycles, and globalization put pressure on organizations to be more creative and innovative - which are conditions to survive, compete, grow and lead [13].

Faced with increasingly complex and emerging environments [10], where unpredictability, dynamism, and uncertainty prevail, the traditional view of leadership centered on the leader-follower relationship is re-evaluated. It is no longer about the leader influencing followers to meet the aspirations of the leaders, but about members interacting to generate innovative results [17][18].

In this case, a new concept of leadership is necessary, allowing multiple models of network influence, creative ideas flow, and the emergence of innovation [18]. Due to

the dynamic, unpredictable, and innovative context, leadership studies are adopting a new paradigm. While the traditional paradigm is based on command and control, the new one, proposed by the Complex Leadership Theory (CLT) [23], prioritizes interconnectivity, based on the Complexity Theory and refutes bureaucratic notions of control and predictability. According to the CLT, leadership is considered a complex, adaptive, nonlinear phenomenon that occurs as an interactive process in a network [42].

CLT is particularly suited to situations where groups or teams need to learn how to solve problems and unpredictable situations, in collaborative [43] and shared [31] ways, especially in emerging and complex environments [10][16][23][32][38]. Groups are considered Complex Adaptive Systems (CAS), networks of

interacting people functioning as interdependent agents, linked by a cooperative dynamic of common goals [22].

The interaction among the members of one SAC and with other CASs generates collaborative learning that, in turn, has a positive influence on innovation [6][9][31]. From this perspective, every innovation team is characterized as a CAS. Innovation, in this context, results not from the leader's view, but from the interaction among agents, who interact to deal with issues that need to be resolved [22]. Marion (1999; 2006) states that many agents working together is better able to create and learn than isolated individuals.

By the CLT, organizations are seen as living systems, which are in continuous motion that describe three leadership functions: adaptive, administrative, and enabling [40], whose intertwining generates the learning necessary for innovation [26]. The theory does not ignore traditional leadership behaviors, but provides a new view on leadership in complex contexts [10][19][41], just like in innovation teams. In these teams, the environment is often characterized as interactive and unpredictable [25], and leadership emerges according to the development in a procedural and shared manner [12][32], generating an environment focused on learning and innovation [6][9][26][31][39].

In scientific literature, there are few empirical studies aimed at understanding the process of leadership in innovation teams according to CLT. In this manner, the present paper intends to answer the following research question: how does leadership take place in an innovation team at Nokia from the perspective of CLT?

## II. LITERATURE REVIEW

### Complex Leadership Theory

Complex Leadership Theory (CLT) originated from complexity theory [21], which considers organizations as Complex Adaptive Systems, that is, composed of a diversity of interacting agents, mutually affecting each other, and thereby generating new behaviors for the system as a whole [22].

SACs are mutable structures that overlap in multiple hierarchies. These systems are linked together in a dynamic and interactive network of people. The resulting structure resembles knowledge flows in organizations, and is therefore called by Hedlund (1994) "temporary constellations of people and units". CAS can solve problems, learn and adapt quickly and creatively.

For CLT, organizations and their leaders are products of these dynamic interactions; therefore, leaders do not create the system, but affect it and are affected by it by an

aggregation and emergence process. It also does not address leadership as necessarily embedded in the formal hierarchy, but as a phenomenon that permeates the organization. With this, the differences between leader and subordinate become smaller, because leadership depends on the context, that is, in a given context, one individual may be the leader, and in another context, the subordinate [21].

According to the theory, the leader can affect the organizational system through what McKelvey (2001) calls distributed intelligence. In this perspective, the results of the organization are achieved due to the connectivity between the several agents that can affect the top of the structure and, thus, establish new ideas that generate innovations.

The model proposed by CLT focuses more on creating conditions that facilitate the emergence of distributed leadership than on the discussion of individual behavior. Distributed leadership is characterized by the dissolution of authority, which makes it possible to solve problems and create innovation in an organization or system, usually by using bottom-up relationships, not solely based on hierarchy [22][23][24].

Figure 1 presents the three complex leadership functions (adaptive, administrative, and enabling), which, according to CLT, explain how leadership emerges and occurs [12][40].

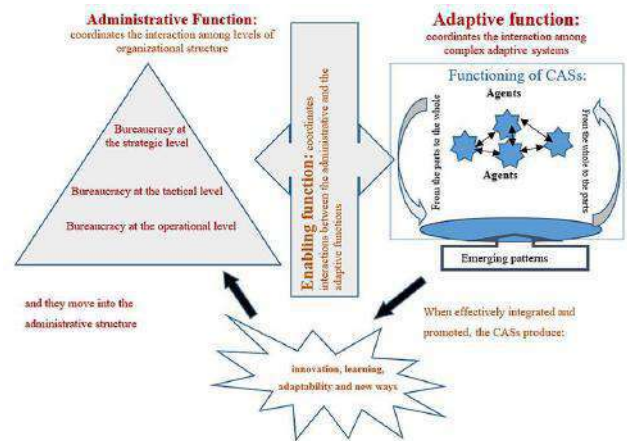


Fig. 1: Three Functions of the Complex Leadership Theory. Source: adapted from [40]

The function is described as follows.

#### Administrative function

The administrative function refers to the actions of individuals in management and formal positions, and their nature varies according to the hierarchical level in the system. At the strategic level, leaders engage in strategic planning, coordination, resource acquisition, and

structuring conditions related to the strategy of the organization. Leaders at the intermediate level are more focused on coordinating creative operations, managing resource allocation, and framework conditions, within which the adaptive function (detailed in 2.1.2) takes place. At the operational level, planned activities are implemented and operationalized. Traditionally, administrative leadership is a top-down function based on the authority and position of power. However, considering the dynamics of complexity, some authors suggest that management leadership should exercise authority by reflecting on the need for creativity, learning, and adaptability in organizations [39][40][41]. According to Uhl-Bien and Marion (2009), the administrative function can impact the organization's adaptive capacity as the formal structure and the resources it manages to impact the interactions between an organization's CASs and, consequently, the organizational performance.

### Adaptive function

For Uhl-Bien and Marion (2009, p. 643), the adaptive function is an informal process that "originates in disputes between agents or collectives as they engage in meaning-making or problem-solving under ambiguous or complex adaptive conditions [.] and dynamic pressures". The adaptive function involves the organization as a whole and results in "cooperative efforts and alliances of people, ideas and technologies" (Uhl-Bien and Marion, 2009, p. 643).

While people are key, the focus of the adaptive function is on interactions between agents since these interactions drive change and innovation in the organization. Adaptive change is produced by the clash of seemingly incompatible ideas, existing knowledge, and technologies. It results in learning, adaptation, or new knowledge and creative ideas. The most common form of this type of change occurs when two interdependent agents debate conflicting perceptions about a subject. At any given time, and perhaps at the same time, they generate a new understanding of the issue discussed - this can be considered the "aha" moment. This moment is the product of a nonlinear combination of meta-perceptions, the discarding of unsustainable arguments, and the fusion of what is sustainable. It can also be the product of rejecting original ideas (meta-ideas), because they are unsustainable, or the creation of another idea entirely new. This type of change represents a process that goes beyond the original assumptions (meta-premises) and generates something different [40].

Adaptation is related to the experience, knowledge, flexibility, and creativity of the agents who act and generate change by creative thinking. Complex systems

[10] depend on these factors and impulses from the internal and external environments to generate innovations.

### Enabling function

The enabling acts as an interface and a facilitator of the intertwining of the administrative and adaptive functions employing two mechanisms: first, it creates conditions for the emergence of adaptive leadership; and second, it enables management leadership to assimilate emerging outcomes produced by adaptive leadership (Uhl-Bien and Marion, 2009, p. 636). Thus, this function creates a favorable environment for emergence and innovation to thrive in the organization [9].

The enabling function partially overlaps the administrative function, as it can be performed by agents acting at the managerial level since they have access to resources and have direct involvement in production systems. Besides, a single agent can aggregate both the enabling and the adaptive function depending on the situation.

The major function of the enabling function, according to Uhl-Bien, Marion, and McKelvey (2007, p. 310), are:

- create and foster conditions that allow mechanisms and contexts to interact so that the adaptive function operates effectively;
- enable the administrative function to intertwine with the adaptive, so that agent networks can interact more intensely, and those products and innovations are disseminated and supported to improve organizational performance;
- promote interdependence and coordination of efforts among agents and CASs to provide articulated work environments with multidisciplinary teams;
- enable tension to be a motivating and articulating factor for interactive dynamics between agents;
- support and promote contact networks and information flows so that agents can develop their activities in an integrated manner;
- promote interaction between several CASs to foster different ideas and, thus, transform them into more valuable ones that generate learning and innovation for the organization;
- promote a flexible environment that is adaptable to environmental changes so that agents can monitor and act on this environment;
- support the empowerment and autonomy (own ideas) of actors, which enables the emergence of "conflicting constraints and allows agents to work with these constraints without interference from formal authorities".

In this manner, according to the CLT, the intertwining of the three functions generates learning and innovation [40], and the next section discusses how it occurs.

### **CLT, learning, and innovation**

CLT presupposes an interactive, adaptive, networked, non-linear leadership process [12][39], in which each team member can, as appropriate, assume the leadership role. Members interact and provide feedback to help with tasks and reinforce learning [38]. Interaction occurs when multiple agents connect meaningfully within an organizational context [15]. For Arrow, McGrath, and Berdahl (2000), small groups that interact with each other and exchange information (eg, teams, departments) act as CASs. These interactions can occur between CAS members, between different CASs, and within the external environment of the organization. These are vital for shared learning [39][42].

According to Delia (2011), shared learning happens when people share and understand knowledge together by interaction and interdependence, which, in turn, are enabled by complex leadership. CLT generates shared learning which, in turn, has a positive influence on the results of the innovation team. Ott (2010) corroborates this understanding by stating that CLT is the most appropriate lens to understand organizational leadership in highly changing and innovative contexts.

In complex contexts, Ott (2010) adds that leaders need to foster interaction among individuals, teams, and information to provide an adaptive and shared learning environment. These factors are relevant to the generation of innovation since leadership is not the sole property of individuals. For O'Connor and Quinn (2004), when leadership is viewed systemically, its effectiveness becomes more than a product of interactions between the parties. Leadership and creativity become the property of the collective, enabling bottom-up interactions and fostering innovation [30][33][34][35].

According to Marion and Uhl-Bien (2001), agents interact, they tend to adjust to each other's worldviews and create temporarily more stable and more interactive sub-units. In this process of interaction, they learn from each other and take the system into new dynamic states [1]. This phenomenon contributes to the emergence of more appropriate adaptive states that usually manifest as innovation [22].

However, not all interactions are effective, and therefore do not promote learning and innovation. Uhl-Bien et al. (2007) point out that interaction between agents can only be effective if they interact freely with each other and with their larger environment, if they are mutually dependent on each other, and if any stress in the

environment requires them to come up with solutions. Boal and Schlutz (2007) corroborate this last statement, concluding that in CAS innovative behaviors can emerge from the interaction of agent groups when they have to solve a problem. Mendes et al. (2016) propose that innovation occurs based on the interaction between CLT's administrative, adaptive and enabling functions. As far as innovation is concerned, these functions do not occur in isolation, and each of them plays an important function within the CLT. Collectively, the three functions extend the ability of organizations to harness the potential for learning and innovation.

### **Leadership in Innovation Teams**

The team-based framework provides the flexibility needed for organizations to respond quickly and effectively to the demands of an ever-changing environment [44]. According to Delia (2011), an innovative team has heterogeneous experts in its composition and is perceived skills as having special learning and innovation.

Also, for Delia (2011), there are two characteristics and dynamics of innovation teams that characterize them as a CAS. The first feature refers to the heterogeneity of the members of an innovation team, made up of people who have varied knowledge and different functional skills and competencies. The second feature is that the interactions of innovation team members can be both internal and external, that is, the members of the innovation team interact with each other and with the external environment. Interaction and interdependence among agents are vital to the functioning of the CAS and produce creativity and learning [41].

After identifying that an innovation team can be analyzed as a CAS, Delia (2011) describes each of CLT's three functions in an innovation team. The managerial function in an innovation team is usually performed by a formally appointed leader, who guides the team and connects their processes to the strategies of the company [5][33][36]. The adaptive function of CLT, in turn, occurs in innovation teams when members need to interact to solve any disagreements or problems. By interacting, they generate behaviors that foster innovation. Finally, the enabling function in teams' innovation, in addition to connecting the administrative and adaptive functions, creates a favorable environment for emergency and innovation to be fostered within the organization [9].

## **III. RESEARCH METHODOLOGY**

To achieve the objective proposed in the present paper, interpretive research [28] was used, having in-depth

interviews as data collection. According to Taylor and Bogdan (1997), this kind of method is characterized by the investigation of a social phenomenon from the perception of the actors themselves, who are immersed in the situation being observed live and investigated [27]. Initially, we sought to understand the characteristics of Nokia's innovation team and its context based on the following aspects:

- general identification of the innovation team (name, age, position, education, professional experience, time in the company/experience in the company);
- understanding of hierarchical levels based on the researchers' perception of relationships in the workplace;
- comprehension of the team routine - how the team routine works in the project development process, including disentangling the technical terms;

- understanding of team interactions with other sectors of the company, as well as external stakeholders such as customers, suppliers, and competitors.

A semi-structured interview script was adopted, with questions based on the CLT functions (administrative, adaptive, and enabling) in an innovation team. Five interviews were conducted with members of the innovation team linked to the Laboratory for Advanced Studies in Mobile Telecommunications Networks - a partnership between the Pontifical Catholic University of Paraná (PUC-PR) and Nokia Networks. Before each interview, the researchers explained the object and the research theme. The respondent was asked to read and, if they agreed, to sign an Informed Consent Form (ICF). The respondents' profile is presented in Table 1:

Table 1. respondents' profile

RESPONDENT'S PROFILE				
Respondent 1 (R1)	Respondent 2 (R2)	Respondent 3 (R3)	Respondent 4 (R4)	Respondent 5 (R5)
- Electrical engineer. - Nokia employee. - Nokia Project Executive Coordinator. - 33 years of experience in R&D project development.	- electrical engineer - PUC-PR employee. - Coordinator of the Electrical Engineering Course at PUCPR. - PUC-PR Project General Coordinator. - 27 years of experience in the areas of information technology, computer networks, and communication systems.	- Computer engineer. - PUCPR employee and technical developer in the project. - 5 months of experience in software development.	- Computer engineer. - PUC-PR Employee and Analyst Technical (Senior) Developer in the Project. - 3 years of experience in software development.	- Computer engineer. - PUC-PR employee. - PUC-PR Coordinator of the Computer Engineering Course. - Ad hoc researcher in embedded systems in the project, with 20 years of experience in the area.

Source: Research Data (2018)

Data analysis was performed using the method proposed by Taylor and Bogdan (1997), which consists of the preparation of information (gathering the necessary material for the analysis); classification of the material into categories (grouping the data by sorting them by similarity or analogy); description (report search results); and interpretation (infer from the data reported in the research).

#### IV. DATA PRESENTATION AND ANALYSIS

In this section, the data collected in the interviews are presented and analyzed. Data analysis is structured based on the CLT macro-dimensions: administrative, adaptive, and enabling functions, to which thematic categories were associated. The results are described from the intertwining of the CLT functions, highlighting the categories that emerged from the interviews.

## Laboratory of Advanced Studies in Mobile Telecommunications Networks

The research was conducted with the Nokia Networks/Brazil innovation team, in partnership with the Pontifical Catholic University of Paraná (PUC-PR), whose project consists of a proof of concept connected to the internet of things using innovative protocols, focused on precision agriculture for monitoring and prediction of the Asian rust, a pest that attacks soy.

The project was developed at the Laboratory of Advanced Studies in Mobile Telecommunications Networks, which is coordinated by the Electrical Engineering Course of PUC-PR/BR. The laboratory is a space for cooperation between the University and Nokia, and its scope is to conduct advanced studies, staff training, and technology development for the 4th and 5th generations.

The solution developed in this project consists of a sensor system, which works seamlessly with a cloud Internet of Things (IoT) platform and the application responsible for analyzing data and notifying end users. It innovates by using emerging cellular technologies focused on IoT applications: LTE-M (Long Term Evolution) and NB-IoT (Narrowband Internet of Things).

The project is expected to last 10 months, and the team was interviewed in April 2018, the last month of implementation. The partnership between PUC-PR and Nokia has been taking place in other projects since 2009, having been intensified since 2014. See as follows the results of the analysis of the leadership process in Nokia's innovation team based on the three functions of CLT: administrative; adaptive and enabling.

### CLT Administrative Function

Regarding the administrative function, we sought to identify the actions of people who held managerial positions, formally designated, in the team. From the data analysis, the following constituents of the administrative function were identified: hierarchical structure, financial resources, technological resources, and people.

Regarding the administrative function, we sought to identify the actions of people who were formally assigned managerial positions in the team. From the data analysis, the following elements of the administrative function were identified: hierarchical structure, financial resources, technological resources, and people. In what concerns the hierarchical structure, it was possible to identify that, despite being formally assigned the functions of Project Executive Coordinator by Nokia, R1, and Project General Coordinator by PUC, R2, the structure of the innovation team is organic [7][8]. Leadership emerges in context and

develops in a procedural, shared form [32], and is distributed [20][21][22][23].

In many situations, project leadership is not based on hierarchy, but on bottom-up relationships, as affirmed by the PUC General Project Coordinator (R2): "In many situations, they (the technical project developers) exercise the leadership (...). Broadly speaking, they take the lead." His words were reinforced by the project's own (senior) technical developer's perception: "When the issue is more technical (...), then I think I should take the lead (...)" (R4).

Therefore, the prevailing administrative function model in the researched team is in line with what Uhl-Bien and Marion (2009) advocate, stating that a company that works with development and seeks innovation as a competitive advantage needs to adopt a more organic structure. This statement is also in line with the studies by Quinn (2004), Sweetman (2010), and Cochran (2013), which demonstrate that an organizational structure that allows for distributed leadership, bottom-up relationships, and clear and fluid communication, promotes the emergence of complex adaptive systems that consequently contribute to generating innovations.

The project team has financial, technological, and human support from both PUC-PR and Nokia. These resources, due to the university-company partnership, are managed by the two project coordinators. According to the PUC-PR Project's General Coordinator for (R2), the largest contribution of financial resources is from Nokia, formally represented by the Project's Executive Coordinator. The Executive Coordinator has "full responsibility for keeping and conducting investments throughout the project" (R2), even if there is a joint definition of the project scope between him and the PUC-PR technical coordinator. Also, according to R2, "He (the executive coordinator) is the project manager within Nokia, (...) he is our interlocutor with Nokia. (...)".

In what concerns technological resources, there is a division of tasks between PUC-PR and Nokia. PUC-PR's team of professors supports the definition of the technological structure of the project, aiming to develop more innovative and complex solutions. Nokia, in turn, invests in new equipment, which is confirmed by R3's statement: "when we need new equipment, something we don't have here, (...) the project's executive coordinator usually passes it on to Nokia and gets the equipment".

Regarding people, data analysis shows the importance of the university-business partnership [11]. Several professionals were ceded by the university. In addition to the Project General Coordinator, who acts as the technical manager, the team has the ad hoc consultancy of a PUC-PR professor who is knowledgeable in embedded systems

and two developers who are engineers hired by PUC-PR involved in the daily execution of the project. According to one of the respondents: "We invite these teachers to participate in the projects, advising on certain subjects that they have the expertise, and they also participate weekly in the project meetings" (R2).

At Nokia, the project executive coordinator acts as a facilitator. He is the interface between the project team and Nokia's strategic group, besides acting as a link between the project and Nokia and promoting the strategic alignment of the team. In the group, he is considered a facilitator for the development of new knowledge and the generation of innovation.

### CLT Adaptive Function

Regarding the adaptive function, we sought to understand how it acts on the learning and innovation processes. To understand this relationship, it was necessary to investigate two points: how the team adjusts to the challenges and unforeseen issues inherent in project execution, and how the process of interaction among team agents and of agents with other CASs takes place.

When asked about unforeseen events that led the team to overcome challenges, thus generating learning and innovation, the case of the LTE-M and NB-IoT protocols was remembered. The providers of these protocols have not delivered the appropriate interface configurations for joint use as initially promised to Nokia. This forced the innovation team to make major design changes, demonstrating flexibility and resilience. At the same time, it also generated great learning since the team had to interact with suppliers in search of a new solution. According to Respondent 1: "We had difficulties with the purchased device (...), we had to contact the suppliers (...), and we re-scheduled our activities. So, this is part of our everyday lives (...) to achieve the objectives of the project."

The learning and innovation processes that occurred in the case of the protocols are supported by Boal and Schluetz (2007) and Delia (2011). According to these authors, in CASs, innovative behaviors can emerge from the interaction between groups of agents whenever they have to solve a problem. Regarding the interaction process within the CAS, it occurred in an emergent, informal, and frequent manner among the members of the innovation team, then generating new solutions. The interaction with other CASs, especially external ones, was facilitated by the university-company partnership [11].

In interacting with external customers, we identify the interactions between Nokia and the telephone operators. To explain this interaction, the ad hoc researcher (Respondent 5) highlighted that: "In general, a demand

between Nokia itself and an outside company often has to do with telephone companies (...) and it is required from it (Nokia) a project idea that is innovative (...), from this on, the team is raised (...)"

Interactions with external customers influenced the project due to the demands they presented to Nokia. In the project studied specifically, the Alfa operator, Nokia partner, showed interest in the project solutions related to incorporating 4G into more innovative products. According to Respondent 1: "For example, one of the partners interested in this project is Alfa operator, because of the 4G communication we will use in the project, so as one of Nokia's customers, it is also interested in the project."

Especially in the early phase of the project, there were interactions of the project team with other areas of PUC-PR to expand the generation of ideas and solutions. According to the General Project Coordinator (R2), "in the planning phase, where the scope of the project was still in discussion, I required technical support from the Agronomy teachers because they had specific competencies", which were necessary to develop agribusiness solutions.

In addition to the partnership with the Agronomy program, the project team counts on the collaboration of teachers from different areas of engineering. They act as consultants and are incorporated into the innovation team when specific problems arise in the project. As observed in the words of Respondent 3: "(...) when we have a major challenge, first we talk to the General Project Coordinator, (...) depending on the area, then we also talk to another teacher. (...) Then we talk to the ad hoc researcher in the area of embedded systems, who is the most experienced in this area to help us."

The innovation team interacts with other internal and external CASs to solve problems and seek innovative solutions. These interactions contribute to the stability and self-efficacy of the team, who consider themselves prepared to face emerging situations. As emphasized by Delia (2011), Ott (2010), and Cochran (2013), these interactions generate collaborative learning which, in turn, has a positive influence on innovation. These effects of interactions were observed by Gramkow (2016), who analyzed a software development team.

In the present case, the interaction of the technical team with project suppliers stands out. For instance, to solve difficulties with the LTE-M protocol, an articulation was promoted between the engineers of the innovation team and the protocol suppliers. Together, they were able to solve the problem and incorporate this protocol into the solution, generating the intended innovation that reduced



energy consumption in the use of the soybean Asian rust monitoring devices. According to one of the respondents (R3): "At the time, we contacted the suppliers directly to find a solution with them (...) and they gave us some solutions for our test environment to make it work, and that's for the LTE-M only."

Another type of interaction considered important for the project is between university and company, fundamental to generating knowledge and innovation. According to Respondent 5: "The scientific knowledge we have here cannot simply be developed to produce paper, it needs to be applied. And who applies are the companies (...). This approach is fundamental. There is no way we want to be isolated". University-company cooperation is critical to learning and developing technological innovations [29]. That is, from this interaction, new methods and improvements in products and processes can emerge, and it brings benefits to all parts involved [3].

### **CLT enabling function**

Concerning the enabling function, we seek to understand how the promotion of a collaborative environment that supports and encourages people's learning, feedback, autonomy, and empowerment creates favorable conditions for innovation to be fostered. In Nokia's innovation team, we have identified that its members are empowered to act autonomously in project development - in particular, developers who are directly involved in project execution and the development of innovative solutions. According to respondent 3: "(...) Usually, the senior developer and I have some freedom in the project. We define our activities ourselves. (...) We are encouraged to define how to do it (...)".

This motivation for team autonomy provides decision-making agility and expands the potential for innovation throughout the project - it makes the team feel confident and motivated for the decisions and discussion of ideas that emerge at meetings. This effect was noted by Gramkow (2016) and like the Nokia innovation team, empowerment was considered one of the driving factors in overcoming the unique challenges of emerging and complex environments [10].

In the researched team, the encouragement of leaders to jointly develop new solutions and knowledge generate a sense of unity, trust, and commitment. The following statements demonstrate that communication and trust among members help the team achieve their goals: "Team tuning is great. (...) Everyone is working together to achieve a goal" (R4). "We work side by side, and we keep a regular conversation. As much as we share the parts of the project, (...) we are always communicating (...), exchanging ideas, and helping each other. (...) I feel that

they trust us a lot" (R3). "We can agree, a consensus of everyone together, contributing to a solution" (R5).

Leaders played a key function in building the commitment of the team members. To a large extent, this commitment was achieved by building interpersonal relationships based on trust and unity. These aspects are emphasized by Ott (2010) and Delia (2011), who emphasize the importance of promoting collaborative work, in which leaders are fundamental in taking the team to a higher level to make them more aware and prepared to face challenges and generate a learning and innovation environment.

A feedback culture is an important element in the enabling function. Plainspoken and open feedback is highly valued and significant for developers directly involved with the project because through feedback, they are aware of what needs to be improved or modified during the project. According to respondent 3: "Usually, there is no right date for this feedback (...) it is according to the development of the project (...). Sometimes the head coordinator/Nokia brings feedback from Nokia on how the project is doing and how they're analyzing the project and its progress (...)". Respondent 5 adds: "We have weekly meetings, every Wednesday, for feedback, (...) so we can understand the timing of things (...)". Feedback given to members is a way of stimulating the team as a whole and reinforcing an environment of transparency and trust needed for the effectiveness of highly complex projects [12].

Another contribution to the successful performance of the enabling function was the learning incentives. Team members received different training and support from project coordinators. In particular, the senior developer expressed satisfaction with the learning incentives: "We have a lot of internal courses offered by Nokia (...)" (R4). Learning incentives are associated with the idea that the search for new knowledge should be the natural way in an innovation team, and that the environment can be a facilitator of the processes of creating new solutions: "Constant acquisition of knowledge and improvement is part of the normal development process in an R&D team (R2).

### **The intertwining of the CLT function**

In the innovation team studied, it was observed that leadership functions are intertwined, even to meet the challenges faced by the team. This aspect has been identified in other studies that have also addressed project teams in complex environments [9][12]. An example is when the horizontal structure (administrative function) contributes to the emergence of flexible, collaborative, and interactive work processes (adaptive function, which

creates a favorable environment for learning and innovation to be fostered within the team (enabling function).

Another example is the weekly meetings. All weekly formal meetings (administrative function) are dynamic and interactive (adaptive function) and create an environment where the discussion of ideas takes place smoothly (enabling function), which facilitates problem-solving, promotes team learning, and makes innovations more effective (adaptive) function). The most typical case of the intertwining of functions is the import and use of devices under the LTE-M and NB-IoT protocols. Before the team received the LTE-M protocol, the product was inaccessible for weeks due to bureaucratic issues. It caused a delay of almost one (01) month in the project (here, it is observed that the administrative function has involuntarily generated a negative impact on the project).

Subsequently, when the team had access to the device, they found that it did not support the LTE-M protocol, contrary to what had been stated by the providers. Nokia initially brokered with suppliers (administrative function), but then developers took over negotiating and finding solutions with suppliers (adaptive function), adopting an empowered and autonomous posture (enabling function) (Respondents 3 and 4). Finally, they were able to update the software and started using the LTE-M protocol on the device.

Regarding the second protocol (NB-IoT), all respondents made it clear that its incompatibility with Nokia software meant that everyone had to work harder on their functions and interact more (enabling function) to find a co-solution (adaptive function). That is, the coordinators had to take the enabling function over, seeking partnerships with other teams within PUC-PR and Nokia, to jointly find possible solutions (adaptive function). All these articulations occurred synchronously and interconnected through meetings and videoconferences with overseas supplier teams (enabling function). Until the conclusion of the present study, the device was still incompatible with the second protocol.

In the case of protocols, it can be stated that the administrative function contributed both to accelerating and slowing down the development process, generating positive and negative impacts at different times. The positive impact comes from the support of both Nokia and PUC-PR so that the innovation team can solve the problem of incompatibility of the NB-IoT protocol with Nokia software. On the other hand, red tape issues negatively impacted the execution of the project. This scenario demonstrates the importance of understanding the functions of complex leadership in an imbricated way

because only then it is possible to understand their influences on project development and the generation of learning and innovation.

## V. FINAL CONSIDERATIONS

The present research sought to understand how leadership processes occur in Nokia's innovation team from the prism of CLT. The use of a qualitative methodology, with in-depth interviews with each member, allowed researchers to understand how leadership processes occur and emerge in a specific innovation context through the CLT functions: administrative, adaptive, and enabling.

Although there is a hierarchical relationship between the members of the team, the administrative function of leadership, many times, occurs in a distributed way, that is, depending on the problem, the one with the highest technical competence leads the process. When an innovative idea comes up, it is soon shared among all members and refined in meetings, generating new learning and innovation in the team. The university-company interaction (Nokia and PUC-PR) acts as a facilitator for idea generation and innovation. There is a strategic alignment between the project team and Nokia's strategic level as the project executive coordinator interfaces with the company's strategic group.

Regarding the adaptive function, some examples of learning and innovation that required team flexibility to promote design changes and solve problems were identified. In these situations of adaptation and problem solving, interactions with other areas for idea generation emerge. During the project, interactions were made with teachers from different areas at PUC-PR, and with other internal and external CASs.

Concerning the enabling function, team members are empowered to act autonomously. This empowerment increased agility in decision-making and improved the effectiveness of innovation processes throughout the project. The team grew in confidence and motivation to make decisions and discuss new ideas.

During the project, the coordinators (technical and administrative) were constantly available to dialogue and develop solutions together, sharing knowledge and seeking new ideas. An environment has been created to allow open discussion of issues, and any team member can give their opinion freely. Feedback culture was considered one of the key foundations for creating an environment of transparency and trust. In this environment, learning incentives motivate team members to continue to invest their time and effort in achieving project goals.

Thus, the results identified allowed us to understand how innovation occurs in Nokia's innovation team when through the lens of CLT. Finally, we identified that leadership in the project studied is a collective process that takes place in a complex context in which the quality of relationships and interactions among individuals (leaders and followers) was fundamental to improving the quality of innovation-related processes. Previous studies have demonstrated this, but the present research has advanced, in particular, in understanding the leadership process in an innovation team, which is linked to two organizations of different natures.

### ACKNOWLEDGEMENTS

Acknowledgments: This work was carried out with the support of the Fundação de Amparo à Pesquisa e Inovação do Estado de Santa Catarina (FAPESC), through resources from the Public Call Notice FAPESC/CAPEs N° 21/2021 – Accreditation of Higher Education Institutions with emerging *stricto sensu* graduate programs and being consolidated in priority areas in the state of Santa Catarina, Termo de Grant CP 21/2021 FAPESC.

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# Knowledge Management Practices Integrated to Teaching Methodologies: An integrative review

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Received: 06 Jul 2022,

Received in revised form: 31 Jul 2022,

Accepted: 05 Aug 2022,

Available online: 12 Aug 2022

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**Keywords**— *Knowledge management, knowledge management practices/tools, teaching methodologies, didactic practices.*

**Abstract**— *This work has as its theme knowledge management practices/tools integrated into the educational scenario. In this bias, the research aimed to map knowledge management practices integrated into teaching methodologies in the educational scenario. To meet this objective, we carried out an integrative literature review to select works on knowledge management practices/tools integrated with teaching methodologies. As a result of the research, we identified such practices: Community of Practice, document (knowledge) management systems, good practices, knowledge mapping, wiki, blog, forum, guide, data mining, and analysis of social interactions. They were mainly used for creating and sharing knowledge with students and teachers. As limitations, we highlight a few current research using practices based on the area of knowledge management.*

## I. INTRODUCTION

The 21st century is characterized by constant changes, uncertainties, and instability resulting from technological advances, and mainly due to the COVID-19 pandemic. In our society, we accompany the transition from the industrial wave to the knowledge wave, and the school must accompany such transformations through changes in its teaching practices/methodologies.

In Education, some changes were implemented slowly, such as the integration of ICTs in didactic teaching practices, however, due to the pandemic, the teaching and learning process, for the most part, abruptly became fully mediated by technologies. digital. From this adaptation of classroom teaching practices to remote teaching, there is a latent need for innovation regarding the teaching methodology and integration of digital technologies (CARNEIRO, 2020).

In studies by Lacerda et al. [19] and Fleacã [14], based on innovation in the teaching and learning model, the authors highlight the importance of interdisciplinary

approaches. In this bias, an area of research that has been gradually applied in the academic scenario is Knowledge Management – KM.

KM aims at the creation, sharing, and dissemination of knowledge, resulting from the interaction between people, processes, and technologies. It supports knowledge processes, and enables knowledge management, ensuring that people have the knowledge they need, where they need it, and when they need it [29].

In research by Alarcon [1], and Silva [30], the authors emphasize that KM contributes to the construction of knowledge among students, and its application in teaching enables innovation in the method of cognitive development, resulting in new ways of learning to learn. Its application is very important for the educational institution, since, like organizations, it aims to create knowledge from academic research, dissemination (education), and sharing through academic services to society.

Many authors highlight the potential benefits of KM for university professors, making professors more effective and knowledge processors more efficient [5]. Thus, knowledge management in education is of great importance to capitalize on recent teaching innovations and channel significant advances in e-learning and technology-enhanced education [5].

Knowledge management practices enhance the sharing, conversion, and creation of knowledge through the application of tools and methodologies, providing learning environments [22]. In this bias, based on the potential for innovation in teaching methodologies, this research aims to map knowledge management practices integrated into teaching methodologies in the educational scenario. We emphasize that aspects related to learning theories are not the focus of this study, but rather to identify research that adapted and used KM (KM practices/tools) to innovate in terms of the teaching practices of the actors involved. For this, a theoretical framework was used on KM and its tools and practices, as described in item two (2) of this article. The research also presents the methodological steps undertaken (item 3), and the results of the integrative review in item four (5).

This research becomes relevant since its result, in addition, to verifying the integration of KM into the teaching methodology, mapped KM practices/tools integrated into teaching methodologies, showed their potential as well as some difficulties encountered.

## II. KNOWLEDGE MANAGEMENT

Research on knowledge management emerged in the early 1990s as organizations became aware that productivity is related to knowledge and not only to the workforce. With the development of the economy and technological advances, the improvement and sharing of knowledge have become increasingly important, since it is the result of a systematic mix between strategies, tools, and techniques, aiming at the creation, sharing, and dissemination of knowledge in organizations.

With the technological evolution, and consequently the unlimited access to all kinds of information, the industrial society becomes the knowledge society, in which organizations start to use intellectual capital as their main wealth [9]. Such a society is characterized by the use of digital technology, mainly through communications networks. Thus, several potential variables that were not considered in the era of industrial society, such as contradictions, dilemmas, and polarities, among others, became important data, helping in the innovation process of companies, and guaranteeing competitiveness in the market.

KM is related to the development of technological and human segments, focusing on the creation, sharing, and dissemination of knowledge, resulting from the interaction between people, processes, and technologies. According to Vaccaro, Veloso, and Brusoni [36], and Davenport and Prusak [10], implementing ICTs in actions that address KM in the organization results in an environment conducive to knowledge sharing. Technological resources can drive greater participation and interaction in collaborative processes, contributing to the dissemination and sharing of knowledge.

In the literature, several definitions for KM are described, based on different scientific perspectives and ideological points of view. In this vein, the present research approaches KM as a multidisciplinary field of study related to three variables: process, people, and technology [9]. The systematic relationship between these variables allows the transformation (conversion) of information into knowledge, which can be made available and shared among individuals. This definition is adhered to, since the multidisciplinary KM has shown applicability in educational institutions, contributing significantly to the teaching and learning process.

According to Alarcon [1] and Silva [30], the application of KM in teaching, using ICT tools and resources as a strategy, enables innovation in the cognitive development method, resulting in new ways of learning to learn. According to Servin [29] KM, through the interaction between people and technology, results in a new culture of collaboration and innovation in organizations. To this end, Servin [29] shows that KM aims to manage knowledge, ensuring that people have the knowledge they need, where they need it, and when they need it.

In contrast to GC's significant achievements in the business arena, GC in the educational and academic arenas achieved far fewer. With the development of society, research on KM in the educational field has become hot and promising.

## III. KNOWLEDGE MANAGEMENT PRACTICES AND TOOLS

To identify, create, store, share, and apply knowledge, it is necessary to carry out routines, and sets of practices that integrate various activities, procedures, techniques, and systems related to the development and application of knowledge in organizations. This set of practices enables the implementation of KM in organizations.

Knowledge management practices aim to develop the skills and knowledge sharing of those involved,

contributing to organizational performance, and job satisfaction, enabling organizational innovation, and contributing to strategic decision making. For this, they involve the use of methodologies and tools for sharing.

Knowledge management practices enhance the sharing, conversion, and creation of knowledge through the application of tools and methodologies, providing

learning environments [22]. According to the institution's need, various KM practices can be integrated into its activities to improve processes, practices, and (or) operations [12]. In the literature there is a diversity of practices and tools related to knowledge management, however, in this research, we will address the practices listed by Pinheiro [28], described below.

Table 2 - KM practices

Practices and tools	Description
After-Action Analysis or Lessons Learned	The technique of evaluating and capturing lessons learned after the completion of a project. It allows the individuals involved to discover what and why it happened, what needs improvement, and what lessons can be learned from the experience
Peer assistance	A technique used to solicit help from colleagues and experts on an important issue being faced. Known as "learn before doing"
Knowledgebases (wikis)	Bases that keep records of important explicit knowledge.
Internal and external benchmarking	Practice is related to the systematic search for the best references to compare the organization's processes, products, and services
Blogs	A simple site whose structure contains a list of entries, usually in reverse chronological order. It allows quick updating and can be written by several people
Brainstorming	Dynamics for generating new and unusual ideas. The process is divided into two phases: divergence and convergence. During the dissenting phase, everyone agrees to defer their judgment and the ideas will be treated as valid. In convergent, participants positively use their judgment, that is, they look for what they like about ideas before finding faults
Capturing ideas and learning	Continuous, collective, and systematic capture of ideas and learning in simple formats based or not on technologies. Such knowledge is captured in auxiliary digital spaces, such as mobile devices, emails, and blogs, among others.
Knowledge clusters or collaborative teams	Groups that, as a result of their meeting, collaborate, create, innovate and share new knowledge
Coaching	The people management style provokes actions for their development. The coach does not participate in the execution of the activities
Communities of Practice or Communities of Knowledge	Sharing knowledge in a group and networking around a common interest
Corporate Education	Learning system where employees develop their skills and behaviors according to the organization's goals. It comprises continuing education processes, established to update personnel uniformly in all areas of the organization. It can be implemented in the form of the corporate university, distance learning systems, etc.
Space (physical)	Physical space with a design suitable for sharing information, interaction, and exchange between employees
Space (Virtual)	A form of communication and sharing where participants can work together, even if physically separated. Experiences, calendars, and projects, among others, are shared. Forums can be created to share opinions and ideas, and virtual interaction rooms, where it is possible to hold video conferences, chats, and web pages, among others
Knowledge Management Assessment Tools	Use of questionnaires to conduct a quick assessment of the organization's readiness for Knowledge Management.
Advanced search tools	Use of advanced commands for searching in search engines. Understanding these tools can result in a significant improvement in the quality of search results. (YOUNG, 2010).
Forums /discussion lists	Spaces to discuss, homogenize and share information, ideas, and experiences that will contribute to the development of competencies and the improvement of the organization's

	processes and activities
Knowledge cafe	Group discussion to reflect, develop and share any thoughts and ideas that arise, informally and suspending all judgments
Finder, white pages, or yellow pages	IT tools are used to locate specialists anywhere in the organization, in an easy and fast way, by mapping their competencies and skills
Knowledge mapping or auditing	Record of organizational knowledge about processes, products, services, and customer relationships. It includes the elaboration of maps or knowledge trees, describing flows and relationships of individuals, groups or the organization as a whole
Best practices (Best practices)	It refers to the identification and dissemination of best practices, which can be defined as a validated procedure for carrying out a task or solving a problem. They are documented through databases, manuals, or guidelines
Organizational Memory	Record of organizational knowledge about processes, products, services, and existing relationships in the organization, which can be retrieved when necessary for the decision-making process
Mentoring	It helps the employee to achieve their goals through personal follow-up in a technical, emotional, and strategic way. The situation in which a more experienced professional intentionally transfers his experience and knowledge to a younger professional, promoting the apprentice's career development
Mining or Data mining	The technique of extracting previously unknown and maximum comprehensive information from databases, to use them in decision making
Skills plan for the knowledge worker	Personal competence plan for individuals to develop the critical skills needed to become knowledge workers
Corporate Portal	web space for the integration of corporate systems, with data security and privacy, providing access to relevant information and applications, and also as a platform for communities of practice, knowledge networks, and best practices. It supports the organization's mission, strategies, and objectives, collaborating for the creation and management of a sustainable business model
Learning review	The technique is used to help individual and collective learning during the work process
Social Networking Services	Services that support social networks are formed by groups of connected people who share common interests, content, and relevant documents
Document Management Systems	This system proposes the organization and categorization of documents and information to make them available in a more practical way to users
Social Network Analysis	Social Network Analysis (SNA), or analysis of social interactions, is a way of mapping and measuring existing interactions and flows in the organization. It has the function of identifying, through this mapping, who are the most sought-after sources of information and among whom the information is most shared.
Storytelling or Narratives	In this practice, people share through words, images, and sounds, facts from their experiences, literally telling a story.
Taxonomy	The technique provides the structure to organize information, documents, and libraries deliberately. It helps people navigate, retrieve and store needed information across the organization. It creates a natural workflow and knowledge needs in an intuitive structure.

KM practices are significant, however, alone, they are not effective, and they need human interaction. In the academic context, knowledge management and practices for its sharing have gradually been integrated into didactic practices since higher education institutions (HEIs) are engaged in significant levels of knowledge production, generated by academics, and it is very necessary to manage this knowledge efficiently [2].

#### IV. METHODOLOGY

The scope of the work is aligned with KM practices/tools integrated into the teaching methodology in the educational scenario. Theoretical studies, or studies that involve practices identified in Table 1, will only be included in the review if they are integrated into the teaching methodology, based on Knowledge Management. As already described, it is not the focus of this investigation to address learning theories, but rather to



identify and describe how KM practices are used in teaching methodologies in the educational scenario.

The problem will be addressed through an integrative literature review, because through this type of review it is possible to present different perspectives on a phenomenon of interest, to broaden the understanding of the topic of study seeking a foundation in theoretical and practical studies that associate knowledge management practices/tools, and teaching methodology in the educational scenario.

For this review, we used the *Scopus database*, as it covers different types of publications in different areas of knowledge.

A search *string* was created in these databases and applied to the fields corresponding to the article title, abstract, and keywords, excluding the book and book chapter file types, as available in each database. The search

strategy developed sought to understand the main terms and descriptors appropriate to the themes of knowledge management practices/tools and teaching methodology, including synonyms, to expand the retrieval of information.

As we had noticed in previous readings, many studies do not use the term “knowledge management practice”, we chose to include in the search strategy the broader term “knowledge management” to identify in studies that addressed KM the use of some of the practices described in table 1. The search *string* also comprised the *Boolean operators OR* and *AND* and can be seen in table 2, and was performed on January 3, 2022.

Table 2 - Search strategy and results obtained

Basis	String	Field	Results
Scopus	(( "knowledge management practice ") OR ("knowledge management") OR ("knowledge management tool") OR ("knowledge management method ") OR ("km practice ") OR ("km tool") OR ("km method ")) AND (( "teaching methodology ") OR ("teaching practices ") OR ("pedagogical practices ")))	Article Title, Abstract, Keywords	129

Of the 129 articles retrieved in the initial search, 4 were eliminated because they were duplicates. After the elimination of duplicates, step 1 of article selection was carried out, which consisted of reading all titles, abstracts, and keywords of the 125 selected articles. At this stage, 47 articles were excluded because they did not fit the proposed theme, or because they did not specifically address KM in the academic setting.

In the second stage of analysis, all texts of the remaining 78 articles were read in full, excluding another 64 works because they were not theoretical or empirical studies on the use of KM practices/tools as methodology, teaching practice, according to the criteria of inclusion and exclusion previously defined, explained in table 3.

Table 3 - Inclusion and Exclusion Criteria

Exclusion Criteria	Inclusion criteria
<ul style="list-style-type: none"> <li>Articles dealing with KM practices/tools in organizations;</li> <li>The article does not present KM practices/tools used in didactic practices.</li> <li>It does not address knowledge management in the educational context.</li> </ul>	<ul style="list-style-type: none"> <li>Articles with a KM approach in the educational context;</li> <li>Articles that address KM practices in didactic practices (or methodologies) of teaching in the educational institution.</li> </ul>

Source: Authors (2022)

The number of documents initially retrieved, as well as the update of the number of documents corresponding to

each review phase, separated from the review phase, can be seen in Figure 1.

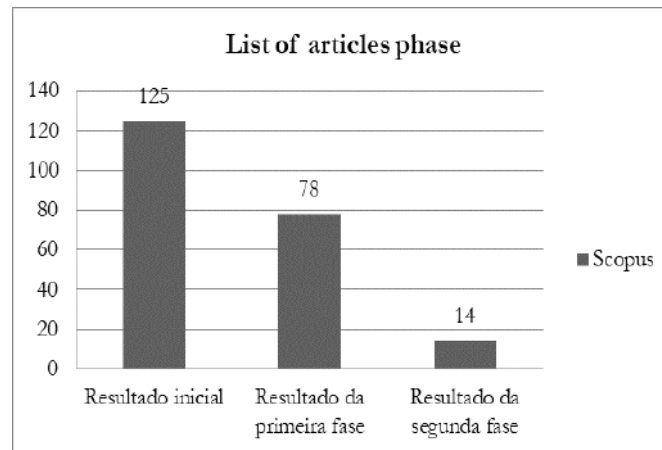


Fig.1 - Quantitative relationship by review phase.

Source: Authors (2022)

Thus, for the composition of this integrative review, a total of 14 articles were exposed in Table 4, whose content was summarized and synthesized in this work.

Table 4 - Articles selected to compose the integrative review

	<b>Title</b>	<b>Year</b>	<b>authors</b>
1	faculty development and community of practices: Exploring their interplay to facilitator change in pedagogical practices at HEI's	2021	Kandakatla and Palla
2	Investigating undergraduate student learning experiences using the good practice learning and teaching for sustainability education (GPLTSE) framework	2021	Holdsworth and Sandri
3	design and Evaluation of a Teaching-Related knowledge Sharing System to Meet the needs of Computer Science Instructors	2020 A	Almujally and Joy
4	The Framework for Enhancing the sharing of teaching practices among university Instructors	2020 B	Almujally and Joy
5	Designing a system for enhancing the sharing of best teaching practices among universities ' instructors	2020 B	Almujally and Joy
6	Twelve tips for implementing a community of practice for faculty development	2019	Carvalho-Filho, Tio and Steinert
7	research on Educational Knowledge Map Application in Japan	2019	Li <i>et al.</i>
8	Using a blog and text mining to evaluate knowledge construction	2019	Zambon <i>et al.</i>
9	The Neuro- Subject : A Living Entity with learnability	2019	Fidalgo-Blanco, Sein-Echaluce and García-Peñalvo
10	Effective reuse and sharing of best teaching practices	2017	Al- Rasheed and Berri
11	Knowledge management practices: a case study of Pre-Forum of teaching practices of Estacio de Santa Catarina	2016	Panisson <i>et al.</i>
12	interaction analysis of a blog/ journal of teaching practice	2015	Pavo and Rodrigo
13	sharing and co-creation of Innovative teaching Practices in Business Analytics – Insights from an Action Design Research Project	2014	Marjanovic
14	Gathering Practice sharing and problem-solving on a Single Platform for Teacher Training: A Collaborative Platform Model for Teacher Professional Development	2011	Condamines

Source: Authors (2022)

Based on the selected research, we identified and described the KM practices/tools used as teaching methodologies in the educational scenario, as described in section four (4).

### V. RESULTS AND DISCUSSION

With technological advances and, consequently, the emergence of new media and digital resources, it is essential to develop new strategies to enhance and innovate the process of building the knowledge of the

actors involved. In this bias, knowledge management is of great importance to capitalize on teaching innovations enhanced by digital technologies [5].

Thus, based on the analysis carried out on the selected articles, we can identify the following knowledge management practices integrated into teaching methodologies, and used as didactic practices by teachers to share knowledge:

Table 5 - Articles selected for analysis

Knowledge Management Practices	Authors
Community of Practice - CoP	Kandakatla and Palla, Carvalho-Filho, Tio and Steinert, Condamines
Good habits	Holdsworth and Sandri, Al- Rasheed and Berri
Document management systems (knowledge)	Almujally and Joy, Fidalgo-Blanco, Sein-Echaluce and García- Peñalvo
Guide	Carvalho-Filho, Tio and Steinert
Knowledge mapping or auditing	Li <i>et al.</i>
blog	Zambon <i>et al.</i> , Pavo and Rodrigo
Forum	Panisson <i>et al.</i>
Analysis of Social Interactions	Pavo and Rodrigo
Wiki	Marjanovic
Data mining	Zambon <i>et al.</i>

Investigations on Communities of Practice - CoPs - were identified in the research of Kandakatla and Palla [18] and Carvalho-Filho, Tio, and Steinert [7]. A CoP can be formed by a group of individuals, in person or online, who share and work collectively towards a common goal. CoPs have the following characteristics: Domain – a shared value or purpose identified by CoP members; Community – membership of a group of people who have agreed to work for the domain through involvement in joint activities and; Practice – a curated list of initiatives, resources, and tools that members share as part of their participation in the CoP.

Kandakatla and Palla [18] aimed to investigate the role of a community of practice in achieving sustainable changes in teaching practices after the completion of the faculty development program in India. To that end, they created a CoP before the start of the technology-enhanced learning teacher development program to encourage and build a sense of community among participants. The results of the thematic analysis of the data revealed that CoP members helped each other through the exchange of ideas, various clarifications, feedback, and exchange of knowledge. Participants with varied prior teaching

experience were observed to support each other in designing and developing course websites (tacit knowledge development).

In addition to the studies by Kandakatla and Palla [18], Carvalho-Filho, Tio, and Steinert [7] developed a guide, through a literature review, with tips for implementing communities of practice for faculty development and, consequently, the implementation of best teaching practices. The authors emphasize that a successful CoP creates and shares knowledge in the context of a specific practice to develop the competencies of those involved and guide the innovative process of creating or reformulating practices, solving critical problems, and facilitating the transfer of best practices.

In the implemented guide Carvalho-Filho, Tio, and Steinert [7] list the following tips: Gather a core group to launch the process; Articulate the goals and value of the CoP; Start with a specific task or project, and make it problem-oriented; Keep the CoP open; Intentionally invite members with experience and new ideas (innovation); Choose a facilitator; Make it worthwhile for the associates and the institution; Work to ensure institutional support;

Promote sustainability; Communicate success; Stay online; Evaluate the CoP.

Another KM practice in the educational scenario refers to the integration of good practices into the teaching methodology in the research identified in the studies by Holdsworth and Sandri [16], Al- Rasheed and Berri [5]. Best or best practices are accumulated practices (activities) that have been proven to work well, give good results, and, therefore, can be recommended as an effective way.

Holdsworth and Sandri [16] investigated good practices for sustainability education. For this, they implemented and applied a model of learning and teaching good practices identified in the literature (synthesis of good practices) for sustainability education called GPLTSE. The study explored the use of GPLTSE best practices, their effectiveness in large first-year core courses, and in developing the skills and abilities of those involved through student-centered activities.

Based on the importance of identifying good practices highlighted by Holdsworth and Sandri [16], we emphasize the importance of identifying and sharing them. Almujally and Joy [2] point out that knowledge is not captured or exchanged efficiently between professors who teach the same courses. In this bias Al- Rasheed and Berri [5] implemented a knowledge management system for communities of instructors, enabling the identification, sharing, and appreciation of good practices used in the educational scenario.

Al- Rasheed and Berri [5], developed a model with identified good teaching practices and used a management system to acquire, codify, share and reuse such practices from a community of instructors. In their investigation, the authors found that: the KM approach seems more suitable for dealing with the experience of instructors, as it takes the form of an accumulation of experiences and best practices to be articulated, helping them to identify and gradually specify their experience using well-specified web forms; instructors who contributed to the system expressed satisfaction that their contributions were rated by the instructor community; the structure developed is intended to support instructors in providing quality teaching and increasing collaboration within specialist communities; incentive for evaluation and sharing of instructors' experiences.

The investigations of Almujally and Joy [2][3][4], approached from the elaboration of the structure, the process of development, and the application of the management system of teaching practices. The authors emphasize that there are several structures and frameworks of systems for knowledge management, but that there is no standardization of them. So they standardized a knowledge

management system to assist instructors in publishing and sharing up-to-date and useful teaching practices in a quick way that can be clearly understood and reused by others.

The structure of the implemented system is composed of a set of pre-specified attribute fields to create a record of teaching practice. The system assists users in describing various teaching practices, controlling the type of information requested, and providing an adequate framework to capture the user's experience. As a result of the research, the authors show that the model provided by the system is effective and of sufficient value to those involved that it supports the capture of complete, clear, and consistent teaching practices [2][3][4].

To apply the concept of organizational learning in academic disciplines, Fidalgo-Blanco, Sein-Echaluce, and García- Peñalvo [13] adapted a management system (plugin for the WordPress content manager ). The authors report that in the proposed case study, the student is considered a member of the organization that can learn and create, and that the organization must improve the learning of its members. For this, it must promote the creation of individual and group knowledge, as well as their management, so that they impact both the organization and the individual himself.

In this bias, they used the RT-CYCLE Model, which uses the basic characteristics of different theories, models, and active learning methods. This model is characterized by being very simple and can be used punctually or continuously in the development of a subject. The RT-CYCLE model is based on the following phases: Phase 1 Action-reflection; Phase 2 Creation of proofs; Phase 3 Feedback; Phase 4 Knowledge creation. This model was used around the realization of an exercise carried out in person and virtual. The knowledge management software created was applied continuously during all phases in real-time, the knowledge produced by students and faculty were presented through the software. As a result, the authors highlight that the activities that generate organizational knowledge and types of corporate content created during these actions encouraged the creation of knowledge among the subjects.

To analyze the interaction between teachers/students Pavo and Rodrigo [27] used two knowledge management practices/tools: the blog for recording and sharing teaching practices and teaching experiences of teachers/students, and the analysis of social interaction carried out on the blog. Blogs are a web tool that allows you to create personal web pages with textual information arranged in reverse chronological order. They provide the means to write diaries in a public web-based space and allow readers to comment or add information. The blog was used

to: give students a space for reflection; allow interaction between students so that they can discuss their experiences and find support; become a faculty monitoring tool, and keep all comments in a structured form for reference when necessary, both for teaching and research purposes and students' records.

To describe significant processes such as group cohesion or collaboration, social interaction analysis was performed. Through such analysis, the authors highlighted the importance of affective and cognitive processes in the interaction of students regarding their teaching practice, being an important factor for greater collaborative construction of knowledge.

The blog resource was also used in Zambon *et al.* [39] as a tool for student collaboration in active learning disciplines. After in-class presentations and discussions, students published the result and participated in new discussions on the online platform. To solve operational issues of workload management, grade assessment, and text quality, an educational data mining tool was developed, based on natural language processing. Educational data mining (EDM) is the application of computerized methods to detect patterns in large collections of educational data that would otherwise be difficult or impossible to analyze. According to the authors, the use of these practices reduced absenteeism and the failure rate of students.

In addition to the blog, Marjanovic [21] describes the results of a design research project focused on sharing and co-creating innovative Business Analytics - BA - practices using the wiki resource. All design artifacts were created and implemented through learning groups. The online environment was used to support the design and sharing of innovative teaching practices. After conducting the research, the authors observed that the design of a wiki-based collaborative environment was not the main challenge of the project. The main challenge identified is related to the learning activities in BA targeting the different levels of knowledge and cognitive skills that could be implemented in the classroom, in different ways, using different instructional projects.

Another KM practice/tool highlighted in the review was the discussion forum. Panisson *et al.* (2016) - analyze the pre-forum of Teaching Practices of Estácio de Santa Catarina aligned with KM practice. According to Batista (2006 *apud* PANISON *et al.*, 2016 ), the forum (in person or online) is an important KM practice linked to people management in higher education institutions. Initially, this practice was applied in the institution at the national level, but soon there was a need for a closer approach between the practice and the teachers, implementing regional

forums to previously select the teaching practices. Panisson *et al.* (2016) highlight that forums enable knowledge management at the team level, allowing the teacher to apply an innovative teaching practice, identify opportunities for application, and creation of new practices, being a tool that allows the storage and sharing of knowledge among all teachers at the regional level through the Pre-Forum.

From an initial investigation into the exchange of innovative teaching practices and experiences between teachers in online forums, Condamines [8] shows that many online environments used are not specific to CoPs, limiting the creation and sharing of knowledge. In this vein, the author proposes an online platform model to support the professional development of a community of practice. For this they implemented a web platform for knowledge elicitation (teaching practice) based on exchanges between teachers, capitalized on individual memories with the associated context; problem-solving exchanges, capitalizing on problems (and their context) and solutions given by other teachers; sociability and participation of members with a Web 2.0 approach and user profile management.

To understand the research and application of knowledge maps in the field of education in Japan, Li *et al.* (2019) perform a literature review based on selected Japanese academic databases. The review shows that knowledge maps are used mainly in the area of education support. According to Li *et al.* (2019), the knowledge map is a concept that originates from the geographic map to map knowledge. Although the knowledge map does not have a clear definition at the moment, generally speaking, it presents knowledge as a map to indicate knowledge catalogs and knowledge resources, and it can store various connections between the knowledge resource and the knowledge itself. As the most important feature is that it can visualize and display information structurally in map form. As a result of the review, the authors show that the knowledge map has many advantages in structuring, visualization, and systematization, but its construction is complex and requires high information technology. Therefore, it is more difficult to apply the knowledge map in education than the concept map and the mind map. There are few research cases, especially in database construction, knowledge point extraction, and multidimensional visualization.

From the evidenced research, we identified interdisciplinary research that addressed the use of KM practices integrated into teaching methodologies, as didactic practices in the educational context, namely: CoPs, document management systems, good practices, knowledge mapping, wiki, blog, forum, guide, data mining

and analysis of social interactions. However, few current studies use the KM approach as practice and/or teaching methodologies among students. We found that most studies focused on sharing innovative teaching practices among teachers.

In addition, many of the excluded works described activities that would fit KM practices/tools but were not based on the KM area. In other words, many strategies used in class are KM practices/tools, however, not have an approach, and do not take advantage of KM's potential for the process of creating and sharing knowledge among students.

## VI. CONCLUSION

This research aimed to map knowledge management practices integrated into teaching methodologies in the educational scenario. To meet this objective, we carried out an integrative literature review, which made it possible to identify the following KM practices/tools: CoPs, document management systems, best practices, knowledge mapping, wiki, blog, forum, guide, data mining, and analysis of social interactions.

It can be seen that most of the selected studies were applied to share innovative teaching methodologies or practices among teachers. Based on this, we highlight the CoPs, being a strategy identified in some studies, in which ICTs can further enhance the creation and sharing of knowledge.

We also evidenced that CoPs and document management systems, or knowledge management systems, as well as forums, were used to share innovative teaching practices among teachers and to improve knowledge. The practices using Blog, Wiki, analysis of social interaction, and data mining were applied to the students. Blogs and wikis encouraged greater participation and interaction of students, in which the analysis of social interactions and data mining contributed to measuring such results.

As limitations, we identified that few current studies use knowledge management practices, taking the area of knowledge management as an approach. Often such practices were used, but with a focus on active methodologies. Further investigations are needed to analyze knowledge management practices/tools and their similarities and differences concerning active methodologies and to propose actions that add the potential of the two approaches in terms of teaching methodologies and practices.

## ACKNOWLEDGEMENTS

This work was carried out with the support of the Fundação de Amparo à Pesquisa e Inovação do Estado de Santa Catarina (FAPESC), through resources from the Public Call Notice FAPESC/CAPES N° 21/2021 – Accreditation of Higher Education Institutions with emerging stricto sensu graduate programs and being consolidated in priority areas in the state of Santa Catarina, Termo de Grant CP 21/2021 FAPESC.

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## Competencies for STEAM areas: a focus on teacher

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Received: 10 Jul 2022,

Received in revised form: 01 Aug 2022,

Accepted: 07 Aug 2022,

Available online: 12 Aug 2022

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**Keywords**— **Competencies, STEAM, teachers.**

**Abstract**— This article aims to present a mapping of teaching skills for STEAM areas. Society is constantly changing, and Education needs to make changes that enable the formation of the subject integrally. From this perspective, STEAM areas are increasingly present in classrooms, intending to prepare future professionals for this connected and technological world. Thus, to embrace this new society, it is pertinent to build new teaching skills that can contemplate the integral formation of the student. Methodology: The research had a qualitative approach of the interpretive type, of an applied nature, being exploratory regarding the objectives and using the case study as a procedure. The instruments were the productions of the participants of an online course and participant observation. Results and conclusions: In this study, 80 teachers participated, and the data presented denote a concern of teachers to build pedagogical competencies in the pedagogical perspective, with methodologies and action strategies, as well as technological ones, from basic training in the use of technologies. Thus, in total, 11 teaching competencies were mapped to work in STEAM areas. In addition, it was possible to glimpse suggestions of educational and digital tools that can be used in pedagogical practices, as well as active methodologies that apply in the presented context.

### I. INTRODUCTION

Society is constantly changing, whether cultural, technological, economic, or social. Thus, to accompany the uncertainties in the new scenarios, Education needs to make changes that allow the formation of the subject integrally.

From this perspective, the STEAM areas (Science, Technology, Engineering, Arts, Mathematics), that is, Arts, Sciences, Technology, Engineering, and Mathematics, are increasingly present in the curriculum of Basic Education and Higher Education, to prepare future students. professionals for this connected and technological world.

STEAM education is not a method or a tool, it is a strategy that impacts the entire education system. It is currently considered an important teaching strategy for the development of skills of professionals of the future, as it uses science, technology, engineering, arts, and mathematics as axes to support the educational development of students. Therefore, it is the union of different subjects in a way that they relate to each other and the real and business world, in a combination of practical and interdisciplinary learning methods that offer the opportunity to engage and enable students in formal education in a fun and interactive [14][15].

Thus, to embrace this new society, it is pertinent to build new competencies that can contemplate integral

formation, in a perspective of enabling innovation and problem-solving in the various fields of knowledge. In this bias, the purpose of this article is to present a mapping of teaching competencies for the STEAM areas. Competencies are considered a set of elements (Knowledge, Skills, and Attitudes) that, when mobilized, can help to solve different problem situations [9].

Given this context, education should enable the construction of skills for the STEAM areas, considering that the subject who goes through this process can apply it in their professional life. In this sense, the mapping of competencies will allow teachers to have this basis to think about actions and methodologies that focus on these needs in classes, whether in Higher Education or Basic Education [14][15][16].

In this way, the next section will present a brief theoretical overview of STEAM competencies and areas. Then, in the next election, a methodology will be pointed out with the characterization of the study. The results will be presented next, pointing out the digital competencies for the STEAM areas mapped. Finally, final considerations are presented. [14][15][16]

## II. SKILLS AND STEAM AREAS: A NECESSARY INTERLOCUTION

The term competence has changed mainly in the area of Education. The new discussions allowed a different view and use that was considered not only as an evaluative instrument but also for the construction of knowledge, skills, and attitudes.

Education adopted in the National Common Curricular Base (BNCC) the use of competencies, with 10 main ones: Knowledge; Scientific, critical and creative thinking; Cultural repertoire; Communication; Digital culture; Work and life project; Argumentation; Self-knowledge and self-care; Empathy and cooperation; Responsibility and citizenship (Brazil, 2018).

The United Nations Educational, Scientific and Cultural Organization (UNESCO) was one of the first to discuss the subject and its application in education, bringing historical milestones such as DigComp and DigCompEdu that specifically bring digital skills.

“Competence is a polysemic word. One of the reasons for the variability of its meanings is the diversity of contexts and fields of knowledge in which it is used” [7]. Complementing the definition, Behar et al [2], mention that “[...] the individual is competent when he can “know”, “know how to do” and “know how to be”, which are associated with the elements of the CHA”.

The CHA is the acronym used for Knowledge (it is associated with the knowledge of a subject and in which it can be constructed); Skill (it is related to “knowing how to do it”, therefore, it is “[...] an automated action, an already built procedure, something of the operational order, not requiring a deeper reflection” [2] Attitude (it is the “knowing how to be”, being necessary the mobilization to face situations that may arise to the subject).

Thus, it is pertinent to build competencies with students, but mainly with teachers through constant training, both in the use of digital technologies and in new practices based on innovative methodologies.

Concerning competencies for the STEAM areas, there are no studies on which teachers could build in the classroom to foster a deeper understanding of the subject. However, there are some publications linked to how these areas can develop skills in students, as is the case of Diego- Mantecón et al [6] and Benites, Barzallo [3]. In addition, Perignat, Katz- Buonincontro [10] cite that the main objective of STEAM is to engage students, develop creativity and improve problem-solving skills in real-world environments. Therefore, the concepts of STEAM and competencies are similar, since your key point of yours is to provide a theoretical-practical basis for the student to solve problem situations.

However, it is pertinent to highlight that “STEAM Education is not characterized as a teaching methodology, but a pedagogical approach that is linked to different proposals for active learning” [8]. It emerged in 2007 and, over the years, new reflections began to be carried out, mainly on how to apply it in the classroom of educational institutions.

STEAM can assume different dimensions in the educational context: approach or methodology; expansion of the Science curriculum; public policy and educational model [11]. Therefore, as popularity grew, scholars proposed a variety of pedagogical models and approaches to develop and integrate [10].

Thus, the perspectives and applications can be varied, which instigates the training of teachers to act or promote these areas.

## III. METHODOLOGY

The investigation had a qualitative approach of the interpretive type, of an applied nature, being exploratory regarding the objectives and as a procedure, a case study was used. The target audience was professors who participated in a distance extension course offered in 2021 at a public university in Santa Catarina in Brazil.

Thus, the productions carried out in the Virtual Learning Environment of the course by the participants were used as a data collection instrument, as well as participant observation in the classes and interactions in the environment. The competence mapping methodology was based on Brandão [4]. For analysis, the steps of Bardin (2010) were used, since this technique allows a general reading and analysis to then categorize the information.

Thus, to meet the main objective of the research, the study had four stages, as shown in Figure 1.



Fig. 1: Research Stages

Stage 1 - Agglutinate the CHA: This first stage aimed to carry out the initial mapping of the knowledge, skills, and attitudes that must be built with the students for the STEAM areas. For this, he used a course called "Digital Skills for STEAM areas". In it, activities and lives were carried out (totaling 4 on YouTube from [omitted for review]) to discuss and reflect on skills, Knowledge, Ability, and Attitudes, in addition to pedagogical strategies focusing on the areas of Arts, Science, Technology, Engineering, and Mathematics.

The participants, in the end, shared their experiences reporting the application in the STEAM areas in an authorial video. In the course, a Virtual Learning Environment (VLE) was used (figure 2) so that the participants had access to the contents and activities, as well as pointing the CHA to the STEAM areas.



Fig. 2: Organization of the course topics

Thus, each participant listed the elements of the CHA, defining the public and interspersing with specific

knowledge of the areas in which they worked. These were presented individually in the AVA.

Stage 2 - Agglutinate the CHA: The second stage consisted of grouping similar knowledge, skills, and attitudes to check for repetitions and inconsistencies. Thus, it was possible to verify traits of competencies and their possible definitions.

Step 3 - Enumerate and categorize the CHA: The third consisted of classifying knowledge, skills, and attitudes into two groups: pedagogical use and technological use. After this process, it was possible to enumerate each CHA and, therefore, perform the competence categorization.

Step 4 - Define and name the competence: Finally, a critical reading of the information was carried out to standardize the verbs used, as well as adjust each element of the competence. Then, it was possible to name them according to the knowledge (knowing, knowing how to do, knowing how to be) indicated by the participants.

IV. RESULTS AND DISCUSSION

The present study aimed to present a mapping of teaching competencies for the STEAM areas. Thus, 80 teachers participated, 38 male and 42 female. The training was varied, as well as the performance that went from Basic Education to Higher Education. However, in the course of the discussions, it was possible to perceive little knowledge about the STEAM areas, but greater depth about the competencies, which made it easier to know and point out the knowledge, skills and attitudes questioned during the process.

Regarding the CHA, the participants pointed out a total of 375 elements, as shown in Table 1. It is worth noting that, despite knowledge about the definition of competence, pointing out knowledge, skill and attitude is a complex process, as participants had no experience in categorizing such elements. Thus, it was necessary to reorganize them, according to the definition of the mentioned literature [9], as well as to remove those that did not agree with the conceptualization.

Table 1 - Organization of the CHA

Elements	cited	reorganized	withdrawn	Final
knowledge	109	0	4	105
Skills	137	4	two	141
Attitudes	129	10	4	114
TOTAL	375	14	10	360

The knowledge obtained was outside the context of "knowing", but linked to the name of competencies or

action outside the requested, as can be seen below: Digital fluency; Digital literacy, choosing which technology(s) to use; Offering better opportunities for teacher training; Ensure better physical infrastructure; Promote technological solutions that take the school routine and day-to-day challenges.

The skills removed were not specifically related to the proposed theme, as can be seen below: You need to take a course on digital skills in education; Many digital tools promote new ways of carrying out pedagogical practice and exploring different skills and competencies. The attitudes taken from the list were related to actions and not necessarily motivations: Overhead projectors; High-quality sound system; The game can create competition between teams.

Therefore, it can be observed that the participants had a lot of difficulty in categorizing each element, and made a little confusion among them, especially between skills and attitudes. Behar et al [2] mention that there is always a difficulty in classifying knowledge, skills, and attitudes, as they are elements closely related to each other.

Thus, after categorizing the CHA, it was possible to list 11 competencies divided into two large groups: Technological use in STEAM areas; Pedagogical use in STEAM areas (figure 3).

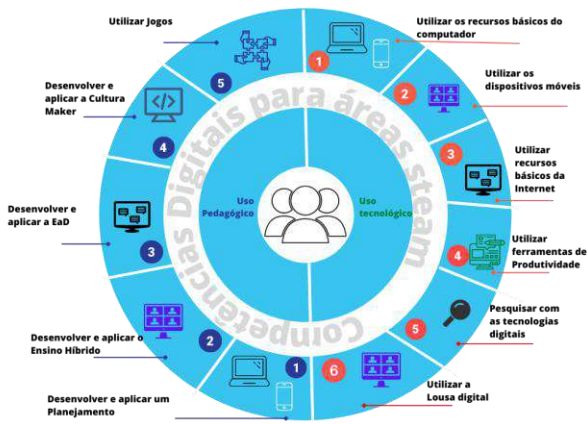


Fig. 3: Competencies for STEAM areas

The complete mapping of the eleven competencies, as well as their elements (CHA), are presented below.

**Competence - Use basic computer resources:** This competence is related to the ability to use the computer (software and hardware) autonomously to use it for educational purposes.

Competency Knowledge, Skills, and Attitudes: Using basic computer resources		
Knowledge	Ability	Attitude

Computer.	Handling of information technologies.	Be resilient.
Basic Computing.	Turning the computer on and off.	To be organized.
Computers.	Make use of the tools.	Empathy.
Knowing how to turn on the desktop and learn to use Jamboard on the computer and cell phone to share with students.	Know the commands and tools to run the software.	Proactivity.
computing.	Know the shortcuts accepted by the software.	Be methodical/organized.
Know how to perform the basic procedures for handling files on computers (create, save, rename and delete files).	Know how to represent the schemes via software.	Be proactive.
Fundamentals of Informatics and Computing.	Become familiar with the software and equipment involved.	
Know what software is.	Handle a computer.	
Know what a computer is.	Turn on the computer.	
Digital technologies.	Create and edit files and folders.	
Technology.	Know how to handle the computer/notebook.	
Digital communication.	Know how to use the tools and computing resources.	
You need to know how to deal with computers.	Know how to turn on the computer.	
Operating a computer	Turn on the computer.	
software.	Use a computer.	
Basic computing.	To communicate.	

Knowledge about the possibilities of the software.	Store data.	
Know the commands of the equipment involved.	Know how to use the computer and/or other machines.	
Know the hardware and basic procedures for using a computer (keyboard, mouse, webcam, microphone, etc.).	Install and keep up-to-date data protection software.	
Know basic system operation procedures (open and save files; install software).	Turn on the computer.	
Understand the functioning of the computer and the internet (digital literacy).	Use mouse and keyboard.	
Find information on how to use the text editor of the operating system it uses. (Win; MAC; Linux; IOS; Android)	Knowing about technologies.	
Learn how to download and install software by looking at your operating system.	Know how to turn on the computer.	
Computers, Windows, Internet.	Access the equipment frequently.	
Observe the necessary conditions for its use (basic settings; online or offline).		
Computer knowledge.		

**Competence - Using mobile devices:** This competence is related to the ability to use the basic features of mobile devices (smartphones, tablets) such as applications, touch screens, etc.

**Competency Knowledge, Skills, and Attitudes: Using mobile devices**

Knowledge	Ability	Attitude
What are the main functions of a tablet or cell phone?	Download apps on mobile or tablet from app stores.	Be committed.
Tablets.	Share computer/mobile/tablet screen or web browser tab in video calling apps.	Be flexible.
Cell phones.	Use smartphones, notebooks, and tablets.	Be creative.
Game of questions and answers in real-time using tablets or smartphones.	Use tablet.	Autonomy.
Operating a tablet.	Know how to handle tablets/smartphones.	Have Motivation.
Know what is smartphone.	Construction of active activities using the application.	Take the initiative to get to know the equipment that will be used and become familiar with it.
Cell phone operation.	Handle the application.	After observing the difficulties he went through, having empathy and motivating the student that it is possible to overcome the difficulties and that he had to learn.
Download and use the app.	Know how to connect mobile.	Search and watch app usage tutorials.
Applications for creating and editing videos.	Know how to send WhatsApp.	
Installing apps via app stores (such as Google Play,	Know how to use messaging apps, images, and/or videos.	

Apple Store, and Microsoft Store).		
Use of video calling apps (such as Google Meet and Zoom).		
applications.		
Knowledge of applications (apps) and their educational uses.		
The teacher needs to know how to use such an application or program so that he can introduce the student.		
Apps for interaction with students.		
Know about using cell phones and notebooks in the classroom, if there is wifi if there are machines available and in good working order in the multimedia room, and if there is enough space and capacity to run the chosen tool. Anyway. KNOW about the facilities and difficulties of the school environment for the adoption of interactive		

strategies using digital tools for their content in the classroom. Choose the tool, find out if it is freely accessible if it has a translation into Portuguese if it needs to be downloaded, logged in, and how long it takes to register students.		
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**Competence - Using basic Internet resources:** This competence is related to the ability to critically and safely use Internet resources such as the means of communication, research, and content production.

<b>Competency Knowledge, Skills, and Attitudes: Using Basic Internet Resources</b>		
<b>Knowledge</b>	<b>Ability</b>	<b>Attitude</b>
websites.	Know how to use the internet.	Respond quickly.
Internet.	Download.	Be proactive.
Email.	Log into websites.	Organized.
Know what the internet is.	Use a browser.	be ethical.
Know how to access the Internet and perform searches in browser software.	Access a website.	Organization of materials.
Know how to search for information.	Use a web browser.	Proactivity to learn new things.
Internet and Web.	Access a website.	Resilience to persist in learning.
Browsing the web through the most common internet browsers (such as Google Chrome and Internet Explorer).	Use hyperlinks.	

Installation of programs via internet browsers.	Know how to send an email.
Know how to browse the internet	Open an email.
Image reading.	Connect to the internet.
	Use social networks for communication.
	Use the internet as a source of knowledge.
	Know how to get on the internet
	Know how to access websites
	Know how to access a web page.
	Download programs to your computer from web pages.
	Locate on the computer where the installation files of programs downloaded from the internet are saved.
	Use social networks.
	Surf the Internet.
	Access the browser.
	Know how to save the explanations and send them by email.
	Use a browser to access the internet.
	Use electronic mail.

	Data show.	
You need to know how to use electronic equipment to make your job easier.	Use office software.	Encourage class participation and engagement.
What is a data show?	Content development and creation.	Create groups and moments for interaction between students.
Know that there are various risks associated with using digital technologies.	You need to master some digital tool that helps in the presentation of your classes.	Encourage autonomy and self-assessment.
Acquire knowledge of the operation and manipulation of the chosen tool.	Know how to turn on the data show.	
Choose a digital tool, canvas.	Using the computer and the internet to read and select content (digital literacy) and then produce the content itself (digital fluency) making connections between the virtual world and the real world.	

**Competence - Using Productivity Tools:** This competence is related to the ability to use productivity tools, being possible to become the author of your material, through text editors, images, presentations, spreadsheets, videos, animations, etc.

**Competence - Research with digital technologies:** This competence is related to the ability to use internet research resources, contemplate the choice of search words, analysis, select, and criticality the information.

Knowledge, Skills, and Competency Attitudes: Using Productivity Tools		
Knowledge	Ability	Attitude
Text Editor (Drive).	Turn data show on and off.	Proactivity.
Powerpoint.	Connect cables to	Have Resilience.

Knowledge, Skills, and Competency Attitudes: Research with digital technologies		
Knowledge	Ability	Attitude
Know how to search the internet.	How to search on Google and YouTube.	Proactivity.
Knowledge of	Compare	Resilience.

commonly used search engines on the internet (Google, Bing, Yahoo, etc.).	information.	
Know how to search for solutions online.	Conduct research on the internet.	Patience.
Know how to search for online guides.	Conduct internet searches.	Be curious.
Master the use of the equipment and the internet to research.	Know how to handle information: summarize, compare and verify.	Have critical thinking.
Search for information about the desired tool.	Treat data in different formats, and organize it.	Creativity.
Acquire knowledge of how to do web searches.	Information search.	Proactivity.
	Know how to use search engines available through internet browsers.	Be Investigative
	Know how to search the internet.	Organization.
	Searching the Internet.	Be critical and reflective.
	Searching the Internet.	Be polite and have patience.
	Practice using the tools and surveys. (repeat this process until you are confident in the results presented).	Be in a good mood.
		be selfless.

**Competence - Using the Digital Whiteboard:** This competence is related to the ability to use the digital whiteboard to present, interact and share materials produced in an authorial way.

<b>Knowledge, Skills, and Competency Attitudes: Using the Digital Whiteboard</b>		
<b>Knowledge</b>	<b>Ability</b>	<b>Attitude</b>
Learn about using the digital whiteboard	Know how to handle a digital whiteboard.	Proactivity.
Know about tools available on the digital whiteboard.	Know how to connect the computer and digital whiteboard.	Organization.
Innovative Digital Whiteboards.	Know how to move, change colors and erase when necessary.	Have Resilience.
Digital board.	Know how to write definitions with the digital pen.	Seek practicality in the use of technology.
		Simplicity and objectivity in the explanation.
		Consistency with the student's level of understanding.
		Availability to serve students.
		Organization.

**Competence - Develop and apply a Plan:** This competence is related to the ability to plan classes, linking the STEAM areas as the main guide.

<b>Competency Knowledge, Skills and Attitudes: Developing and Applying a Plan</b>		
<b>Knowledge</b>	<b>Ability</b>	<b>Attitude</b>
Educational Technologies.	Select and know how to use software, OVAs, and educational games.	Look for alternatives, solutions, and ideas for use.
Active Teaching Methodologies.	Apply active methodologies in conjunction with educational digital resources.	creative.



Study basic concepts and terms by applying what you know about technologies in the classroom.	After studying and taking courses, apply what you learned about technologies with your students using applications such as Kahoot, Google forms, mind maps, and others.	Try different alternatives and solutions.
Information management.	Once you know your school environment to use digital tools and the possible tools to be used, plan your class and test it with the tool. Anticipate possible errors, and doubts, see the time (remember that the student does not have the same ability as the teacher).	Don't be afraid to try or fail.
Know how to schematize the content.	Design the instructional model, which methodology would be more assertive in this practice, and create the problem or problems that should permeate the activity. Always start with the WHY of it. Students engage and learn what they believe they know the meaning of, why, and not just because it has to be studied.	Organization.
Know some basic software in the area of operation.	Enhance knowledge.	Interdisciplinarity.

Assess students' learning levels.	Create a lesson plan aligning the digital tool, the programmed content, and the chosen methodology.	You need to be willing to learn technologies you may not be used to.
Adapt the class theme to the use of the chosen tool.	Have an alternative plan if you depend on an internet connection.	Practice.
Integration of knowledge of Arts, Sciences, Technology, Engineering, and Mathematics.	Create a lesson plan aligning the digital tool, the programmed content, and the chosen methodology.	Take initiative.
Integration as the center of didactics: knowledge of the basic curriculum to choose ways to present concepts to students in an integrated way.	Simulate the application of the proposal for previously trying to find possible errors using the tool. (repeat this process until you have confidence in using the tool).	Be curious and be connected with world reality.
	Have an alternate plan. in case the ICT stops working	Be up to date with digital tools.
	Make interdisciplinary and collaborative partnerships.	Valuing the particularities of each student.
	Be the mediator, challenging students to understand how to learn by doing.	Foresee possibilities for the student to prepare for challenges as a citizen and also for the job market.
	Point out new ways to solve the same issue.	-Development of socio-emotional skills, through group exchange work, as empathy and cooperation

		are necessary to reach an answer.
	Creation of workshops: divide students into groups and propose that they find a practical solution to a given problem.	
	Elaboration of activities that provoke and stimulate the solution in several fronts of the areas that are part of STEAM.	
	Classroom debates lead students to questions in which they arrive at different hypotheses and share the how of the solution.	
	Bring real problems to the classroom, involving issues, and problems that affect the daily life of the community, family, and school, that is, the context of students.	
	Use of different platforms such as computer rooms, maker environments, implementation of games, use different platforms, not being so stuck	

	only with notebooks and books.	
	Plan and build learning experiences and pathways (teaching and lesson plans).	
	Use the correct teaching method according to the chosen technological tool.	
	Use different forms of learning assessment.	
	At first, take a digital literacy course and then other courses to learn how to use technologies with your students inside and outside the classroom.	
	Explain the Why, the objective at the beginning, to lead the student to understand the strategy that was designed and planned for his learning, for light and incredible moment, which is this class. Explain the methodology, HOW this will all happen, and what is expected at the end. Show the entire course, but	

	allow the speed and manner of traversing this course to be the student's choice.	
	Knowing which technological device students find interesting Knowing what they would like to learn or master when it comes to technology.	

**Competence - Develop and apply Hybrid Teaching:**

This competency is related to the ability to plan classes focused on the hybrid modality, considering innovative educational practices.

<b>Knowledge, Skills, and Competency Attitudes: Developing and Applying Blended Learning</b>		
<b>Knowledge</b>	<b>Ability</b>	<b>Attitude</b>
Knowledge about blended learning.	Prepare an activity using the chosen tool(s).	Autonomy to decide what to do.
Digital devices (cell phone, tablet, etc.).	Make slides, and presentations to make student learning the best experience.	Be positive.
Technologies.	Adapt and present the information correctly in its context (public and media).	Flexible.

Notions of technology.	Use learning environments.	Patient.
Virtual Learning Objects (OVA).	How to produce videos, photos, podcasts, slides, and blogs.	Open to learning new things.
Collaborative learning process.	Pay attention during the activity. Watch the groups. There will be groups that will not be motivated. Help them, motivate them. Play the role of Tutor at this time. Listen to the debate between them, the doubts, when they stopped. This is your assessment of the day: you will know exactly which gap to fill! Do a self-assessment socialization at the end. Listen and motivate to always improve, yourself and the class. There's no mistake!	Organized.
Knowledge of educational software.	Look for new materials to aid in learning.	Try to be optimistic even if the learning process is complicated.
		Always seek to update in the use of digital tools.
		Do not get discouraged when you have problems in the processes inherent to your main objectives.

		If it doesn't work, or rather when it doesn't work, try again. (repeat ad eternal ).
		Autonomy.

**Competence - Develop and apply distance education:**

This competence is related to the ability to plan classes focused on the Distance Education modality, considering innovative educational practices and online interaction.

**Knowledge, Skills, and Competency Attitudes: Develop and apply distance education**

Knowledge	Ability	Attitude
EAD _	Use Google Meet.	Purpose.
Interactive material.	Know how to present and share the class through Jamboard for collaboration.	Good relationship.
Know how to use computers or others.	Use online collaboration tools.	Commitment.
Educational Software.	Access course content.	Organization.
Virtual Learning Environments Learn about interactive tools available online.	Perform and submit tasks.	Empathy.
	Watch videos and read texts.	Good relationship.
	Help the student to use digital tools when solving problems.	Encouraging.
	Log in to the course platform.	animator.
		Autonomy.
		Collaboration.
		Encourage student interaction.
		Set goals and

		propose challenges.
		Humility to ask for and accept help.
		Be a good listener.
		Have a good relationship with students.
		Arouse student interest.

**Competence - Develop and apply the Maker Culture:**

This competence is related to the teacher's ability to plan pedagogical practices based on the maker culture ("hands-on").

**Knowledge, Skills, and Competency Attitudes: Developing and Applying the Maker Culture**

Knowledge	Ability	Attitude
Software, simulators, research tools.	Record and edit a video.	Use quick thinking.
Digital labs.	Projections in 3 dimensions.	Persistent.
Maker Culture.	Knowing and knowing how to apply experiments in digital laboratories.	creative.
Remote labs.	Know the commands to access materials and/or practical activities.	Curious.
Technology.	Know what tools will be needed.	Have Resilience.
Observe the necessary conditions for the use of your access ICT.	Build and transform information.	Know how to work in a team.
3D printing devices.	Watch tutorial videos.	interpersonal.
Know how to use the tools interactively.	Watch tutorial videos.	Flexibility.

Pedagogy laboratory (toy library). Knowledge related to the laboratory and the area of pedagogy.	Use video tutorials.	Commitment.
	Instructions for access to the laboratory, usability, and operation of the laboratory. Doing related to the laboratory (toy library).	Mediator.
	When choosing to start the manipulation of this move in canvas identify its functions.	Critical.
	Observe and practice before taking it to students, trying to predict what difficulties students will have when using the tool suggested and chosen by the teacher for practice.	Be dynamic.
	Relate the discipline of pedagogy with the purpose of the laboratory and experience games and play to value play and children's culture.	Be perceptive and adapt.
		Apply the proposal with enthusiasm.
		Trying to motivate students in the learning process.
		Stimulate students' curiosity the

		process.
		Resilience.
		Curiosity.
		Adaptation to changes.
		Be active, and persistent, and do it as often as it takes.

**Competence - Using Games:** This competence is related to the ability to plan lessons using games as a basis for pedagogical practices in STEAM areas.

<b>Competency Knowledge, Skills, and Attitudes: Using Games</b>		
<b>Knowledge</b>	<b>Ability</b>	<b>Attitude</b>
Educational Games.	Create the game.	Empathy.
Adapt the course content to the game format.	Share the game link with students.	Commitment.
Know how to search, use and use online games.	Explain how to play and how to pass the level.	Proactivity.
	Reward who completes the mission (the reward is common in games: trophies, medals, lives...).	Organization.
	Introduce the game to students.	It becomes fun and dynamic causing interest in learning.
		Motivate them to log in and play.
		Leadership.
		Flexibility.

In this way, it can be observed that the participants had a concern regarding the pedagogical use and technology when it is built with the students (Figure 4). The inclusion of other modalities in addition to face-to-face was also pointed out included in the mapping, mainly Distance Education ( EdD ) and Hybrid. It was also possible to

observe that the participating teachers perceive the need for actions to introduce technologies, considering the basic use of digital tools, as well as becoming the author of their materials. The games, as well as the maker culture, proved to be issued in the participants' notes.

The digital whiteboard was a surprise in the notes, however, when observing the Brazilian reality in which many public schools and universities obtained or won this governmental action tool, it becomes pertinent to consider this competence so that the teacher himself knows how to use the resource to build, dialogue, reflect and present their productions.

Thus, when analyzing the data, it was also possible to identify educational tools mentioned to be used in the construction of competencies, highlighting remote laboratories as recurrent, as is the case of the Remote Labs Learning Environment (RELLE) (<http://relle.ufsc.br/>) (figure 5). RELLE is a platform that provides 20 remote laboratories, with 26 instances, for use in practical activities in the classroom. Therefore, the platform allows the teacher to integrate the STEAM areas, and, according to the participants' testimonies, it is essential to understand its functionality and applicability in pedagogical practices.



Fig 5. Educational tools cited to build competencies for STEAM areas.

Other tools, not necessarily for educational purposes, but which can support teaching and learning processes, were also mentioned, mainly gamification ( Kahoot, Quizzes, H5P, etc.) (figure 5). Gamification in the context of learning is understood through different prisms, since, although gamified learning and game-based learning have overlapping research literature, they do not have the same definition. Game-based learning implies the design of complete (serious) games. Gamification is a design process of adding game elements to build learning [12]. Therefore, many tools and games are used in gamification, which impacts the skills for the STEAM areas, since it can help the student to reflect in the course of the knowledge construction process.



Fig 5. Tools cited to build competencies for STEAM areas.

In addition, the participants were concerned about considering methodologies that can help in the construction of competencies, pointing out five methodologies that can be applied (figure 7).



Fig 7. Methodologies aimed at building competencies for STEAM areas.

The aforementioned methodologies are considered active since there is an "interrelation between education, culture, society, politics, and school, being developed by active and creative means" [1]. Therefore, it can be highlighted that they are linked to the authorship and production of the students, mainly considering the STEAM areas that need practical actions, and applying theoretical knowledge daily. Maia, Carvalho, and Appelt [8] denote that in STEAM the student must become the center of the process, being possible to experiment, build, interact and collaborate with colleagues, being pertinent to the use of active methodologies such as those mentioned above. Thus, it can be seen that the participants understood more deeply the importance and how to carry out the construction process in these areas.

Thus, the research made it possible to understand the importance of teacher training that includes knowing the STEAM areas, since an "approach to pedagogical work that favors the development of creative and active learning

is necessary, allowing students to make decisions and evaluate results, through of interdisciplinary projects that seek to solve real-world problems” [8]. In this bias, training that encompasses the use of digital technologies as support for pedagogical practices is also necessary, since these resources are already part of the student's reality and must be integrated into classes. In addition, little knowledge of the participants on this topic can be observed, and new training based on the skills presented in this study is relevant.

## V. CONCLUSION

The present research aimed to present a mapping of teaching competencies for the STEAM areas. Thus, 80 teachers who work with different audiences and teaching modalities participated in the research.

The data presented show a concern on the part of teachers to build teaching skills from a pedagogical perspective, with methodologies and action strategies, as well as technological ones, based on basic training in the use of digital technologies. From this perspective, in all, 11 teaching skills were mapped to work in the STEAM areas: Using mobile devices; Using the digital whiteboard; Using basic computer resources; Using basic Internet resources; Research with digital technologies; Using productivity tools; Developing and apply the Maker Culture; Develop and apply distance education; Develop and apply Blended Learning; Develop and apply a Plan; Use Games. For each competence mapped, the knowledge, skills, and attitudes that must be built with the teacher were also presented.

In addition, it was possible to glimpse suggestions of educational and digital tools that can be used in pedagogical practices, as well as active methodologies that apply in the context in question.

It is worth noting that other teaching skills for STEAM areas must exist, as well as the importance of evaluating and validating these, as well as their CHA in different contexts and teaching modes. In this sense, this study aimed to present a first version of the mapping of teaching competencies for STEAM areas, and this theme is relevant to the current society that needs critical training and subject.

## ACKNOWLEDGEMENTS

Acknowledgments: This work was carried out with the support of the Fundação de Amparo à Pesquisa e Inovação do Estado de Santa Catarina (FAPESC), through resources from the Public Call Notice FAPESC/CAPES Nº 21/2021 – Accreditation of Higher Education Institutions with emerging stricto sensu graduate programs and being

consolidated in priority areas in the state of Santa Catarina, Termo de Grant CP 21/2021 FAPESC.

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# In Vitro inhibition of plasmodium falciparum by substances isolated from antimalarial plants.

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Received: 15 Jul 2022,

Received in revised form: 04 Aug 2022,

Accepted: 09 Aug 2022,

Available online: 13 Aug 2022

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**Keywords**— *Neosergeolide*, *Aspidocarpine*, *4-nerolidylcatechol*, *Jurinea dolomiaea*, *Alstonia scholaris* and *Datura stramonium*.

**Abstract**— *In the present study, a neosergeolide, isolated from the roots of Jurinea dolomiaea Boiss (Asteraceae), the indole alkaloid aspidocarpine, isolated from the bark of Alstonia scholaris (Apocynaceae) and 4-nerolidylcatechol, isolated from the seed of Datura stramonium Linn. (Solanaceae), all presented significant in vitro inhibition (more active than quinine and chloroquine) of the multi-drug resistant K1 strain of Plasmodium falciparum. Neosergeolide presented activity in the nanomolar range. These compounds are good for pre-clinical tests as novel lead structures with the aim of finding new antimalarial prototypes and provide support to the traditional use of the plants.*

## I. INTRODUCTION

Malaria is the main cause of economic loss and high morbidity in the world today. The lack of an effective vaccine and the increasing expansion of strains of Plasmodium falciparum presenting resistance towards commonly used, low-cost antimalarials make control of this disease difficult [1]. As a result, the World Health Organization (WHO 1978, 1995) has been promoting research on natural product based drugs for treatment of disease and many plant species have been evaluated for antimalarial activity [2,3]. In these studies, emphasis has been on the discovery of lead compounds for drug development. The search for active substances in medicinal plants is a very promising and cost-effective discovery for antimalarial drug. This approach benefits from the limited knowledge of the curing capacity of plant inhabitants of malaria in endemic regions and permits the extensive evaluation of natural products [4, 5].

The medicinal knowledge of these traditional plants is useful and effective and is an extremely important source of therapeutic compounds in use today. Important semi-synthetic, low-cost, highly effective antimalarial drugs

such as the quinolines (chloroquine, mefloquine, primaquine, etc.) and artemisinin derivatives (sodium artesunate, arteether, artemether, etc.) owe their initial discovery to the isolation and structural identification of antimalarial natural products (quinine and artemisinin, respectively) from traditionally used antimalarial plant species. Recent studies on traditionally used antimalarial remedies have revealed that the plants which produce indole and isoquinoline alkaloids, sesqui-, di- and triterpenes, flavonoids and other substances presenting proven in vitro activity against P. falciparum [6, 7, 8, 9].

Research on new antimalarials from natural products involves coordinated scientific effort on the part of different professionals. These professionals generally represent distinct academic disciplines, most importantly, botany, natural product, and synthetic chemistry, pharmacology, parasitology, and molecular biology. Groups with these characteristics can in the short and long run produce sound knowledge of the chemical, pharmacological, and biological diversity. Based on scientifically sound facts, the most promising agents for

further clinical and industrial development can be identified.

In this work, the pharmacological potential of several substances isolated from traditionally used antimalarial plants was evaluated through screening for in vitro inhibition of human malaria parasite species *P. falciparum*. The ultimate goal of this work is to identify new classes of antimalarial substance which may serve as prototypes for the development of drug having novel mechanisms of action.

## II. MATERIALS AND METHODS

### *Plant material extraction and chemical constituent isolation*

The plants from which the substances under study were isolated and are traditionally used for the treatment of malaria are the roots of *Jurinea dolomiaea* Boiss (Asteraceae), bark of *Alstonia scholaris* (Apocynaceae) and the seed of *Datura stramonium* Linn. (Solinaceae). All plant materials were collected in the state of Jammu and Kashmir. Plant materials were collected from Himalayan region of upper Danchigam in south Kashmir about 38- 45 meters above the sea level. The plants were identified taxonomically and authenticated at the Herbarium, Department of Botany, Kashmir University. Plants were washed thoroughly 2 - 3 times with running tap water and then with sterile water followed by shade-dried, powdered and used for extraction. Structural elucidation of isolated compounds was performed by analysis of 1-D / 2-D NMR, mass, infrared and ultraviolet spectral data and comparison to spectral data available in the literature.

### *Isolation of neosergeolide (1) from J.dolomiaea*

Roots and stems (6.5 kg) were degreased with hexanes in a soxhlet apparatus then repeatedly extracted with water using the same equipment. Continuous liquid-liquid extraction of the resulting concentrated H<sub>2</sub>O extract with CHCl<sub>3</sub> was then performed. The procedure was essentially described by [10] for the isolation of other quassinoids. We developed a method which obviates the need for a chromatography step. The concentrated chloroform extracts (35.1 g) were dissolved in a minimum of hot water and acetone (2:1). The resultant precipitate was fractionally recrystallized to give pure neosergeolide (1) (685.4 mg, 0.011% based on dry weight of plant).

### *Isolation of aspidocarpine (2) from Alstonia scholaris (Apocynaceae)*

Isolation and purification of 2, was essentially the same as described above for 1, wherein bark (1.2 kg) yielded ethanol extract (35 g) which was partitioned and yielded an alkaloid rich pH 8 fraction (1.45 g). Sequential normal-phase chromatography on a portion (1.40 g) of this fraction yielded aspidocarpine (68.5 mg, 0.0057% based on dry weight of plant).

### *Isolation of 4-nerolidylcatechol (3) from Datura stramonium*

Roots (150 g) were extracted with a 1:1 mixture of CHCl<sub>3</sub>/EtOH (3 × 150 ml; 15 min each) in an ultrasound bath. After total evaporation, the extract (19.5 g; 13%) was chromatographed on silica gel using a 9:1 mixture of CHCl<sub>3</sub>/EtOH 9:1 which yielded pure 1 (8.6 g, 44.1% w/w based on extract, 5.7% based on dry weight of plant).

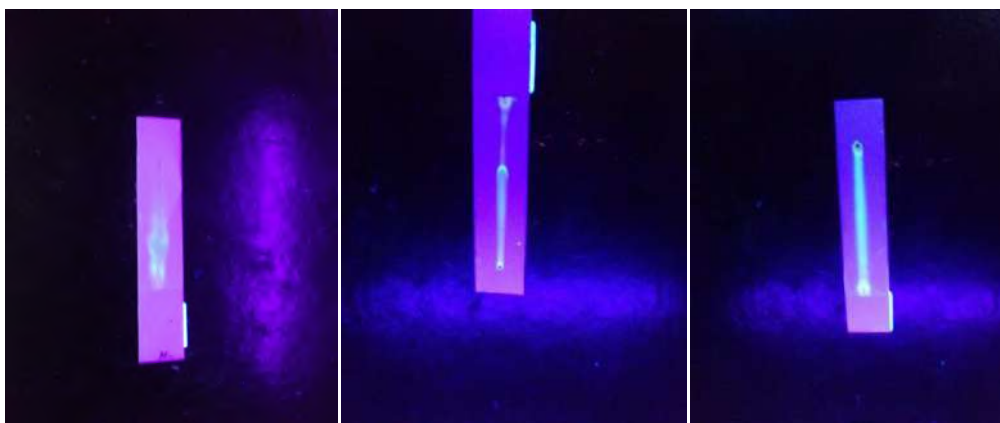


Fig.1 TLC plates of crude extracts of *J.dolomiaea*, *Alstonia scholaris* and *Datura stramonium*

### *Parasite culture and in vitro antimalarial tests*

Chloroquine, pyrimethamine, and cycloguanil resistant *P. falciparum* strain K1 was acquired from MR4 (Malaria Research and Reference Reagent Resource Center, New

Delhi, India) and was used in the in vitro tests. Parasites were maintained in continuous culture in A+ human erythrocytes, using RPMI medium supplemented with 10% human serum, as described by [11]. The antiparasitic effect of the compounds was measured by growth inhibition

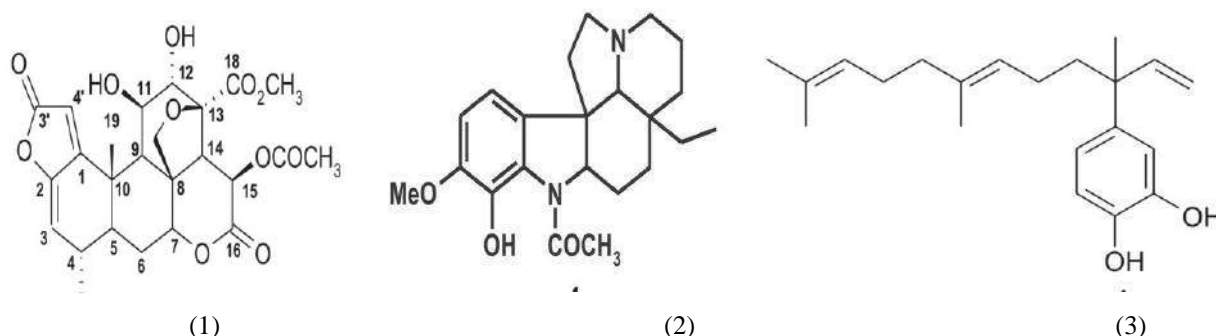
percentage as described by [12]. Briefly, trophozoite stages in sorbitol-synchronized blood [13] were cultured at 1-2% parasitaemia and 2.5% hematocrit and then incubated with the plant extracts or isolated compounds (maximum 1 mg/ml in serial dilutions), diluted with 0.02% final concentration of DMSO in culture medium (RPMI 1640) for a total of 48 h at 37°C. A positive control with reference antimalarial drug (chloroquine and quinine) in standard concentrations [14] was used in each experiment. The stock solutions were further diluted in complete medium (RPMI 1640 plus 10% human serum) to each of the used concentrations (0.0001 up to 100 µg/ml in seven dilutions). The half-maximal inhibitory (IC<sub>50</sub>) responses as compared to the drug-free controls were estimated by interpolation. Each duplicate experiment was repeated three times and blood smears were read blind.

*Statistical analysis - The data of in vitro antimalarial tests were analyzed with the Biostat 1.0 MCT-CNPq software package using Anova and Students t-test.*

### III. RESULTS

*Table 1. The half-maximal inhibitory concentrations (IC<sub>50</sub>) of isolated substances from Jurinea dolomiaea, Alstonia scholaris and Datura Stramonium towards Plasmodium falciparum (K1 strain). a: mean values in representative assay.*

Compound Name	Structural class	Plant species/source	Mean IC <sub>50</sub> values <sup>a</sup>	
			µg/ml	µM
Neosergeolide	Quassionoid/terpenoid	Jurinea dolomiaea	0.001	0.002
Aspidocarpine	Indole alkaloid	Alstonia scholaris	0.007	0.019
4-Nerolidylcatechol	Phenylpropanoid/terpenoid	Datura Stramonium	0.21	0.67
Chloroquine diphosphate salt	Quinoline	Synthetic commercial standard	0.46	0.89
Quinine salt	Quinoline alkaloid	Natural commercial standard	0.004	0.012



*Fig.2 Chemical structure of antimalarial isolated compounds Neosergeolide, Aspidocarpine and 4-Nerolidylcatechol.*

The results of the in vitro tests with compounds obtained from plant extracts against multidrug-resistant *P. falciparum* K1 strain are presented in the Table 1. The IC<sub>50</sub> of compounds ranged from 2.0 nM to 0.67 µM. Neosergeolide (1), a known quassionoid which has previously been isolated from *Jurinea dolomiaea* but for which no data on antimalarial activity has been previously reported, showed significantly higher activity (IC<sub>50</sub> = 2.0 nM) than did the other compounds tested. Fig. 1 illustrates the dose-response curve for this quassionoid showing a tendency of standard curve; this analysis was performed for all tested compounds. Aspidocarpine are known indole alkaloids for which antimalarial activity has not apparently been previously described. A significant inhibition of parasite growth (IC<sub>50</sub> = 73nM). 4-Nerolidylcatechol, a metabolite found in *Datura Stramonium* for which no data is available as to antimalarial activity, presented good parasite inhibition (IC<sub>50</sub> = 0.67 µM). The in vitro sensitivity of the *P. falciparum* strain to the compounds tested was similar and reproducible in assays in duplicate on separate occasions.

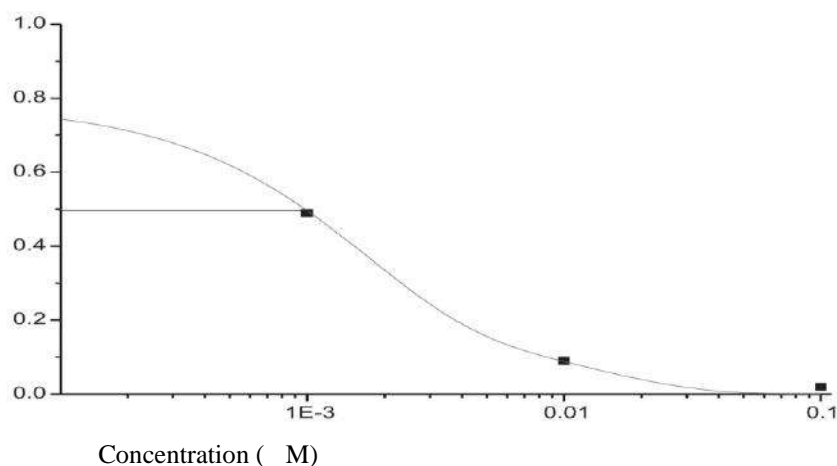


Fig. 3: Illustrative dose-response curve for multi-drug resistant *Plasmodium falciparum* K1 strain in the presence of different concentrations of the quassinoid neosergeolide (1) tested with IC<sub>50</sub> value in representative experiment; confidence interval (95% CI) = 0.00 – 0.01. Statistical analysis among additional assays showed: standard error = 0.0007;  $p = 0.10$ .

#### IV. DISCUSSION

Plants of the family Asteraceae are widely used in traditional medicine for the treatment of malaria, cancer, dysentery, and other diseases in countries around the world [15]. Quassinoids are a group of degraded triterpenes found in the family Asteraceae, that show many biological activities such as antitumor [16], antifeedant [17], phytotoxic [18], antiviral [19] and antihelminthic [20]. The antimalarial activity of some quassinoids like brusatol, glaucarubinone and quassin has been demonstrated previously [21].

An ethnopharmacological study in French Guyana showed that *Alstonia scholaris* root, stem and bark alcohol extract is used in local traditional medicine as a curative treatment of malaria. In a subsequent study [22] demonstrated that *A. scholaris* water extract can inhibit hemozoin formation. In vitro assays demonstrated the antimalarial activity of this extract against the chloroquine resistant *P. falciparum* strain W2. Sergeolide and isobrucein B are quassinoids which have been isolated previously from *A. scholaris* and exhibit high antiplasmodial activity against chloroquine-sensitive FUP strain, sergeolide exhibited an IC<sub>50</sub> which was five times less than that of isobrucein B and three times less than that of chloroquine in the same strain. In vivo assays demonstrated that sergeolide was capable of inhibiting *P. berghei* strain NK65 with an ED<sub>50</sub> of 0.2 mg/kg/day, five times less than chloroquine [23].

Our data show that the quassinoid isolated from the roots and stems of the *A. scholaris* was more active than quinine and chloroquine; with activities in the micromolar ranges comparable to recently reported results. Several quassinoids are known to inhibit the growth of *P. falciparum* in culture at nanomolar concentrations [24].

The quassinoids orinocinolide and simalikalactone D, isolated from the root bark of *Simaba orinocensis* were found to be potent in vitro against *P. falciparum* clones D6 and W2 [25]. Research has also revealed quassinoids which are 4 and 12 times more active in vivo (via oral) against rodent malaria parasite [26] than chloroquine and artemisinin, respectively [27]. Despite these antimalarial activities, quassinoids usually present toxicity due principally to protein synthesis inhibition and it is likely that parasite and host cell ribosomes are too similar to allow for the development of selective inhibitors [28]. Some structural requirements, like and  $\alpha$ ,  $\beta$ -unsaturated ketone in the A ring, an epoxymethylene bridge in the C ring and an ester function in C-15 are considered very important for the antimalarial activity presented by quassinoids [29, 30].

*Datura stramonium* plant produce the secondary metabolite of mixed terpene and phenylpropanoid biosynthetic origin, 4-nerolidylca-techol, which was evaluated in the present study. Qualitative tests have shown the presence of this compound in the seed, and leaf. Reductions in parasitemia of 66, 55, and 28% were observed for the *D. stramonium* [31] evaluated seed ethanol extracts of the same species by subcutaneous and oral administration and found in the seed extract significantly reduced blood parasite levels at different doses. On the other hand, [32] evaluated *D. stramonium* seed hexane and methanol extracts in vivo through oral and subcutaneous administration in *P. berghei* infected mice and found that these extracts were inactive against blood forms of *P. berghei*. These results lead [33] to conclude that the oral or subcutaneous administration of plant extracts in *Plasmodium berghei* infected rats was not effective at detecting the antimalarial activity of these plants [34]. Tested the in vivo and in vitro antimalarial

activity of *D. stramonium* seed and leaf water extract using a new method. Briefly, this method involved oral administration in adult rats via gavage tube (6 x 6 ml) for 2 days. After this period of treatment, the rats were bled and blood sera were tested in vitro in microcultures of *P. falciparum* using tritium-labeled hypoxanthine incorporation for parasite quantification. In vitro *P. falciparum* inhibition (49%) was observed for serum obtained from rats inoculated with *A. schlaris peltata* water extract versus controls. From the results of this and other experiments, differences in *P. berghei* and *P. falciparum* blood-stage biology might be thought to be responsible for the lack of in vivo activity observed [35]. Also evaluated *D. stramonium* seed hexane and methanol extracts in vitro in human malaria parasite species *P. falciparum*. The methanol extract presented greater inhibition of *P. falciparum* growth than the hexane extracts.

In more recent studies [36] observed the in vitro antiplasmodial activity of *A. schlaris* bark ethanol extract (IC<sub>50</sub> 3.7 µg/ml) in chloroquine and pyrimethamine resistant *P. falciparum*. We obtained a similar result for the alcohol root extract of *J. dolomiaea* in vitro in the K1 strain of *P. falciparum*. In preliminary work, 4-nerolidylcatechol (3) was shown to be active against *P. falciparum* in vitro [37].

The screening of natural products provides the chance to discover new molecules of unique structure with high activity and selectivity which can be further optimized by semi- or fully synthetic procedures [38].

Alkaloids are one of the most fascinating classes of natural products, providing many drugs for human use [39, 40]. In general, indole alkaloids are a class of compound having a range of biological activities, including antibacterial, trypanocidal, leishmanicidal and anticancer [41, 42, 43, 44, 45]. The antiplasmodial activity of monoterpene indole alkaloids has been investigated [46]. Promising results have been obtained previously by others for aspidospermidine structural analogues isolated from *A. pyrifolium* and *A. megalocarpon* to Nigerian chloroquine-sensitive and a Cameroon chloroquine-resistant (FcM2) strain of *P. falciparum*. In the chloroquine-resistant strain, apidospermine, 10-methoxyaspidospermidina and N-formylaspidospermidine presented, after 24 h, IC<sub>50</sub> of 16.3, 19.5 and, 16.1 µM, respectively, whereas after 72 h, IC<sub>50</sub> were 3.8, 3.2, and 5.6 µM, respectively. In the chloroquine-sensitive strain, after 24 h, IC<sub>50</sub> were 11.0, 13.1, and 22.0 µM, respectively, and after 72 h, 4.6, 5.1, and 5.9 µM, respectively [47]. Here, the isolated monoterpene indole alkaloid aspidocarpine was more active. The activities against K1 strain were of the same

order as those observed for the terpeneoid phenylpropanoid compound 4-nerolidylcatechol.

Those compounds or chemical groups have already shown potential as new drug leads or may have an impact on future drugs. Further studies should explore these compounds as a prototype for an antimalarial aimed at the *P. falciparum* multi-resistant parasites.

Adaptation of the protocol cited above to highthroughput platforms, as well as implementation of modern indirect methods for the quantification of in vitro parasite growth, such as fluorimetry [48] are underway and will be essential for an increase in the scale and dynamism of studies on antimalarial plants, isolated natural substances and their semi-synthetic derivatives, potentializing a process of continuous screening in the near future.

Additionally, stabilization of geographically specific *P. falciparum* populations in continuous in vitro culture is underway and should permit investigations into the real susceptibility profile of these regional parasites to the active substances and plant extracts which present promising inhibitory concentrations. It is our hope that knowledge of this regional profile can be useful for the identification, based on sound experimental evidence, of the most important and effective medicinal plants for development of new and effective antimalarials for local use. Furthermore, simultaneous studies on the macromolecular profiles of these parasites in association with analysis of genetic resistance markers [49] should contribute to the elucidation of possible mechanisms of resistance of the parasites to the natural products tested as well as aid in the discovery of new targets (and/or new mechanisms of action) for antimalarial chemotherapy.

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# Application of PCA-CNN (Principal Component Analysis – Convolutional Neural Networks) Method on Sentinel-2 Image Classification for Land Cover Mapping

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Received: 09 Jul 2022,

Received in revised form: 01 Aug 2022,

Accepted: 07 Aug 2022,

Available online: 15 Aug 2022

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**Keywords**— Land Cover, Sentinel-2, Deep Learning, PCA, CNN.

**Abstract**— Land cover information based on remote sensing imagery is effective information for land use management. The use of Sentinel-2 imagery is considered to be able to provide better information on land cover because it has a spatial accuracy of 10 meters. Convolutional Neural Networks is one of the deep learning methods that can be used for image interpretation in order to obtain image classification results which will later obtain information about land cover. PCA-CNN (Principal Component Analysis-Convolutional Neural Network) is a development method of the Convolutional Neural Network method which gives special treatment to the dimension reduction process in the input data. The dimension reduction process is carried out by utilizing the PCA method so that the data processing process becomes faster without losing important information so that better method performance is obtained. The PCA-CNN method is implemented on a dataset of the Situbondo district which is classified into five land cover classes. The results of the PCA-CNN method have an Overall Accuracy of 94.4% and Kappa Indeks 0,92 with 100 epochs of repeated experiments.

## I. INTRODUCTION

The large area and the mapping of the Situbondo area that has not been mapped properly are separate obstacles in the process of developing and planning the area. Automation of land cover monitoring and classification is required to monitor existing land use. The technology needed to analyze the earth's land cover automatically and cover a large area is by utilizing geospatial data in the form of satellite image data. One of the satellite images that can be used is the Sentinel-2. Sentinel-2 imagery is an image generated from remote sensing by the Sentinel-2 satellite. The Sentinel-2 satellite is equipped with a

multispectral and has 13 bands obtained from the multispectral imager [11]. Automation methods for processing Sentinel-2 satellite imagery include the use of deep learning. Deep learning is a learning method for data that aims to create a multilevel data representation [1]. The most important thing about deep learning emphasizes that the data representation is not made explicitly by humans but is generated by an algorithm [5]. According to Heryadi and [5] in the last ten years the application of deep learning shows that models based on Convolutional Neural Networks (CNN) with deep structures have excellent performance in the field of



pattern processing, such as object classification in images. CNN or ConvNet is a *deep feed-forward artificial neural network* that is widely applied in image analysis. CNN consists of one input layer (*input layer*), one output layer (*output layer*), and a number of *hidden layers* [10].

**II. METHODOLOGY**

**2.1 Principal Component Analysis (PCA)**

Dimensional reduction is a process carried out to simplify the existing variables to be fewer without losing the information contained in the initial data. One of the methods used in dimension reduction is *Principal Component Analysis* (PCA). The workings of PCA is to change the initial variable as many as  $n$  variables are reduced to  $k$  new variables called *Principal Component* (PC). Sum The number of  $k$  is less than  $n$  but by using a number of  $k(PC)$  can produce a value that is close to the same using  $n$  variables.  $PC$  that is formed is a linear combination of the initial variables that are *independent* or not correlated with  $PC$  other. The following are the steps to perform dimension reduction using PCA:

1. Compile the input matrix  $X$  as one of the  $k$  attribute vector data  $x_{ij}$  where  $i = 1, 2, \dots, n$  and  $j = 1, 2, \dots, m$ .

$$X = \begin{bmatrix} x_{11} & x_{12} & \dots & x_{1m} \\ x_{21} & x_{22} & \dots & x_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ x_{n1} & x_{n2} & \dots & x_{nm} \end{bmatrix}$$

2. Calculating the mean  $X = \bar{X}$  which satisfies the following equation

$$\bar{X} = \frac{1}{n} \sum_{i=1}^n x_i$$

3. Calculating the covariance matrix  $C$  which satisfies the following equation

$$C = \frac{1}{n-1} (X - \bar{X})(X - \bar{X})^T$$

4. Calculating the eigen values  $\lambda$  which satisfies the following equation

$$|C - \lambda I| = 0$$

5. Calculating the eigen vector  $v$  which satisfies the following equation

$$[C - \lambda I][v] = 0$$

6. Extract the diagonal values from the eigen values and sort them in descending.

7. Here are some ways to determine I column eigen vector to be selected as  $PC$ .

- a. Using a scree plot of the proportion of variance, based on the point of the curve that no longer

decreases sharply and generally shows  $PC$  with eigen values of more than 1.

- b. Using the cumulative proportion of variance which is formulate as follows

$$pPC_k = \frac{\sum_{i=1}^k \lambda_i}{\sum_{i=1}^n \lambda_i} \times 100\%$$

with  $\lambda_1 > \lambda_2 > \dots > \lambda_p$ . The number  $PCs$  has at least a cumulative proportion of variance of 80% [8].

8. The new variable resulting from the reduction is obtained by using an eigen vector matrix with an input.

$$\begin{aligned} PC_1 &= e_1'X' = e_{11}X_1' + e_{21}X_2' \dots + e_{p1}X_p' \\ PC_2 &= e_2'X' = e_{12}X_1' + e_{22}X_2' \dots + e_{p2}X_p' \\ &\vdots \\ PC_p &= e_p'X' = e_{1p}X_1' + e_{2p}X_2' \dots + e_{pp}X_p' \end{aligned}$$

**2.2 Convolutional Neural Networks (CNN)**

Convolutional Neural Networks (CNN) or ConvNet is a deep feed-forward artificial neural network that is widely applied in image analysis. CNN consists of an input layer (input layer), an output layer (output layer), and a number of hidden layers (hidden layer). Hidden layers generally contain convolutional layers, pooling layers, normalization layers, ReLu layers, full connected layers, and loss layers. All the layers are arranged in a pile. CNN uses a three-dimensional architecture, namely width, height, and depth. The width and height dimensions on CNN are representations of the image (texture and morphology) while the inner dimensions represent color channels [11]. The following is the architecture of CNN can be seen in Figure 1 [1].

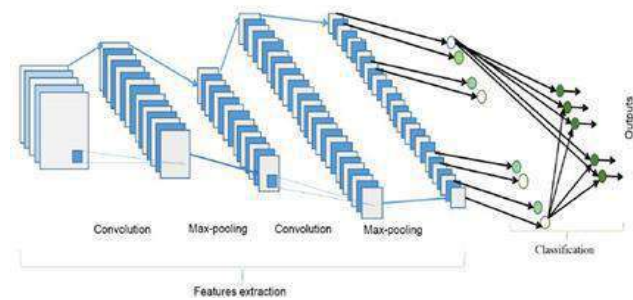


Fig.1. CNN Architecture

**2.3 Sentinel-2**

The Sentinel-2 satellite is a European optical imaging satellite that was first launched in 2015 which was launched as the Europe Space Agency (ESA) Copernicus program. The Sentinel-2 satellite has 13 spectral bands carrying various swaths of high-resolution multispectral imager. The Sentinel-2 satellite system is often referred to as a twin satellite, namely Sentinel-2A (S2A) and Sentinel-

2B (S2B) because it works in sync so that it looks like one satellite. Each satellite has a revisit frequency (temporal resolution) every 10 days. Sentinel-2A and Sentinel-2B satellites have a revisit time offset of 5 days (phase shift 180°), so that the same location on the earth's surface will be recorded by Sentinel-2A (S2A) and Sentinel-2B (S2B) every 5 days alternately. The Sentinel-2 satellite has several sensors, including Visible and Near Infrared (VNIR) and Near Infrared (NIR) to Short Wave Infrared (SWIR). The Sentinel-2 satellite can be used for supporting services such as forest monitoring, land cover change detection and natural disaster management [2].

2.4 Evaluation of the model

The evaluation of the model in this study was carried out based on accuracy tests performed using a confusion matrix to determine the producer's accuracy, user accuracy, overall accuracy and kappa index. Producer's accuracy is the accuracy seen from the side of the map producer, while user accuracy is the accuracy seen from the side of the map user. Overall accuracy is the model's accuracy value, while the kappa index is a measure that states the consistency between two measurement tools or methods. Mathematically it can be seen in Table 1.

Table 1. Size of Classification Evaluation Model

No	Ukuran	Rumus
1.	Producer's Accuracy	$\frac{X_{ii}}{X_{+j}} 100\%$
2.	User Accuracy	$\frac{X_{ii}}{X_{i+}} 100\%$
3.	Overall Accuracy	$\frac{\sum_{i=1}^n X_{ii}}{X_{mn}} 100\%$
4.	Indeks Kappa	$\frac{\sum_{i=1}^n X_{ii} - \sum_{i=1}^n X_{i+} X_{+j}}{1 - \sum_{i=1}^n X_{i+} X_{+j}} 100\%$

Where  $X_{ii}$  is the diagonal value of the i-th row and i-th column matrix.  $X_{+j}$  is the number of pixels in the j-th column,  $X_{i+}$  is the number of pixels in the i-th and  $X_{mn}$  is the number of pixels in the example. The following is a description of the confusion matrix as illustrated in Figure 2.

		Actual Class				
		i1	i2	i3	i+	ij
Prediction Class	1j	$X_{11}$	$X_{12}$	$X_{13}$	...	$X_{1n}$
	2j	$X_{21}$	$X_{22}$	$X_{23}$	...	$X_{2n}$
	+j	$X_{31}$	$X_{32}$	$X_{33}$	...	$X_{3n}$
	⋮	⋮	⋮	⋮	⋮	⋮
	ij	$X_{m1}$	$X_{m2}$	$X_{m3}$	...	$X_{mn}$

Fig.2. Confusion Matrix

According to [8] the following is a suitability category between the two tools or methods of measuring the kappa index. as shown in Table 2.

Table 2. Strength Of Kappa Index

Kappa Index (%)	(Strength of Agreement)
<0,20	Poor
0,21 – 0,40	Fair
0,41 – 0,60	Moderate
0,61 – 0,80	Strong
0,81 – 0,99	Very strong

III. RESEARCH

3.1 Study area and data source

The research was conducted in January – July 2022. The research area covers part of Situbondo Regency. Data collection was carried out based on the Sentinel-2 satellite image from the <https://scihub.copernicus.eu/>. The tools and materials used in this study are a laptop with specifications Intel® Core™ i5-3337U CPU @ 1.80GHz, 8.00 GB RAM, NVIDIA GeForce GT720M with 2GB VRAM and 64-bit OS. Software ESA SNAP8.0 used for preprocessing data Google Colab Software is used for the data classification process. Sentinel-2 data used in this study is part of the Situbondo district, East Java province. Image data was taken on July 14, 2021 at 02:25:41 GMT. The following is a Sentinel-2 image format that was successfully downloaded “S2A MSIL2A 20210714 T 022551 N0301 R046T49MHM 20210714 T070327”.

3.2 Model Input Variables and Parameters PCA-CNN

Modeling on satellite imagery for land cover analysis in Situbondo Regency has several stages. The first stage is the determination of parameters. The parameters used in the PCA-CNN model include the determination of the number of convolutional layers, the selection of the pooling and the activation function. Parameters on the PCA-CNN model can be seen in appendix 4. The second step is to determine the batch\_size and the number of

iterations (*epochs*) on the model to be run. The PCA-CNN model uses *batch\_size* = 20 and the number of iterations (*epochs*) = 100. A total of 1000 images are used as training data for each class and 500 images are used as testing data for each class.

### 3.3 Classification Result and Visual Assessment

The following are the results of the classification process using the PCA-CNN model which are presented in the “*Training and test accuracy*” graph and the “*Training and test loss*” graph can be seen in Figure 3.a and Figure 3.b.

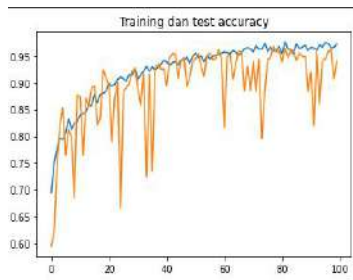


Fig.3.a Graph of “*Training and Test Accuracy*”

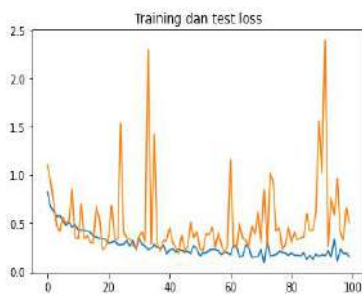


Fig.3.a Graph of “*Training and Test Loss*”

Seen from graph 3a. The blue line shows the accuracy of the *training*. The results that show an increase in accuracy in each iteration indicate that the model runs well at the *training* so that the accuracy results are stable and continue to increase. Different things are shown in the orange line which shows the accuracy of the test results. The results obtained in the test process indicate the value of the test accuracy is fluctuating. These results indicate that the model experiences heavy learning in each iteration of the test results. The test results at the end of the iteration show an accuracy value that is not too far from the training so that the model can be said not to be *overfitting* or fail to guess the results of the predictions. The results obtained in graph 3.a will be equivalent to the results that occur in graph 3.b The results in graph 3.b show the ability of the model to make errors in the classification process. If in graph 3.a the results show a high accuracy value, then the results in graph 3.b will show a loss in the same iteration. The detailed results of the PCA-CNN model classification

process are shown in the confusion matrix in Figure 4.

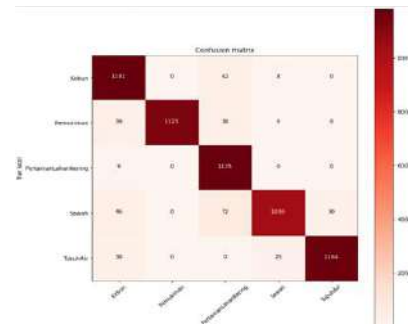


Fig.4. Confusin Matrix Of PCA-CNN Model

### 3.4 Classification accuracy assessment

The model test is carried out using *testing* originating from the distribution of data sets using the *hold-out method*. The model test carried out provides predictive results from the PCA-CNN method which can be seen in Table 2.

Table 2. PCA-CNN Model Prediction Results

Kelas	PCA-CNN	
	Producer Accuracy (%)	User Accuracy (%)
Kebun	90,5	95,9
Perumahan	100	93,6
Pertanian Lahan Kering	88,54	99,23
Sawah	96,9	87,5
Tubuh Air	97,5	95,5
Overall Accuracy (%)	Indeks Kappa	
94,4	0,92	

Values from Table 1 are obtained from the *confusion matrix* Figure 4 above. Table 1 shows that the highest accuracy value for the prediction of the five land cover classes is the *Producer Accuracy* in the housing class, which is 100%. That is, by using the PCA-CNN *Producer Accuracy* on the housing class, each prediction is successfully guessed accurately for each existing data. *Overall Accuracy* of the PCA-CNN model has a value of 94.4% with a *kappa index* of 0.92. This value shows the results of the model prediction on the test data are very good, which is above 80%.

## IV. CONCLUSION

The PCA-CNN method as a whole can be applied to land cover classification using Sentinel-2 imagery with

five main classes namely kebun, perumahan, Pertanian lahan kering, sawah, and Tubuh Air. The PCA-CNN method has the *Overall Accuracy* of the PCA-CNN model which has a value of 94.4% with a *kappa index* of 0.92.

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## Classification of environmental crimes related to the integrated inspection of Ponta do Abunã in Rondônia, Brazil

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Received: 14 Jul 2022,

Received in revised form: 07 Aug 2022,

Accepted: 11 Aug 2022,

Available online: 15 Aug 2022

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**Keywords—** Environmental Crimes,  
Integrated Surveillance, Ponta do Abunã,  
Rondônia.

**Abstract—** The main research problem is whether it is possible to typify and establish a correlation of environmental crimes from the integrated inspection operation known as "Ponta do Abunã" in Rondônia, in the border region between the states of Acre, Amazonas and Rondônia, in two different periods? To answer this question, the general objective of the research was to analyze the typology of environmental crime resulting from the integrated inspection action of IBAMA Superintendências do Acre, Amazonas and Rondônia and other command and control bodies carried out in the Ponta do Abunã region, located in municipality of Porto Velho, Rondônia, Western Amazon. This is a documentary and qualitative research, having as place of research the legal office of IBAMA/Rondônia. For the documentary analysis, 2 semi-structured instruments composed of 3 axes were used, containing the typology of the environmental crime, infraction notices and instruction and embargo term and, current stage or judgment of the process. The results indicate that the harmful conducts to the environment are prolonged throughout the analyzed period. Legislation is able to typify illegal actions and concrete actions fit the legal precept issued by the legislator. The delay in the judgment of the infraction notices analyzed is a real fact that requires a more agile response from the environmental sanctioner.

## I. INTRODUCTION

Crime is a violation of law. Thus, any damage or loss caused to the elements that make up the environment will be an environmental crime: flora, fauna, natural resources and cultural heritage [1]. According to these authors, for violating a protected right, every crime is subject to sanction (penalty), which is regulated by law. The environment is protected by Law No. 9,605 of February 12, 1998 - Environmental Crimes Law [2], which determines criminal and administrative sanctions derived from conduct and activities that are harmful to the environment. In the evaluation of Duram and Martins [1] before the existence of Law n° 9.605/98, the protection of the environment was a great challenge, since the laws were sparse and difficult to apply: there were contradictions such as, for example, the guarantee of free access to the beaches, however, without providing for criminal punishment for those who impeded it. Or inconsistencies in the application of penalties. Killing a wildlife animal, even for food, was a non-bailable crime, while mistreatment of animals and deforestation were simple misdemeanors punishable by a fine. There were gaps such as the lack of clear provisions regarding experiments carried out with animals or the release of balloons [1].

According to the Environmental Crimes Law n° 9.605/98, environmental crimes are classified into five different types: Against fauna (arts. 29 to 37): These are aggressions committed against wild, native animals or animals on a migratory route, such as hunting, fishing, transport and commercialization without authorization; ill-treatment; carrying out painful or cruel experiments with animals when there is another means, regardless of the end. Also included are attacks on the animals' natural habitats, such as modifying, damaging or destroying their nest, shelter or natural breeding ground. The introduction of foreign animal specimens into the country without proper authorization is also considered an environmental crime, as is the death of specimens due to pollution. Against flora (art. 38 to 53): Cause destruction or damage to the vegetation of Permanent Preservation Areas, at any stage, or to Conservation Units; cause a forest or forest fire or manufacture, sell, transport or release balloons that may cause it in any area; extraction, cutting, acquisition, sale, display for commercial purposes of wood, firewood, charcoal and other products of plant origin without proper authorization or in disagreement with it; extract from public domain or permanent preservation forests stone, sand, lime or any kind of mineral; prevent or hinder the natural regeneration of any form of vegetation; destroy, damage, injure or mistreat ornamental plants in public places or on the private property of others; commercialize or use chainsaws without proper authorization.

Pollution and other environmental crimes (art. 54 to 61): All human activities produce pollutants (garbage, waste and the like), however, only pollution above the limits established by law will be considered an environmental crime subject to penalty. In addition to this, pollution that causes or may cause damage to human health, animal deaths and significant destruction of flora is also criminal. As well as that which makes places unsuitable for human use or occupation, water pollution that makes it necessary to interrupt public supply and not adopt preventive measures in case of risk of serious or irreversible environmental damage. Environmental crimes are the research, mining or extraction of mineral resources without authorization or in disagreement with the obtained and non-recovery of the explored area; the production, processing, packaging, import, export, marketing, supply, transport, storage, abandonment or use of substances that are toxic, dangerous or harmful to human health or in violation of the law; the operation of projects with polluting potential without an environmental license or in disagreement with it; This category of environmental crime also includes the dissemination of diseases, pests or species that may harm agriculture, livestock, fauna, flora and ecosystems.

Against urban planning and cultural heritage (art. 62 to 65): Environment is a broad concept, which is not limited to natural elements (soil, air, water, flora, fauna). In fact, the environment is the interaction of these, with artificial elements, those formed by the urban space built and altered by man and cultural elements that, together, provide a balanced development of life. In this way, the violation of urban order and/or culture also constitutes an environmental crime. Against the environmental administration (art. 66 to 69): These are the conducts that make it difficult or prevent the Public Power to exercise its supervisory and protective function of the environment, whether practiced by individuals or by officials of the Public Power itself. A public official who makes a false or misleading statement, omits the truth, withholds information or technical-scientific data in authorization or environmental licensing procedures commits an environmental crime; Or one that grants a license, authorization or permission in disagreement with environmental standards, for activities, works or services whose performance depends on an authorization act by the Government. A person who fails to comply with an obligation of relevant environmental interest also commits an environmental crime, when he has a legal or contractual duty to do so, or who makes it difficult to inspect the environment. This is what the authors Duram summarize; Martins [1].

In the case of aggression to the environment and its penalties, these same authors express that in addition to aggression that exceeds the limits established by law, conduct that ignores environmental standards are also considered environmental crimes, even if no damage is caused to the environment. This is the case of enterprises without the proper environmental license. In this case, there is disobedience to a requirement of environmental legislation and, therefore, it is punishable by fine and/or detention. The penalties provided for by the Environmental Crimes Law are applied according to the seriousness of the infraction: the more reprehensible the conduct, the more severe the punishment. It can be deprived of liberty, where the convict will serve his sentence in a penitentiary regime; restrictive rights, when applied to the subject - instead of imprisonment, penalties such as community service, temporary interdiction of rights, suspension of activities, payment in cash and home collection or fine. There are numerous cases of lawsuits pending in the judiciary in the fight against environmental crimes. The Environmental Crimes Law n.º 9.605/98 has a fundamental role of paramount importance in the Brazilian legal scenario in order to contribute to the balance in the ecosystem.

To further elucidate this introductory part, we turn to Sirvinskis [3]. For this author, environmental crimes are called criminal offenses. This is a useful doctrinal classification in the interpretation of the penal norm. The most used classification is: "Common Crime" – these are crimes committed by any person. For example, the provisions of article 29 of the Environmental Crimes Law; "Own Crime" – is that committed by a certain, determined person, a person who is invested in a public position, function or job. Example: crimes committed by a public official; "Own Hand Crime" - this can only be practiced by the person himself. We can cite as an example, the crime provided for in article 66 of the Environmental Crimes Law; "Crime of Harm" – in this case, it is necessary that the injury is carried out to a legal asset protected by criminal law. For example: the offense provided for in article 66 of the Environmental Crimes Law; "Crime of Danger" - this is consummated with the mere possibility of damage occurring. It is the exposure of a legal asset to danger of damage. As an example: the crime provided for in article 54 of the Environmental Crimes Law; "Material Crime" - It is consummated, with the effective result, that is, with the production of the result. For example: the provisions of article 39 of the Environmental Crimes Law; "Formal Crime" – in this case, a result is not required, and it is still possible for it to occur. . For example: the offense provided for in article 51 of the Environmental Crimes Law; "Crime of Mere Conduct" – is that crime in which the legislator describes only the initial conduct without

requiring a result. For example: the offense provided for in article 52 of the Environmental Crimes Law; "Commissive Crime" - is one committed for active conduct. For example: cutting down trees in permanent preservation forests, art.39 of the Environmental Crimes Law; "Omissive Crime" – in this case the agent commits the crime by omission. Sirvinskis [3] cites the example: the offense provided for in article 66 of the Environmental Crimes Act; "Own Omissive Crime" – is one in which the agent does not have a legal duty to act, not answering for the result. Answer yes for omissive conduct, only. For example: the offense provided for in article 2 of the Environmental Crimes Law; "Improper Commissive Crime or Commissive by Omission" – is one in which the agent has a legal duty to avoid the result and does not do so, example: article 48 of the Environmental Crimes Law; "Instant Crime" - is one whose consummation occurs at the moment of its practice. For example: the offense provided for in article 62, I, of the Environmental Crimes Law; "Permanent Crime" – its consummation extends over time. For example: the offense provided for in article 38 of the Environmental Crimes Law.

Faced with this rice paddy, we enter the Major Law, the current Constitution of the Federative Republic of Brazil. The legislation through a provision expressed in the Federal Constitution of Brazil of 1988 [4] welcomed the possibility of criminally holding legal entities responsible for environmental crimes, as provided in article 225, § 3: The conduct and activities considered harmful to the environment will subject the violators, individuals or legal entities, to criminal and administrative sanctions, regardless of the obligation to repair the damages caused. Silva [5] recognizes the chapter on the environment as one of the most important in the Federal Constitution and shows that it predominantly imposes preservationist behaviors, but also repressive measures, such as accountability in the civil, administrative and criminal spheres, highlighting the possibility of criminal liability of legal entities, regardless of the liability of their administrators. Cruz [6] understands that the Federal Constitution of Brazil aims to impute criminal responsibility to legal entities by extension in relation to the behavior of their directors, officers, representatives or agents, since, through their will, and only in this way, can a legal entity to engage in conduct that is harmful to the environment. It is important to preserve the principle of supremacy of constitutional norms, including art. 225 of the Federal Constitution, which must be interpreted according to the principles of maximum effectiveness and normative force of the constitution. Finally, this provision should govern the interpretation of all other infra-constitutional laws, such as the Environmental Crimes

Law.

In the case of the Brazilian Amazon, possible environmental crimes are publicized by the national and international press and are known to a significant part of the world population, in this scenario Rondônia is included. In order to elucidate this context, we used the indicators resulting from an inspection operation to combat environmental crimes in a region of environmental conflict, Ponta do Abunã, in Rondônia, Western Amazon. According to Salton [7] the integrated environmental inspection operation was due to the contextualization that the region known as Ponta do Abunã represents the focus of direct and indirect action in the performance of federal, state and municipal public institutions of command or control. Considered the western arm of the state of Rondônia, Ponta do Abunã is thus known for being a strip of land that extends from the limits of the state of Acre, on the left bank of the Abunã River to its mouth in the Madeira River. The area is limited to the north by the Municipality of Lábrea, in the south of the state of Amazonas; to the East with the municipality of Acrelândia, in the state of Acre; to the south, separated by the Abunã River, it borders the Department of Pando in the Republic of Bolivia; and to the West, it finds its border with the District of Abunã, across the Madeira River.

The main economic activities in the region are cattle ranching and logging, both of which have been illegal over the years, and have recently intensified, especially in illegal logging and fraudulent transactions in the control system (DOF). Over the last few years, the Ponta do Abunã region has been the target of large illegal deforestation aiming at the implementation of livestock activity, as well as the commercial use of high-value forest species by logging companies. In addition to the activities of illegal deforestation and use of wood by timber industries, frauds are also witnessed with the DOF System, aimed at acquiring wood credits to “warm up” (legalize) them. According to IBAMA intelligence reports, companies from the States of Amazonas, Roraima and mainly Rondônia, carried out fraud in the DOF system, through the replication of credits in the order of 360,000 m<sup>3</sup> of sawn wood in the period from November 2016 to September 2017. Converting this amount to roundwood, it is estimated that such credit would heat up the value of nearly 1 million cubic meters of roundwood. Given this context, the actions that are currently carried out by IBAMA headquarters and PNAPA in this region are inefficient, making a new type of action necessary, with a more constant presence of the Superintendencies of the States that constantly act in the triple border of the Ponta region. of Abunã [7]. The relevance of a more effective participation is highlighted, since the agents of these

decentralized units know the region in depth and can contribute more effectively and efficiently, as well as identify the necessary partnerships to combat environmental infractions and crimes in the region. The general objective of the research is to analyze the typology of environmental crime resulting from the integrated inspection action of IBAMA Superintendências do Acre, Amazonas and Rondônia and other command and control bodies carried out in the Ponta do Abunã region, located in the municipality of Porto Velho, Rondônia, Western Amazon.

## II. MATERIALS AND METHODS

The research is characterized primarily as to the means or according to the collection procedures as a Documentary Research. As for the use of the results or their purpose, it can be classified as applied research, qualitative as to its nature or approach point of view, and descriptive as to the purposes or objectives. According to Sá-Silva, Almeida and Guindani [8], document analysis is a procedure that uses methods and techniques for the apprehension, understanding and analysis of documents of the most varied types. In this way, document analysis can be developed from several sources, from different documents, not only the written text, since excluding books and materials already with analytical treatment, the definition of what is meant by documents is broad, including among them, laws, photos, videos, newspapers, etc. The methodological proposal can be used both as a qualitative and quantitative method and is concerned with seeking concrete information in the various documents selected as the research corpus [9]. Therefore, qualitative research stands out as a methodological path, being thus understood as an instrument for a detailed, in-depth understanding of the facts that are being investigated. According to Minayo [10] qualitative research in understanding works with the universe of meanings, motives, aspirations, beliefs, values and attitudes. According to Lima Junior et al., [9] the data collected can be obtained in different ways, and it is necessary to determine the objective of the research in order to define the form of data collection that can be used. Furthermore, it is necessary to make it clear that the use of Document Analysis - which seeks to identify factual information in documents based on questions and hypotheses of interest - uses the document as an object of study. The qualitative approach, according to the ideas expressed by Tuzzo and Braga [11], is as a research exercise, it is not presented as a rigorously structured proposal, allowing imagination and creativity to lead researchers to propose works that explore new approaches, suggests that qualitative research offers the researcher a vast field of investigative possibilities that describe routine



and problematic moments and meanings in the lives of individuals. Researchers in this field use a wide variety of interconnected interpretive practices, in the hope that they will always be able to better understand the subject at hand [11]. For Lima Junior et al., [9] Document Analysis, in a qualitative perspective, is configured in a procedure that uses specific techniques for the apprehension and understanding of different types of documents and that adopts for such a cautious process of selection, collection, analysis and interpretation of data.

Data collection was carried out in the official system of the IBAMA Superintendence in Rondônia. The main researcher used his password as a career server at IBAMA Rondônia, exercising the position of administrative analyst and responsible for the sector of conciliation of environmental processes within the superintendence in Rondônia. The data were collected from the Notices of Infraction, Instruction and Judgment and Embargo Terms, which led to the opening of administrative processes in the Electronic Information System (SEI). Specifically, the processes available were consulted by the legal attorney of IBAMA (Advogacia Geral da União - AGU), operational nucleus of instruction and judgment of administrative processes within the scope of IBAMA. Documentary analysis was carried out by the application of 2 semi-structured instruments. The first instrument comprises three axes: 1st Axis – typology of environmental crime; 2nd Axis - characterization of infraction notices and instruction and term of embargo; 3rd Axis – current stage or judgment of the process. The second instrument for collecting data and information is constituted by the sequential systematization of the environmental legislation applicable to possible environmental crimes resulting from the actions of the Ponta do Abunã integrated inspection operation, in two distinct periods (corresponding to the interval of 3 years). Although the main researcher is a career servant of IBAMA, his advisor and the direction of the Department of Legal Sciences of the Federal University of Rondônia officially requested SUPES/IBAMA/ access to the processes of environmental crimes, object of the research. The study suffered limitations due to the slowness of the environmental agency in judging the records. Until the period of access to the records, none, that is 0% (zero) of the cases had been judged in the first instance.

### III. RESULTS AND ANALYSIS OF ENVIRONMENTAL CRIME PROCEEDINGS

The first part of the document analysis was carried out by the application of a semi-structured instrument, consisting

of three axes: 1st Axis – typology of environmental crime; 2nd Axis - characterization of infraction notices and instruction and term of embargo; and, 3rd Axis – current stage or judgment of the process. In this context, the analysis was carried out based on infractions corresponding to the years 2017, 2018 and 2020, presenting infractions resulting from the integrated inspection operation known as "Ponta do Abunã" in Rondônia, in the border region between the States of Acre, Amazonas and Rondônia.

24 infraction notices were analyzed, including deforestation infractions, destruction of native forest and Amazon forest with the use of fire and tractor, destruction of native vegetation, among them species listed on the official extinction list, impediment of natural regeneration of the Amazon forest, transport and storage of illegal wood, including endangered species, false information in the Documento de Origin Florestal – DOF system. The analysis also consisted of an IBAMA report referring to a Notice of Infraction, totaling 24 documents analyzed. It should be noted that in all the records, the assessment appears specifying that the actions were carried out without prior authorization from the responsible body. In the case of storage of wood in a warehouse, without the proper permit for the entire storage period granted by the competent authority.

The analyzed records are presented below, being specified by codes, authored by the author, to maintain the security and secrecy of their proceedings, as well as the integrity of the defendants, as ensured by Federal Law n° 10.650/2003, in its Art. 2, § 2: "Commercial, industrial, financial or any other secrecy protected by law, as well as that relating to internal communications of government bodies and entities, is ensured". In them are also highlighted: the Federal Law and the Decree, with respective articles, items and paragraphs that gave the legal support so that the infringement actions could be carried out, ensuring the legality of the assessment, the suggestions of applicable sanctions in each one, as well as as the defendant's defense security, as guaranteed by Federal Decree No. 6514/2008, in its Art. 96: "If the occurrence of an environmental administrative infraction is found, a notice of infraction will be drawn up, of which the notified party must be informed, ensuring the adversary system and the full defense". Cars for the years 2017, 2018 and 2020. (Table 1).

<b>notice of infringement (2017)</b>	<b>Infringement</b>	<b>sanctions</b>	<b>violated the law</b>
XXXXXX-1:	Providing false information to IBAMA's Official Control System – DOF System – Document of Forest Origin.	simple fine.	- Federal Law No. 9605/98 - Art. 70.1 and Art. 72, II. - Federal Decree No. 6514/08 - Art. 3, II and Art. 82.
XXXXXX-2	Providing false information to IBAMA's Official Control System – DOF System – Document of Forest Origin.	simple fine.	- Federal Law No. 9605/98 - Art. 70.1 and Art. 72, II. - Federal Decree No. 6514/08 - Art. 3, II and Art. 82.
XXXXXX-3	Providing false information to IBAMA's Official Control System – DOF System – Document of Forest Origin.	simple fine.	- Federal Law No. 9605/98 - Art. 70.1 and Art. 72, II. - Federal Decree No. 6514/08 - Art. 3, II and Art. 82.
XXXXXX-4	Providing false information to IBAMA's Official Control System – DOF System – Document of Forest Origin.	simple fine.	- Federal Law No. 9605/98 - Art. 70.1 and Art. 72, II. - Federal Decree No. 6514/08 - Art. 3, II and Art. 82.
Relatório AI nº XXXXXX-5	Deforestation was identified in the area that occurred in the time period from 2016 to 2017, being, therefore, within the period liable to notice for deforestation, in accordance with Art. 1, caput, of Law No. 9,873 of 1999 and Art. 21 of Decree 6,514 of 2008, which establish a period of five years for the Public Administration to investigate the administrative infraction and consolidate the sanction to be applied.  Framework: fine and embargoed area through the Embargo Term No. 758085-E.	fine, seizure and deposit.	- Federal Law No. 9605/98 - Art. 70.1 and Art. 72, II and VII. - Federal Decree No. 6514/08 - Art. 3, II and VII; and Art. 51.
<b>notice of infringement (2018)</b>	<b>Infringement</b>	<b>sanctions</b>	<b>violated the law</b>
XXXXXX-6	Destruction of 68.48 hectares of native forest in a Legal Reserve area, without prior authorization from the competent environmental agency.	simple fine, embargo of the work or activity.	Federal Law No. 9605/98 - Art. 70.1 and Art. 72, II and VII. - Federal Decree No. 6514/08 - Art. 3, II and VII and Art. 51.
XXXXXX-7	Deforestation, clear cutting of 20 hectares, outside the Legal Reserve, without prior authorization from the competent environmental agency.	simple fine, embargo of the work or activity.	Federal Law No. 9605/98 - Art. 70.1 and Art. 72, II and VII. - Federal Decree No. 6514/08 - Art. 3, II and VII and Art. 52.
XXXXXX-8	Deforestation of 3.00 hectares of native forest, outside the Legal Reserve, without prior authorization from the competent environmental agency.	simple fine, embargo of the work or activity.	Federal Law No. 9605/98 - Art. 70.1 and Art. 72, II and VII. - Federal Decree No. 6514/08 - Art. 3, II and VII and Art. 52.

XXXXXX-9	Deforestation of native forest in a Legal Reserve area, without prior authorization from the competent environmental agency.	simple fine, embargo of the work or activity.	- Federal Law No. 9605/98 - Art. 70.1 and Art. 72, II and VII. - Federal Decree No. 6514/08 - Art. 3, II and VII and Art. 51.
XXXXXX-10	Destruction of 12.7 hectares of native vegetation in a Legal Reserve area, without prior authorization from the competent environmental agency.	simple fine, embargo of the work or activity.	- Federal Law No. 9605/98 - Art. 70.1 and Art. 72, II and VII. - Federal Decree No. 6514/08 - Art. 3, II and VII and Art. 51..
XXXXXX-11	Destruction of 10 hectares of secondary forest, outside the Legal Reserve area, without prior authorization from the competent environmental agency.	simple fine.	- Federal Law No. 9605/98 - Art. 70.1 and Art. 72, II. - Federal Decree No. 6514/08 - Art. 3, II and Art. 52.
XXXXXX-12	Destruction of 429.79 hectares of native vegetation, in a Legal Reserve area, without prior authorization from the competent environmental agency.	simple fine, embargo of the work or activity.	- Federal Law No. 9605/98 - Art. 70.1 and Art. 72, II and VII. - Federal Decree No. 6514/08 - Art. 3, II and VII; and Art. 51.
XXXXXX-13	Violation: To suppress 16 hectares of native vegetation in a Legal Reserve area, without prior authorization from the competent environmental agency.	simple fine, embargo of the work or activity.	- Federal Law No. 9605/98 - Art. 70.1 and Art. 72, II and VII. - Federal Decree No. 6514/08 - Art. 3, II and VII; and Art. 51.
XXXXXX-14	Destruction, using a tractor, of 40 hectares of native forest, in a Legal Reserve area, without prior authorization from the competent environmental agency.	simple fine, embargo of the work or activity.	- Federal Law No. 9605/98 - Art. 70.1 and Art. 72, II and VII. - Federal Decree No. 6514/08 - Art. 3, II and VII; and Art. 51.
<b>notice of infringement (2020)</b>	<b>Infringement</b>	<b>sanctions</b>	<b>violated the law</b>
XXXXXX-15	Make logging activities work without a license from the competent environmental agency. Operating License No. 145871 was canceled through Cancellation Agreement No. 109/2020.	simple fine.	- <b>Federal Law No. 9605/98 - Art. 70.1 and Art. 72.</b> - <b>Federal Decree No. 6514/08 - Art. 3, II and VII; and Art. 66.</b> <b>Conciliation Hearing: scheduled.</b>
XXXXXX-16	Transport 23.59 cubic meters of logs, without Document of Forest Origin – DOF.	environmental fine and confiscation of wood.	- Federal Law No. 9605/98 - Art. 70.1 and Art. 72. - Federal Decree No. 6514/08 - Art. 3, II and IV; and Art. 47.1. Conciliation Hearing: scheduled.
XXXXXX-17	Have in storage 23.88 cubic meters of sawn wood, of an endangered species, without a license valid for all time, granted by the competent environmental authority.	environmental fine and confiscation of wood.	- Federal Law No. 9605/98 - Art. 70.1 and Art. 72. - Federal Decree No. 6514/08 - Art. 3, II and IV; Art. 47.1 and 2; and Art.60, I and II. Conciliation Hearing: scheduled.

XXXXXX-18	Destroy 532,965 hectares of native forest, in a Legal Reserve area, without prior authorization from the competent environmental agency.	simple fine, embargo of the work or activity.	- Federal Law No. 9605/98 - Art. 70.1 and Art. 72. - Federal Decree No. 6514/08 - Art. 3, II and VII; and Art. 51. Conciliation Hearing: scheduled.
XXXXXX-19	Have in deposit 91,247 cubic meters of sawn wood, including endangered species, without a license - Document of Forest Origin - DOF, valid for the entire time of storage, granted by the competent environmental authority.	environmental fine and confiscation of wood.	- Federal Law No. 9605/98 - Art. 70.1 and Art. 72. - Federal Decree No. 6514/08 - Art. 3, II and IV; Art. 47.1 and 2; and Art. 60, II. Conciliation Hearing: scheduled.
XXXXXX-20	Deforestation of 315,662 hectares of native forest, in a Legal Reserve area, without prior authorization from the competent environmental agency.	simple fine, embargo of the work or activity.	- Federal Law No. 9605/98 - Art. 70.1 and Art. 72. - Federal Decree No. 6514/08 - Art. 3, II and VII; and Art. 51. Conciliation Hearing: scheduled.
XXXXXX-21	Destruction of 26,137 hectares of native forest, in a Legal Reserve area, without prior authorization from the competent environmental agency.	simple fine, embargo of the work or activity.	- Federal Law No. 9605/98 - Art. 70.1 and Art. 72. - Federal Decree No. 6514/08 - Art. 3, II and VII; and Art. 51. Conciliation Hearing: scheduled.
XXXXXX-22	Prevent natural regeneration of 140 hectares of Amazon forest, embargoed through the embargo term nº 288252-C, by the competent environmental authority.	environmental fine, embargo of the work or activity.	- Federal Law No. 9605/98 - Art. 70.1 and Art. 72. - Federal Decree No. 6514/08 - Art. 3, II; and Art. 48. Conciliation Hearing: scheduled.
XXXXXX-23	Prevent natural regeneration of 827.68 hectares of Amazon forest, embargoed through embargo terms No. 716108-e; 775136-e; 555101-c and 653522-e, through the use of fire and destruction of endangered species ( <i>Bertholletia excelsa</i> ) included in the official list.	simple fine.	- Federal Law No. 9605/98 - Art. 70.1 and Art. 72. - Federal Decree No. 6514/08 - Art. 3, II; and Art. 48. Conciliation Hearing: scheduled.
XXXXXX-24	Destroy 315,096 hectares of Amazon forest, a special object of preservation, consumed by the use of fire, with the destruction of an endangered species ( <i>Bertholletia excelsa</i> ) without authorization from the competent environmental authority.	simple fine.	- Federal Law No. 9605/98 - Art. 70.1 and Art. 72. - Federal Decree No. 6514/08 - Art. 3, II and VII; Art. 50; and 60, I and II. Conciliation Hearing: scheduled.

Source: From research

Environmental crimes have taken on enormous proportions, thus requiring the effectiveness of environmental protection norms, a right contained in the Constitution, but which still faces obstacles [12].

Environmental Law in Brazil has always been disseminated in several and varied laws. According to Freitas and Freitas [13], in the criminal sphere, it was the Criminal Code of 1830 that took the first initiative. Decree

23,793/34, known as the Forest Code, divided criminal offenses into crimes and misdemeanors. However, in 1940, the Law of Introduction to the Penal Code, in its art. 3, provided that the facts defined as crimes in the Forest Code, when not included in the provisions of the Penal Code, would become misdemeanors. Law 4,771/65 introduced several criminal offenses in its art. 26, all considered contraventions, as well as the Fauna Protection Law, n. 5.197/67, and the Fishing Code, Decree-law 221. These diplomas resulted in criminal proceedings [13]. In 1988, Law 7,653/88 was enacted, elevating the violations of the Fauna Protection Law to crimes and creating criminal figures for facts related to fishing. Subsequently, crimes against fauna were considered non-bailable. However, Law nº 9.605/98 of Environmental Crimes did not define the concept of Environmental Crime, being necessary to study separately the concepts of crime and environment.

According to Jesus [14] for there to be a crime, it is first necessary to have a positive or negative behavior (action or emission). This author defines crime as a human factor typically provided for by a legal norm sanctioned by a penalty in the strict sense (criminal penalty), harmful or dangerous to goods or interests considered worthy of the most energetic protection. Machado [15] argues that crimes and penalties should be established in laws. The Federal Constitution says: "there is no crime without a previous law that defines it, nor punishment without previous loyal punishment." (article 5, XXXIX). Takada; Ruschel [12] defend that environmental crime is the aggression to the environment and its components (physical, chemical, biological factors, natural and cultural resources) that exceed the legal limits, and such qualification must fit the terms of the environmental legislation. Law 9,605/1998, although called the Environmental Crimes Law, was also concerned with administrative infractions and with aspects of international cooperation for the preservation of the environment [16]. For Machado [15] Law 9.605/98 has as remarkable innovations the non-use of incarceration as a general rule for criminal individuals, the criminal liability of legal entities and the valorization of the intervention of the Public Administration, through authorizations, licenses and permissions.

With regard to criminal sanctions, Law 9,605/98 sought to adapt to the guidelines that have been drawn up by criminal and environmental policy in Brazil. It is about finding alternative ways of imposing sanctions on the convict, while avoiding, as far as possible, his incarceration and contact with other prisoners. In the specific scope of Environmental Law, there is the principle of prevention, one of the main pillars of Environmental

Law. The legislator took this circumstance into account, seeking, in addition to the character of retribution and punishment of penalties, to emphasize their preventive character [13]. According to Sirvinskas [17] nowadays, the criminal protection of the environment remains an indispensable necessity, especially when measures in the administrative and civil spheres do not have the desired effects. The criminal measure aims to prevent and repress conduct committed against nature. The repression of environmental criminal offenses are: deprivation of liberty; restrictive rights; and fine. Freitas and Freitas [13] argue that the custodial sentences provided for environmental crimes in Law 9,605/98 are imprisonment and detention. In criminal types, the penalty of imprisonment is reserved for the most serious conduct and the closed regime is prohibited in convictions to the penalty of detention (Criminal Code, article 33, caput). They add that according to article 7 of the Environmental Crimes Law, it is concluded that the substitution of the custodial sentence for the restrictive one, if the conditions established by the device are present, is mandatory.

For these authors, article 76 of Law 9099/95 defines criminal transaction as the immediate application of a penalty restricting rights or fines: "In the event of representation or in the case of a crime of unconditional public criminal action, in the case of filing, the Public Prosecutor's Office may propose the immediate application of a penalty restricting rights or a fine, to be specified in the proposal". Regarding rights-restrictive penalties, the authors argue that according to article 7, I and II of Law 9,605/1998, rights-restrictive penalties are autonomous and replace custodial sentences in cases where it is a negligent crime or the penalty of deprivation of liberty of less than four years is applied; the culpability, background, social behavior and personality of the convict, as well as the motives and circumstances of the crime indicate that the substitution is sufficient for the purposes of reprobation and prevention of the crime. That the penalties restricting rights, which will have the same duration as the custodial sentence, include: provision of services to the community; interdiction of rights; partial or total suspension of activities; cash benefit and home collection (article 8). The penalty of fine, according to article 18 of Law 9.605/1998, will be calculated according to the criteria of the Penal Code. This type of sanction may be applied cumulatively, separately or alternatively. For legal entities, the applicable penalties, individually, cumulatively or alternatively, in accordance with the provisions of article 3, are: fine, restrictive rights and provision of services to the community. Souza [18] makes the following analysis of the Environmental Crimes Law: the Environmental Crimes Law aims to restore environmental damage through

punishment and application of fines as well as the application of administrative sanctions resulting from illegal acts committed against the environment. For Gomes and Maciel [19] the law 9.605/98 brings general provisions on environmental infractions and a special part that defines crimes in kind. The general parts contain their own and specific rules on the criminal liability of the legal entity; application of the penalty; probation; seizure of instruments of crime; criminal transaction; conditional suspension of the process etc. For these authors, the Environmental Crimes Law is complemented by the general rules of the Penal Code, the Criminal Procedure Code. It is very important to emphasize that this law has the express objective of repairing environmental damage. The clear purpose of the Environmental Law is the reparation of environmental damages or at least their compensation [19]. Thus, Law n° 9.605/98 aims to punish legal entities and individuals who practice illegal acts against the environment, because with the unregulated increase in environmental crimes in Brazil, the environment has been harmed, these crimes have as penalties fines, restrictive penalties, deprivation of liberty and also the reconstruction of the affected environment. Thus, the Environmental Crimes Law came to apply punishments and penalize offenders who commit environmental crimes in Brazil [18].

For Gomes and Maciel [19] the Environmental Penal Law had the merit of systematizing and unifying criminal offenses against the environment in a single legal diploma, although there are still environmental offenses typified in other normative texts. With this, it can be seen that Law n° 9.605/98 brought legal certainty to the understanding of the concept and protection of the environment, as well as brought its own rules for some criminal and procedural institutes with regard to environmental crimes aiming at guarantee and reparation of the degraded environment. However, according to the research released by the United Nations Environment Program (UNEP), in partnership with Interpol, environmental crimes have been growing in an excessive way due to the lack of applicability of the Crimes Law, Law n° 9.605/98, due to the lack of structure of environmental inspection bodies, that is, the ineffectiveness of the law is one of the factors that cause the increase of environmental crimes in the world [18]. According to this author, referring to the report "Environmental Crime is the Fourth Most Profitable Illegal Activity in the World" released by the United Nations Environment Program (UNEP), environmental crime, which includes the illegal trade in wild animals, the illegal exploitation of logging, illegal exploitation of gold and other minerals, illegal fishing, trafficking in hazardous waste and carbon credit fraud, is the fourth most profitable

illegal activity in the world, after drug trafficking, counterfeiting and human trafficking. Environmental crime has been growing at 5 to 7% a year in the world over the last decade, two to three times faster than the world's GDP. "The result is not only devastating for the environment and local economies, but for all those who are threatened by these criminal enterprises [18].

The state of Rondônia and the Amazon have been reported on the world stage as a region responsible for immense social and environmental conflicts, including fires, forest devastation, illegal mining, environmental contamination/population, public land grabbing and conflicts. of land regularization among other chronic and emerging problems. Law No. 6,938/81 recognizes the entire environment as public heritage, delegating to IBAMA the responsibility for planning and monitoring its resources, extending its responsibility to the preservation of ecosystems. In addition, the aforementioned power of environmental police, ensuring that the norms and standards of the national environmental policy are complied with. IBAMA (Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis) is a federal institution whose main objective is to create environmental preservation policies and monitor whether the laws to protect flora and fauna in Brazil are being complied with. In other words, this is the autarchy that monitors deforestation, controlling the population of animals or verifying that companies are applying environmental preservation laws [7]. Focusing on the environmental issue in the analysis in question, it is prudent to remember that Brazilian law makes use of a list of legal regulations to safeguard the environment. Thus, our legal system has in the Federal Constitution - CF (1988) the mark of change in mentality, introducing a systematized treatment to the theme "environment", aiming at the protection of all the elements that compose it and that are essential to the existence of life in all its forms [20]. In the context of environmental protection, the Federal Constitution (1988) establishes the importance of sustainable development and an ecologically balanced environment, as a right of every Brazilian citizen, described in 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 present and future generations" [4]. By assuming the awareness of the environment as a fundamental right for the quality of human life and by regulating conduct and activities harmful to the environment through the environmental crimes law, the country assumes its guardianship. In this sense, Silva teaches [21]: Constitutional norms assumed the awareness that the right to life, as the matrix of all other fundamental human rights, is what must guide all

forms of action in the field of environmental protection. He understood that it is a preponderant value that must be above any considerations such as development, such as respect for property rights, such as those of private initiative. They are also guaranteed in the constitutional text, but, in all evidence, they cannot prevail over the fundamental right to life that is at stake when the protection of the quality of the environment is discussed, which is instrumental in the sense that, through this protection, the what is protected is a greater value: the quality of human life [21].

From the Environmental Crimes Law, a notorious concern with the protection of the environment can be observed, in a more uniform and orderly way, showing greater zeal for environmental issues. According to the records presented, it is necessary to point out referring to the 1st Axis, and in compliance with the main questioning of the present research regarding the classification and establishment of a correlation of environmental crimes from the integrated inspection operation known as "Ponta do Abunã" in Rondônia, in the border region between the states of Acre, Amazonas and Rondônia, in two different periods, the following aspects: 1. Analyzed in the light of their peculiarities, the actions of infractions under study, present characteristics that are similar in the different cases studied; 2. All the records clearly demonstrate that environmental damage was caused, in some cases to considerable extent; 3. The suggestions concerning the sanctions to be applied, in no case are they subject to value aberrations, since they are in line with the provisions of Art. 72, Items II and VII of Federal Law No. 9605/98, regarding administrative infractions; 4. With regard to typification, it should be noted that the character of the actions of infractions committed presents similar characteristics, evidencing in all aspects the particularities of the infractions, in each case, specified; 5. In view of the establishment of a correlation between environmental crimes, the similarity between the acts of infraction committed becomes evident, there being no doubt that there is a causal link between the activity concerned and the environmental damage found, in the assessment of the authors.

Given the context presented and, in response to the first problem presented in this research, it should be noted that it is possible to typify and establish a correlation of environmental crimes from the integrated inspection operation "Ponta do Abunã", in the different periods studied, since the analyzed records point to infractions of Law 9605/98, typifying crimes committed against fauna, against flora, pollution and other environmental crimes,

crime against cultural heritage, crime against environmental administration and administrative infractions, all subject to sanctions, duly supported by the legal apparatus established within the records, more specifically Federal Law No. 9605/98 and Federal Decree No. 6514/08, which govern environmental crimes in the country. By typifying crimes against flora, Law 9.605/98, in its Art. 38 deals with conduct of damage and destruction of the permanent preservation forest, even if it is being formed or its use is contrary to the observance of protection norms. Analyzed by the doctrinal scope and the country's jurisprudence, the concept of forest refers to the dense vegetation, composed of large trees. Fernando Pereira Sodero teaches [22] that "all vegetation, generally considered, is flora. Forest, that is, it is the dense vegetation, made up of large trees, covering a large area of land". Philippi Jr., Freitas and Spínola [23] teach that the caput of article 70 of the aforementioned law defines environmental administrative infraction as "any action or omission that violates the legal rules of use, enjoyment, promotion, protection and recovery of the environment". There being, for each infraction identified by the competent body, the appropriate sanction, in accordance with the legal norm. However, we point out the teachings of Soares and Baptista [24] that the sanction for the environmental administrative infraction is configured with the simple drawing up of the infraction notice, but it can only be considered applied after the establishment and instruction of an administrative process, in attention to the principle of due process of law.

In the 2nd Axis, the emphasis is given to the characterization of the infraction notices and instruction and term of embargo, which leads us to the existence in the legal basis of uncontested environmental crimes proceedings based on Brazilian legislation and legal norms, and it is up to us to compliance with the fact that the consolidation of environmental protection is based on the Federal Constitution of 1988, being the first to deliberately address the environmental issue, assuming the treatment of the matter in broad and modern terms [21]. From the sanction of Federal Law 9.605, of February 12, 1998, the application of criminal and administrative sanctions are established for conduct and activities harmful to the environment, as determined in Art. 6 and its respective items: Art. 6 For the imposition and gradation of the penalty, the competent authority will observe: I - The seriousness of the fact, in view of the reasons for the infraction and its consequences for public health and the environment; II - The offender's background regarding compliance with legislation of environmental interest; III - the economic situation of the violator, in the case of a fine.

The wording given by Law 9.605/98 in the items of Art. 6 clearly shows the legislator's concern with the aspects inherent to the collectivity, when referring to public health and the environment, and with the economic aspects, when dealing with the attenuation of the sentence, if low income is verified. It is noteworthy that factors such as the seriousness of the fact, history of infraction and consequences of the actions must be taken into account when applying the sanction for environmental infraction. With regard to the existence of uncontested legal basis in environmental crimes proceedings based on Brazilian legislation and legal norms, it is important to highlight the proper character in them, since there are specific cases that must be analyzed. An example to be given is the following Resource: "ENVIRONMENTAL. SPECIAL RESOURCE. FINE ADMINISTRATIVELY APPLIED FOR ENVIRONMENTAL INFRINGEMENT. TAX EXECUTION FILED AGAINST THE PURCHASER OF THE PROPERTY. PASSIVE ILLEGALITY. FINE AS ADMINISTRATIVE PENALTY, DIFFERENT FROM THE CIVIL OBLIGATION TO REPAIR THE DAMAGE. These are, in origin, embargoes on tax enforcement filed by the appellant now for appearing in the passive pole of an executive deed carried out by IBAMA to collect a fine imposed for an environmental violation. The appellant explains - and he does this from the beginning of the bill of review and the reasons for appeal that resulted in the contested decision - that the credit executed concerns the violation of arts. 37 of Decree no. 3.179/99, 50 c/c 25 of Law no. 9,605/98 and 14 of Law n.6,938/81, but that the infraction notice was drawn up against his father, who, at the time, was the owner of the property. The ordinary instance, however, understood that the proper rem and solidary nature of the environmental obligations would be sufficient to justify that, even though the infraction had been committed and launched in the face of his father, the appellant now bore its payment in tax execution. In the reasons for the special, the appellant claims that there was a violation of arts. 3 and 568, inc. I, of the Civil Procedure Code (CPC) and 3, inc. IV, and 14 of Law No. 6,938/81, on the grounds that it lacks passive legitimacy in the tax execution carried out by IBAMA in order to see the fine imposed due to environmental violations paid. This Superior Court has a peaceful understanding in the sense that the civil liability for the repair of environmental damage adheres to the property, as a proper rem obligation, and it is also possible to charge the current owner for conduct derived from damages caused by the former owners. That was the case law invoked by the origin to maintain the appealed decision. The

controversial point in these records, however, is another. Here, the possibility that a third party is liable for a sanction imposed for an environmental violation is discussed. The issue, therefore, is not limited to civil liability, but administrative liability for environmental damage. By the principle of transcendence of penalties (art. 5, inc. XLV, CF88), applicable not only to the criminal scope, but also to the entire Sanction Law, it is not possible to file a tax enforcement against the appellant to collect a fine imposed in the face of conduct attributable to his father. This is because the application of administrative penalties does not obey the logic of strict liability of the civil sphere (to repair the damages caused), but must obey the systematics of the theory of culpability, that is, the conduct must be committed by the alleged transgressor, with demonstration of its subjective element, and with demonstration of the causal link between the conduct and the damage. The difference between the two spheres of punishment and its consequences is clearly shown in the reading of art. 14, § 1, of Law n° 6.938/81, according to which "[w]ithout preventing the application of the penalties provided for in this article [among them, it should be noted, the fine], the polluter is obliged, regardless of the existence of , to indemnify or repair the damage caused to the environment and to third parties affected by its activity". the art. 14, caput, is also clear: "[w]ithout the penalties defined by federal, state and municipal legislation, failure to comply with the measures necessary to preserve or correct the inconveniences and damages caused by the degradation of environmental quality will subject the transgressors: [ ...]". (SPECIAL APPEAL N.1251.697-PR. MINISTER RAPPORTEUR MAURO CAMPBELL MARQUES).

The aforementioned example translates the definition by the law itself of responsibility for environmental degradation, that is, the person who acquires the property, cannot reverse the damage, even if indirectly caused by it. Thus, the obligation continues and its transmission is automatic, and the purchaser does not have the right to refuse to assume it. In the infraction notices analyzed, we could observe that there were no disputes or disharmony in the reported information. The sanctions being suggested, as specified in the aforementioned records, in accordance with the Articles, Items and Paragraphs established both by Federal Law 9605/98 and by Federal Decree No. 6514/08, legislation in force at the time of the assessments. In spite of the characterization of the infraction notices and procedural instruction, the applicability is foreseen in the environmental legislation. It is prudent to point out that, when the infraction exists, the offender must pay for it within the limits imposed by the Environmental Crimes



Law. In the case of the infraction notices analyzed, Federal Decree No. 6514/08 should be highlighted, which provides for infractions and administrative sanctions to the environment and establishes the federal administrative process for the investigation of these infractions, determining in its Art. 3, Items II and VII: Art. 3. Administrative infractions are punished with the following sanctions: I - Warning; II - Simple fine; [...]; VII - embargo of work or activity and their respective areas; [...][25].

In all the analyzed cases, the simple fine was suggested. It can be applied separately or cumulatively with the other sanctions, based on the hectare and cubic meter, objects of the case under discussion. The seizure of goods or products, as suggested for wood, takes place when the environmental infraction notice is drawn up, and must be evaluated, sold, destroyed or donated, according to local reality and needs. The embargo of the work or activity was suggested in most of the records because it is a preventive measure, with a view to preventing or continuing the environmental damage, as a way of promoting regeneration to the environment and making the recovery of degraded areas viable [26]. The infractions instructed in the infractions are clearly characterized, facilitating the legislator's understanding of the action committed, the space of its accomplishment, time and the legal parameters that support it. Thus, each suggestion of sanction to be applied is legally based on the provisions that support it, and for the majority, the simple fine and the embargo of the work or activity are suggested, provided for by Article 3, items II and VII of the Federal Decree in comment.

The 3rd Axis, in turn, has little support in the face of the analyzed records because, as previously specified, they refer to the years 2017, 2018 and 2020, and in a very small number of them, the order referring to the assessment of scheduling a conciliation and defense hearing. It should be noted that both in the AI Report No. XXXXXX-5, as in the other records, the processes were in progress at the time of the analysis. In this context, all infraction notices are under procedural instruction, and in none of them there was approval of the amount of the fine, since it was not processed even in the first administrative instance. Which translates and makes very clear the slowness of the public administration in the face of the issues presented: records that have been without judgment since 2017 until the present moment. A parenthesis is in order here about the quality of services provided by the public administration. The Federal Constitution (1988) ensures in its Art. 37 that: Art. 37. The direct and indirect public administration of any of the Powers of the Union, the States, the Federal District and the Municipalities shall obey the principles of

legality, impersonality, morality, publicity and efficiency [...].[4]

Efficiency is one of the principles that governs the administration and, by its concept, it is understood by its concept the existence of economy, evaluation of results and, consequently, the quality of the services performed. Since slowness is a reality of the judiciary for the control of legality, it must be admitted that it presents itself as a factor that causes inefficiency in its routine, failing to perform its services with perfection, promptness and functional performance [27]. Alexandrino and Paulo [28], in turn, argue that, based on the efficiency of the services provided by justice, society has an express legal basis to demand the effectiveness of the exercise of social rights and has the right to question the quality of public works and activities. However, it should be noted that Ponta do Abunã operations are coordinated by the DITC of the SPES – AC, AM and RO, using geospatial techniques that allow for the execution of remote and in loco environmental inspection activities, through satellite images, spatial databases and other geo-information that make it possible to identify the practice of environmental crimes against flora and environmental management, especially with regard to forest exploitation, illegal deforestation, illegal transport of wood, breaches of embargoes, impediment to the regeneration of the native vegetation, operation of activity without an environmental license and presentation of false information, as specified in the different infraction notices analyzed.

It is noteworthy that the administrative procedures are supported by cross-referencing information from the Documento de Origin Florestal - DOF system, among others, and comparing images with available data on rural properties, with data declared by the owners, allowing geospatial, multi-temporal analysis of images of satellites, as well as the individualization, delimitation and framing of the different infractions perpetrated. There is also, according to the need of each case, an on-site visit to the environmental illicit indicator of the and related companies. Finally, it should be noted that the methodology applied by IBAMA in the inspection procedure brings with it a range of criteria that allow compliance with the environmental regularity of a property as a whole, making it quite effective in terms of the materiality of infractions committed against the environment. and the sanctions applied to them.

#### IV. FINAL CONSIDERATIONS

From the analyzed infraction notices, the occurrence of the conducts typified in Decree n° 6514/2008 in its articles 50; 51; 52; 82; 66; 47; 48, are related to deforestation and the

illegal transport and commercialization of the product obtained by the criminal practice. This makes it possible to verify that the conducts harmful to the environment continued during the analyzed period and that there is an interdependent mechanism for the illicit conduct, whose one activity sustains and drives the other so that financial advantage can be taken with the resources of the forest. The Brazilian legislation is capable of specifying the illegal actions found in Ponta do Abunã with specificities, as well as offering mechanisms of deterrent power to the competent environmental agencies. The infraction notices are supported by Brazilian legislation and the concrete actions are perfectly suited to the legal precept issued by the legislator.

Despite this, it appears that none of the infraction notices analyzed was judged, even in the first instance, and they remain in the procedural instruction phase. This demonstrates the procedural delay and the bottleneck in the environmental sanctioning process. In this vein, the first axis analyzed (typology of environmental crime); the second axis (characterization of infraction notices); as well as the third axis (current stage or judgment of the Notices of Infraction), were duly analyzed and, from them, each reader can draw their own conclusions, as well as the public managers responsible for the sanctioning process to seek solutions for the weakest points observed. in this academic study.

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# An overview of a long-life battery technology: Nickel–iron

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Received: 14 Jul 2022,

Received in revised form: 07 Aug 2022,

Accepted: 11 Aug 2022,

Available online: 15 Aug 2022

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**Keywords—** *Electrochemical storage, lead–acid, long lifespan, nickel–iron, photovoltaic cells*

**Abstract—** *This survey was designed following the progress of the use of solar energy. Madagascar is one of the countries that benefit enormously from this energy. As a result, many Malagasy people use photovoltaic cells for domestic and professional applications especially those who are outside the electrified areas. However, the used batteries last only 5 years or even 10 years at most, hence the idea of updating Thomas Edison's research in 1901, a nickel–iron battery technology which is distinguished by its long lifespan of more than 25 years. It is therefore a question of determining the chemical reactions involved into the battery, its aging process, its characteristics, its advantages and disadvantages compared to the lead–acid technology. Once the theoretical studies are carried out, the study proposes an application of nickel–iron technology in a photovoltaic installation in Madagascar.*

## I. INTRODUCTION

Photovoltaic (PV) solar energy is considered to be the most flexible of the renewable energy sources due to its use in almost all power classes ranging from *mW* to *GW* and in most places in the world. However, a PV system requires a storage unit for the energy produced during the sunny day(s) to continue to distribute it at night or on days when the cloud cover is too great for the PV cells to operate. Batteries not only ensure the appropriate response time and storage capacity to meet production and grid needs, but must also show long life and be able to withstand a large number of charge–discharge cycles: these are often the most expensive and fragile components of a solar system. [1, 2]

In this article, we will discuss an energy storage technology with a long lifespan and of which existence is little known: it is nickel–iron technology. The nickel–iron (Ni–Fe) battery is a rechargeable electrochemical power source which was created in Sweden by Waldemar Jungner around 1890. By substituting cadmium for iron, he improved cell performance and efficiency, but he abandoned its development in favor of nickel–cadmium.

While Thomas Edison believed that the Ni–Fe battery could replace the lead–acid (Pb–acid) battery, he was granted his patent in 1901. [3, 4]

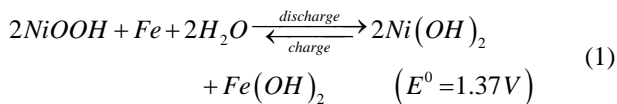
The Thomas Edison battery factory in West Orange, New Jersey, USA, manufactured cells from 1903 to 1972, when it was sold to Exide Battery Company (its name at the time) which production continued until 1975, when the plant closed [3]. The Ni–Fe battery has lost its market share to the Pb–acid battery [5]. Despite this, besides Germany, companies such as Kursk Accumulator in Russia and ChangHong Battery in China still manufactured Ni–Fe cells [3, 6].

Ni–Fe batteries have been applied to almost all fields in which they are used. A list of uses [6–8] to which they are applied include electric trucks, forklifts and industrial tractors, mining locomotives and industrial, electric road vehicles, lighting and air conditioning in trains, railway signaling systems, maritime services, isolated lighting plants, clocks, the system in lighting and emergency alarm circuits, miners' capped lamps, power supplies for instruments and laboratories, communication equipment and portable lighting units. Finally, the Ni–Fe battery is

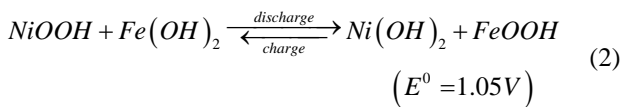
suitable for storing electrical energy derived from solar energy via photovoltaic cells [8].

## II. PRINCIPLE OF OPERATION

With regard to the active materials which constitute it, the Ni-Fe battery is composed of nickel oxyhydroxide as the positive electrode, iron as the negative electrode and a solution of potassium hydroxide, with a little lithium hydroxide added in order to exert a stabilizing effect on the capacity of the positive electrode during the charge-discharge cycle, as an electrolyte [9, 10]. These materials were originally enclosed in rectangular pockets of perforated thin sheet steel which were attached to steel frames to form the positive and negative electrodes [7]. The overall reactions that occur at the electrodes ensue from a transfer of oxygen from one electrode to another. In general, the Ni-Fe battery is represented by:  $(^{-})Fe(s)|KOH(aq)|NiOOH(s)^{(+)}$ . [6]



At this stage, the reactions of the cells are highly reversible. Reaction (1) proceeds under deep discharge. A Ni-Fe cell will undergo yet another discharge reaction (2), but with a lower voltage compared to the first stage: [4, 11]



Unlike lead-acid technology, the electrolyte does not participate in chemical reactions. It is therefore not possible to determine its state of charge for any measurement of the density of the electrolyte. [5]

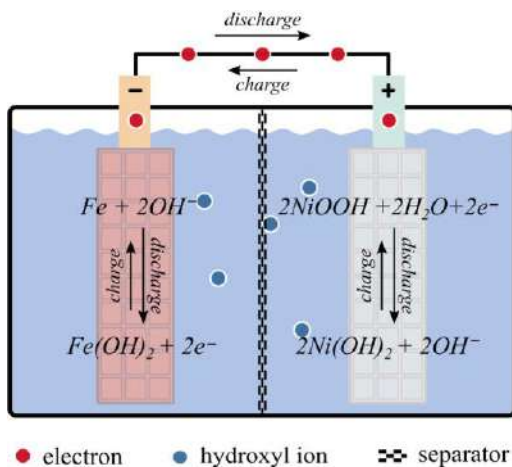


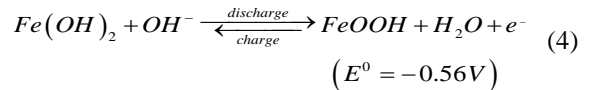
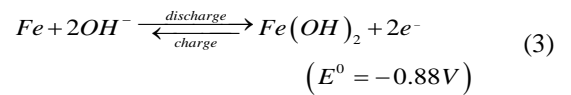
Fig. 1: Schematic representation of the operating principle of a Ni-Fe cell.

## III. AGING PROCESS

### 3.1 Negative electrode

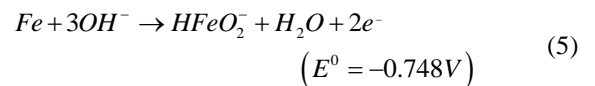
Iron is an element known since prehistoric times. Unlike other battery electrode materials such as cadmium, lead, nickel and zinc, iron electrodes are quite environmentally friendly. Furthermore, iron electrodes are both mechanically and electrically robust [11]. Iron has a high theoretical capacity of around  $0.97 Ah.g^{-1}$ . Depending on the design and manufacture of the electrodes, there are three different types of iron electrodes [8] namely pocket or tubular electrodes, pressed or compacted electrodes and sintered electrodes.

The charge-discharge reactions at the negative electrode of a Ni-Fe battery occur in two stages corresponding to two distinct voltage levels: [8, 11-13]

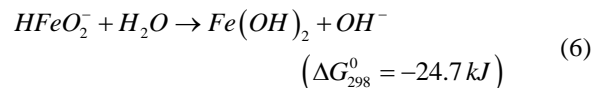


Under strong alkaline conditions, the main process expressed by equation (3) manifests the reduction of ferrous ions ( $Fe^{2+}$ ) to metallic iron ( $FeO$ ) during charging and vice versa during discharging. In case the Ni-Fe battery is designed with excess iron, reaction (4) rarely occurs in the battery. [8, 14]

Equation (3), in its general form, reflects the initial and final states of the active material [12]. The overall mechanism of the electrode reaction (3) involves both solid (homogeneous mechanism) and liquid (heterogeneous mechanism) phases with  $HFeO_2^-$  ions as dissolved intermediates which convert to iron hydroxide ( $Fe(OH)_2$ ) during a new discharge [11, 13]: the iron is therefore oxidized into  $HFeO_2^-$  ions, then into porous  $Fe(OH)_2$  [12]. Accordingly, the actual course [11-13] of the reaction (3) electrodes can be expressed as follows:

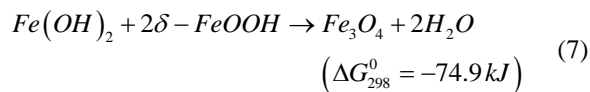


followed by:



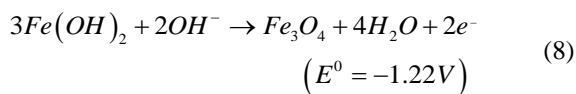
During prolonged discharge, the composition of the active  $\delta$ - $FeOOH$  in iron hydroxide is similar to the positive electrode in nickel. The electrode reaction involves the diffusion of protons between the solid lattices of  $Fe(OH)_2$  and  $\delta$ - $FeOOH$ . [11]

It has been speculated that the formation of magnetite  $Fe_3O_4$  in different oxidation states between iron hydroxides results in the reaction:

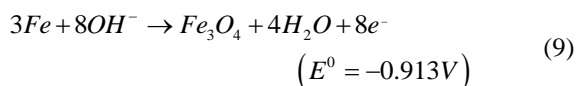


rather than by an electrochemical process [11].

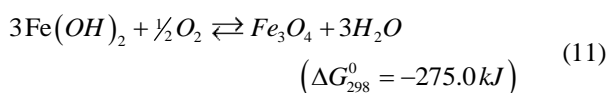
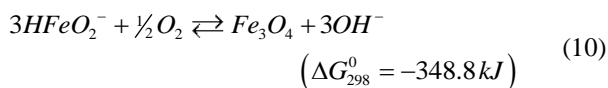
X-ray phase analysis of the electrodes removed from the solutions after discharge demonstrated a decrease in the amount of iron(II) hydroxide formed in the electrodes during the first anodic process and an increase in magnetite. Therefore, the conversion of  $Fe(OH)_2$  to  $Fe_3O_4$  is described by the reaction equation: [11]



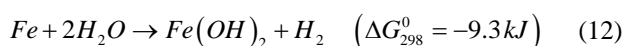
On the other hand, in the case of anodic polarization of an iron electrode in the range of the first potential plateau at 328 K, a considerable amount of magnetite is formed together with the main discharge product  $Fe(OH)_2$ . A direct electrochemical conversion of  $Fe$  to  $Fe_3O_4$  has been estimated: [11]



Magnetite can also be formed by the following reactions involving dissolved oxygen in the electrolyte: [12]



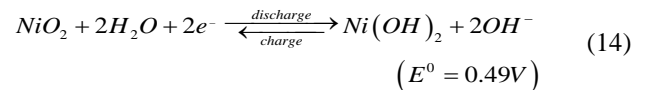
Since reaction (8) takes place in the electrolyte, it results in the formation of a black deposit of magnetite on the surface of separators and battery reservoirs. Equation (12) shows the reaction of iron with water and hydrogen evolution that occurs during charging: [11, 15]



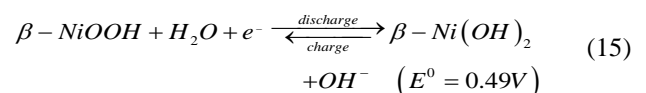
On one side, the hydrogen evolution reaction takes place since the electrode potential for this reaction is positive with respect to that of reaction (3) and on the other side, water is electrochemically decomposed into hydrogen and hydroxyl ions during charging [14, 15].

### 3.2 Positive electrode

Used for more than a century, nickel hydroxides ( $Ni(OH)_2$ ) compose the active material of the positive electrodes of several alkaline cells. Understanding the reactions at these electrodes has been very slow due to the complex nature of the reactions. [16] Its maximum theoretical capacity is around  $0.289 Ah.g^{-1}$  [17]. In battery terms, the nickel electrode is often referred to the nickel oxide ( $NiO_2$ ) and charge-discharge reactions are expressed as: [11, 13]

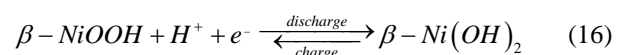


The nickel oxide forms the active material of the positive plate with nickel hydroxide as the discharged product which is recovered as nickel oxide during recharging. In practice, the discharge product, converted to beta-nickel oxyhydroxide ( $\beta-NiOOH$ ) during recharging, is  $\beta-Ni(OH)_2$ . Equation (14) becomes: [11, 13, 17, 18]



During charging,  $\beta-Ni(OH)_2$  is therefore converted to  $\beta-NiOOH$  by a deprotonation mechanism and the reaction is reversed during discharging reducing nickel oxyhydroxide 3+ to nickel hydroxide 2+ by protonation [17]. The mechanism of reaction (15) involves an equivalent diffusion of protons through the solid state lattices of  $\beta-Ni(OH)_2$  and  $\beta-NiOOH$  so that there is a continuous change in the composition of the material active between fully charged  $\beta-NiOOH$  and fully discharged  $\beta-Ni(OH)_2$ .

Thus, equation (15) can also be written: [11, 13]



Three crystal modifications of nickel hydroxide appear as a lattice structure with alternating layers of nickel ions and hydroxide ions. The starting material for the transformation of the alkaline electrode is the  $\alpha$  form. [11] Fig. 2 gives an overview on the structural changes of nickel hydroxides during charging, discharging, overcharging and aging (dehydration) [11, 13, 16]

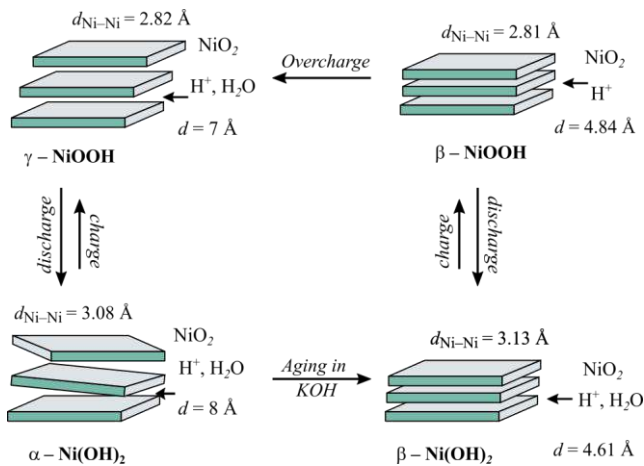


Fig. 2: Bode reaction diagram showing the various transformations of a nickel electrode. [11]

The oxidation (charge) voltage of the  $\alpha$  and  $\beta$  materials, 60 mV and 100 mV respectively, is more positive than the discharge voltage. The  $\beta$ -Ni(OH)<sub>2</sub> is the usual electrode material. Oxidized, it is converted on charge to  $\beta$ -NiOOH with about the same molar volume. In case of overcharge, the  $\gamma$  structure can form. This form also incorporates water and potassium (and lithium) into the structure. Its molar volume is about 1.5 times the  $\beta$  form. This shape is believed to be largely responsible for the volume expansion (swelling) which occurs during battery charging. The  $\alpha$  form then results on discharge of the  $\gamma$  form. Its molar volume is about 1.8 times that of the  $\beta$  form and the electrode can swell further on discharge. On discharge, the  $\alpha$  form converts to the  $\beta$  form in a concentrated electrolyte. Additions of cobalt (2 to 5%) improve the charge acceptance (reversibility) of the nickel electrode. [5, 13, 16]

#### IV. PERFORMANCE CHARACTERISTICS

The theoretical energy density of a Ni-Fe battery, lying between Ni-Cd (244 Wh.kg<sup>-1</sup>) and Ni-MH (278 Wh.kg<sup>-1</sup>), is 268 Wh.kg<sup>-1</sup>. The practical energy density depends on the technology used to manufacture the electrodes. It is between 20 Wh.kg<sup>-1</sup> and 30 Wh.kg<sup>-1</sup> for tubular electrodes and can reach 40–60 Wh.kg<sup>-1</sup> or even up to 80 Wh.kg<sup>-1</sup> [19] for sintered or fiber electrodes. The open circuit voltage, discharge voltage and charge voltage of Ni-Fe cells are 1.37 V; 1.3 V at 1.0 V and 1.7 V at 1.8 V, respectively. Its nominal voltage is 1.2 V. [5, 8, 20]

Constant voltage charging of conventional Ni-Fe cells which can lead to thermal runaway and cause serious damage is not recommended. As the cell approaches full charge, gassing reactions generate heat and the cell temperature increases: a limited galvanostatic charge of

1.7 V per cell has been shown to be beneficial in controlling cell temperature. Its discharge capacity depends on the discharge rate. Indeed, when a nickel-iron system is discharged at a rate of C/1, the realized capacity is only 50% of the nominal value and the voltage varies between 1 V and 0.8 V. Batteries with tubular positive electrodes are designed for low or moderate discharge rates i.e. C/8 to C/1 while those with sintered electrodes can provide high power due to its low internal resistance. The nominal (operating or discharging) cell voltage variation is approximately 1.23 V at C/8 rate to 0.85 V at C/1 rate. The change in cell voltage on a C/8 rate is 1.32 V to about 1.15 V at 10% and 90% depth of discharge (DoD), respectively. On a rate of C/10, the voltage of the battery in the 50% charged state is 1.35 V and for low discharge currents (C/100), the voltage varies from 1.5 V (charged state) to 1.35 V (discharged state). [8, 11, 20]

Table 1: Comparison of characteristics of nickel-iron and lead-acid batteries. [6, 19, 21-23]

Main characteristics	Nickel-iron	Lead-acid
Nominal voltage (V)	1.2	2
Theoretical specific energy (Wh.kg <sup>-1</sup> )	268	170 – 252
Specific energy (Wh.kg <sup>-1</sup> )	20 – 80	10 – 20
Energy density (Wh.L <sup>-1</sup> )	60 – 110	50 – 70
Life cycle (100% DoD)	> 1000	20 – 50
Calendar lifetime (years)	> 25	~5 – 10
Operating temperature (°C)	-10/+45	-10/+40

Its discharge capacity also depends on the surrounding temperature. When the temperature drops, the output power drops dramatically. The derived capacity is approximately 50% of nominal value at 255 K when discharged at a C/8 rate, performance is reasonably good at ~308 K. The behavior at subzero temperatures is due to passivation of the iron electrode. Self-discharge represents 0.1 to 2.5% of the nominal capacity per day below 293 K, 1 to 2% at ~298 K and 8 to 10% at ~313 K. Self-discharge of a Ni-Fe battery manifests itself more than for Ni-Cd and Ni-MH batteries. It increases significantly with temperature. As an example, self-discharge is minimal (about 10% in 1 month) at 273 K, but a cell will discharge almost completely in 15 days at +313 K. Ni-Fe batteries can be stored for long periods without any deterioration whether in a charged or discharged state. The service life is from 7 to more than 25 years. Batteries requiring high power use sintered electrodes. [8, 20]

## V. ADVANTAGES AND DISADVANTAGES

The nickel–iron battery was and is almost indestructible. It has a very robust physical structure that can withstand mechanical and electrical shocks such as vibration, overcharging and over-discharging for long periods. Storage under charged or discharged conditions will not affect performance. A long service is therefore possible thanks to its long service life. Battery maintenance is quite simple. It is sufficient to top up the electrolyte by adding water or to replace it well after a considerable period of operation. [5, 8, 20]

The active materials of the battery are insoluble in alkalis. In addition, the separator does not present any particular difficulties unlike silver–zinc (Ag–Zn) and nickel–zinc (Ni–Zn) batteries. The Ni–Fe battery also does not present any toxic or corrosive effect neither for the environment nor for the working personnel. The alkaline electrolyte allows the use of mild steel in battery construction. The battery performs very well at an ambient temperature of approximately 308 K. [5, 8, 20]

Known for its long life, the Ni–Fe battery has a specific energy 1.5 to 2 times higher than that of a Pb–acid battery [24, 25]. It is also noted for its roughness and long life cycle under deep discharge [9, 10]. It is a promising

technology in terms of safety since it does not contain toxic elements or heavy metals: it has the lowest environmental impact and risk factor during operation [8, 10, 15].

The energy efficiency of the battery is around 50%. The self-discharge is, however, quite high: 30 to 50% of its capacity is lost over a period of one month. [6] The main causes of these two aspects are the low hydrogen overpotential of the iron electrode and the close proximity of the potential of the iron electrode (in alkaline medium) and that of the hydrogen evolution reaction. As a result, hydrogen is released during charge–discharge and on the carrier. Additionally, the battery exhibits poor performance at sub-zero temperatures due to passivation of the iron electrode. [5, 8, 20, 24] The discharge capacity of a Ni–Fe battery depends on the rate of discharge and the operating temperature: which limits the operation of the battery for high discharge at low temperature [13, 23]. Compared to lead–acid technology, nickel–iron technology exhibits poor performance at low temperature, high corrosion and self-discharge rates, and low overall energy efficiency due to the low overpotential for hydrogen evolution at the iron electrode. In addition, a need for frequent maintenance due to considerable gassing which is undesirable [15] during charging is however required. [5, 9, 25]

Table 2: Summary of comparison of lead–acid and nickel–iron technologies. [5, 15, 25, 26]

Battery technology	Advantages	Disadvantages
<b>Lead–acid</b>	<ul style="list-style-type: none"> <li>• Low manufacturing cost</li> <li>• High cell voltage</li> <li>• Available in maintenance-free mode</li> <li>• No memory effect</li> </ul>	<ul style="list-style-type: none"> <li>• Short lifespan</li> <li>• Low energy density</li> <li>• Presence of heavy metals</li> <li>• Low cycle life</li> <li>• Gas release</li> </ul>
<b>Nickel–iron</b>	<ul style="list-style-type: none"> <li>• Long life (cyclical and calendar)</li> <li>• Resistant to mechanical abuse (robust)</li> <li>• Resistant to electrical abuse (overcharging, over-discharging, shorting)</li> <li>• Non-toxic, non-corrosive</li> <li>• Does not contain heavy metals</li> <li>• No memory effect</li> </ul>	<ul style="list-style-type: none"> <li>• Low cell voltage</li> <li>• Significant self-discharge</li> <li>• Gas release</li> <li>• Poor performance at low temperature</li> </ul>

## VI. CONCLUSION

This review emphasizes nickel–iron battery technology for stationary application. It has been observed that the considerable self-discharge due to low hydrogen overvoltage is a major limitation of iron electrodes. A capacity loss of approximately 5% in 4 h extending to 20%

in 14 days for fully charged iron electrodes has been reported. The positive electrode made of nickel hydroxide has also been the subject of much research to study how different additives can change its properties or prevent different phases from occurring. Thus, the control of the composition of the electrolyte and the use of a combination of additives at the level of the electrodes

bring a good performance to the battery. It should be noted that the performance of a nickel–iron cell also results from the way the electrodes are manufactured. Finally, its years of existence allow us to deduce its longevity and even in the event of negligence and abuse under severe operating conditions, a long service life is possible.

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# Strength Optimization Models for A Multi-Variant Binder Concrete using Osadebe's Optimized Mixes

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Received: 03 Jul 2022,

Received in revised form: 31 Jul 2022,

Accepted: 06 Aug 2022,

Available online: 15 Aug 2022

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**Keywords**— *Mathematical modelling,  
optimized mixes, three-variant binder,  
concrete*

**Abstract**— Cement production has now inevitably become associated with increased health risks and unpalatable economic implications. As a result, it has become imperative that concrete be produced from locally sourced, naturally occurring and eco-friendly materials that can either partially or fully replace cement in concrete, and yet maintain its structural viability and constructional adequacy. This paper therefore focused on assessing the structural and strength properties of a three-binder concrete with Rice Husk Ash (RHA) and Mound Soil (MS) as partial replacements of Ordinary Portland Cement (OPC). Compressive strength tests were conducted on the concrete cubes after 28 days of curing. The laboratory work was done with the guidance of the provisions of the Osadebe's model for the actual components of the MS-RHA concrete. There were ten (10) test points and ten (10) control points taken for this research. The highest compressive strength predicted in this work was 35.0N/mm<sup>2</sup> corresponding to a Water/Cement ratio of 0.55 with mix ratio of 0.55:1:1:2 for a 10% replacement of OPC with 5% each of RHA and MS. The least value predicted by the model was 15.20N/mm<sup>2</sup> with W/C ratio of 0.47 in mix ratio 0.47:1:5:8. The adequacy of the model was tested using the student's t-test and passed for adequacy, with  $t_{\text{calculated}} = 0.303$ , less than  $t_{\text{table}} = 2.262$ , thereby annulling the alternate hypothesis and sustaining the null hypotheses respectively proposing significant and insignificant differences between the experimental and predicted values.

## I. INTRODUCTION

Concrete is practically the basic and most common construction material at present, and it is estimated that globally, the consumption of cement, which is its basic component, has reached 10 billion metric tons annually. [1,2]. Concrete is produced from a blend of various components such as cement, fine and coarse aggregates and water [3], and is classified as a composite inter material comprising binder, filler or aggregates and then water [4]. Sometimes admixtures are added to concrete to accentuate certain desired properties of the concrete, but alternatively optimum concrete (strength) properties can be achieved by optimization. In this situation, optimization can be done using mathematical modelling, which is the

process of mathematically representing a phenomenon for the purpose of gaining better understanding [5]. Optimization can be said to refer to any activity or process aiming at achieving maximum results with minimal inputs or investments [6].

This study seeks to optimize the strength properties of concrete having Ordinary limestone cement, mound soil and rice husk ash as binders. Rice Husk Ash (RHA) is an agricultural waste obtained from rice husks which are the outer coatings of rice paddy burned in open air in rice mills. It is estimated that global rice production has reached 700 million tons with countries like China and India being notable farmers of the grain. According to [7], the chemical composition of rice husk is 50% of cellulose,

25 – 30% of lignin, 15 – 20% of silica, 30 – 50% organic carbon, and 10 – 15% of water (or moisture) and that by percentage of weight, the rice husk contributes 20% to the total weight of rice with a low bulk density of 90 – 150kg/m<sup>3</sup>. The disposal of RHA is a problem to waste managers but if RHA, which is a proven pozzolan, and a more natural, local and affordable material is used in concrete to partially replace the more expensive cement, then the problem of its disposal will be significantly solved [8].

The influence of various RHA sources on the properties of road subgrade materials has been investigated by [9]. It has been reported that RHA obtained from various states of Nigeria can be used for sub-grade stabilization because of their pozzolanic properties.

Replacing OPC with up to 30% RHA reduces chloride penetration, decreases permeability, and improves strength and corrosion resistance properties at an optimal replacement proportion of 25% [10]. According to [11], compressive strength is converted to their corresponding tensile strength by multiplying them with a conversion factor 0.8, and available literature provide that the tensile strength of concrete is about 10 – 12% of the compressive strength, or computed from empirical formulas.

Mound-building termites are largely considered to be a threat, especially to the agroindustry. They are known to be destructive to crops, trees, and general manmade structures. However, research has further revealed that not all species of termites pose negative impacts on humans' socio-economic activities [12]. A termite mound is a mixture of clay components and organic carbon cemented by secretions, excreta, or saliva deposited by the termites. The mounds could be conical, lenticular cathedral or mushroom-like, depending on the species, temperature, clay availability, level of termite presence in an area and general site conditions [13]. Mound soils result from termite activities over time and serve as shelter for the termites and are predominantly clay. This clay is exceptionally improved by the secretions from the termites in building the mound [14]. These secretions improve on the plasticity of the mound soil, making it a better moulding material than the surrounding soil. Mound clay has been reported to perform better at dam construction than ordinary clay without the termite secretions [15]. Following the need for affordable materials for construction of functional, adequate and low-cost housing for the teeming populace, the search is now for local materials to serve as alternatives for the more expensive conventional building materials [16]. Hence, with a view to decreasing the cost of building construction, effective steps are now being taken to partially replace cement with

industrial waste [17], agricultural waste [18] and plastic waste materials [19].

The assessment of the performance of Termite-Mound Powder (TMP) as partial replacement for cement in the production of lateritic blocks was studied by [20]. The concern of the researchers was clearly on the over-dependence on cement, increase in construction costs, health concerns with the toxic emissions of cement production and usage. The results of the research showed that the compressive strength of the bricks increased with curing, reaching an optimum value at 10%, but decreased with increase in percentage TMP.

The spatial variation of the chemical properties of Rice Husk Ash has been investigated using X-ray fluorescence (XRF) technology [21]. The results of the study showed that Rice Husk Ash (RHA) varies in pozzolanic properties depending on the location they are found, and that RHA can be used as a partial replacement to OPC due to its chemical composition.

It has been reported that termite mound soil is silty-sand, with sand and silt constituting over 80% of particle size and <30% gravel fraction, and has specific gravity ranging from 2.59 to 2.68 and maximum dry density ranging from 1.63 – 1.84g/cm<sup>3</sup> which are higher than those of the surrounding soil [22].

## II. MATERIALS AND METHODS

The mound soil (MS) was obtained as a disturbed sample from a termite mound in an open field in Calabar, Nigeria.



Fig.1: Termite mound

A digger was used to claw open the hard termite mound and the mound clods were collected in an airtight nylon bag for the avoidance of moisture loss. In all, 15kg of the sample was collected and taken to the laboratory. 93g of the collected sample was used to determine the natural moisture content and the rest of it was crushed and spread out on a pan in a damp-free area to air-dry under

room temperature. To obtain the finest particle sizes, the crushed, air-dried mound soil was passed through the smallest aperture-sized sieve and the residue collected in the pan was kept ready for the concrete still under dry condition. The RHA sample was also collected as a disturbed sample from a heap in the Obubra rice mill in Cross River State of Nigeria.

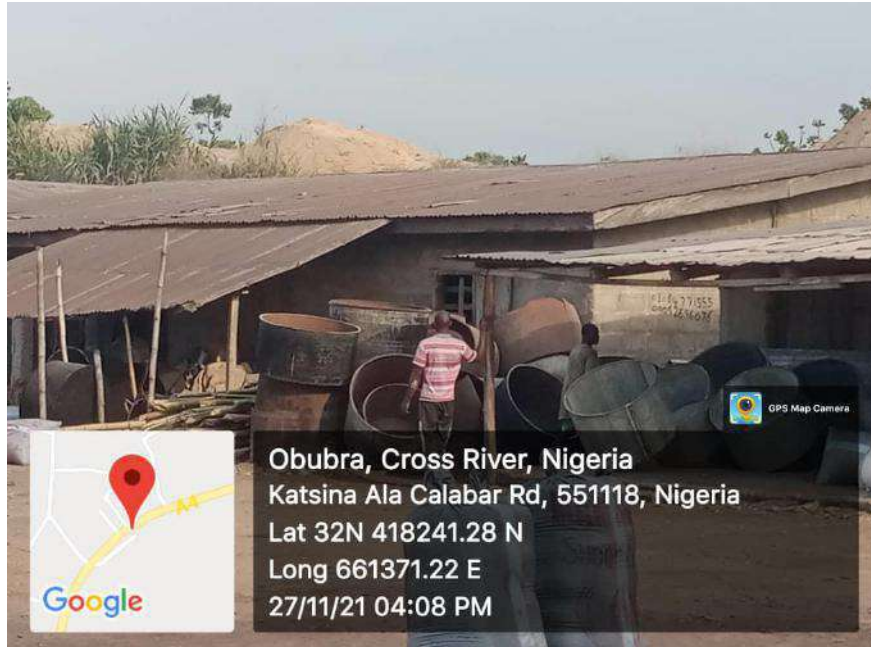


Fig. 2: Location of Rice Mill in Obubra, Cross River State, Nigeria

It was transported under airtight condition to the laboratory where 29g of it was oven-dried to determine its natural moisture content. The rest of it, 10.5kg, was sieved to remove all unwanted materials contained in the sample before being used for the research work.

OPC was obtained from the Lafarge cement producing company in Akamkpa Local Government Area of Cross River State, Nigeria, and the fine and coarse aggregates were respectively obtained from the dredged Calabar river and Saturn Quarry, all in Cross River State, Nigeria. 15-22mm average coarse aggregate size was adopted for this research work, and fine aggregate classified as fine sand with particle size range of 125-250 $\mu$ m.

The procedure for producing this three-binder concrete followed the usual concrete production procedure except for the use of three distinct materials as binder in the same concrete mix. To achieve this three-binder concrete, OPC was replaced with both RHA and MS, simultaneously, in predetermined percentages. Adopting the provision of 1:2:4 concrete mix ratio for this study, the binder constituent of the concrete matrix was split to accommodate OPC, RHA and MS such that 10, 20, 30, 40,

and 50% of OPC was replaced by equal amounts each of RHA and MS. These percentages were measured out volumetrically using a calibrated container. The conventional concrete with 100% OPC was also produced to serve as the standard basis for comparison, giving a sum total of six (6) different batches of concrete.

The tests carried out were to determine the workability of the concrete, determine water absorption percentages, and determine compressive, flexural and tensile strengths. Workability was assessed by conducting slump tests on fresh mixes of the conventional and test concrete in accordance with BS EN 12350-2:2009. For determination of percentage water absorption, the fresh concrete was cast into 150m<sup>3</sup> moulds, demoulded and weighed after setting, and then cured in a water tank. Each batch of concrete had 15 cubes cast, 3 cubes for 5 curing ages, in order to have an average value. The curing ages were 3, 7, 14, 21 and 28 days. Water absorption tests assess the capillary action of concrete and is basically the difference in dry and wet weights of the concrete cubes before and immediately after curing. It therefore serves as a durability check on concrete to predict the rate of possible ingress of corrosive fluids into concrete.

The compressive strength of a material is basically its ability to carry the loads on its surface without any crack or deflection. This procedure was carried out on the hardened concrete cubes of 150mm x 150mm x 150mm dimensions in accordance with the provisions of BS EN 12390-3:2019. The procedure was conducted such that the moulds were first cleaned and oiled internally and then the freshly mixed concrete was placed in the moulds in approximately 5cm thick layers. Each layer of concrete was compacted with 35 strokes using a tamping rod of 16mm diameter, 60cm in length and bullet-pointed at lower end and top surface of concrete was always smoothed with a trowel before being left to harden. The cast concrete cubes were left to harden for 24 hours after which they were cured and tested for 3, 7, 14, 21 and 28 days using a Universal Test Machine (UTM), from which loading was generated across the entire surface area of two opposite faces of the test sample. The loading was in such a manner as to flatten the sample, tending to shorten the sample in the direction of the applied load, while expanding it in the direction perpendicular to the load. Loading was applied on each sample gradually at the rate of 140 kg/cm<sup>2</sup> per minute until it failed. Compressive strength for each cube sample was then computed as the load at failure divided by the area of the cube sample, expressed mathematically as:

$$\sigma = \frac{F}{A} \tag{1}$$

where F is the applied load in (N) and A the cross-sectional area in (mm<sup>2</sup>).

According to I.S. 456-2000,

$$\text{Flexural strength } f_s = 0.7\sqrt{f_{ck}}$$

(2) where  $f_{ck}$  is the compressive strength cylinder of concrete in MPa (N/mm<sup>2</sup>).

Likewise, tensile strength can be computed as follows;

$$F_{ct} = \frac{2P}{\pi Ld} \tag{3}$$

Where  $F_{ct}$  = Tensile strength of concrete

P = Maximum load in N/Sqm

L = Length of the specimen (300mm)

D = Diameter of the specimen (150mm)

## 2.1 OSADEBE'S OPTIMIZATION THEORY

The mixes of the elemental components of the MS-RHA concrete were guided by a mathematical component developed by Osadebe (Osabebe 2016). Osadebe developed an optimized mixes model, which is an application of Talyor's series. The model showed that concrete is multivariant unit mass whose strength is

dependent on the variation in the volume of the constituent material. His regression equation is another form of experimental model. He expressed the response Y as a function of the proportions of the components of the mixture Z, where the sum of all the proportions must add up to 1. That is,

$$Z_1 + Z_2 + \dots + Z_q = \sum_{i=1}^q Z_i = 1 \tag{4}$$

where q is the number of mixture components and  $Z_i$  the proportion of the components in the mixture.

Osadebe assumed that the response Y is continuous and differentiable with respect to its predictors and can be expanded in the neighbourhood of a chosen point  $Z_0$  using Taylor's Series.

$$Z(0) = (Z_1^{(0)}, Z_2^{(0)}, \dots, Z_q^{(0)})^r \tag{5}$$

$$Y(Z) = \sum_{m=0}^q F^m(Z)^{(0)}(Z_i - Z_i^{(0)}) \tag{6}$$

Expanding to second order:

$$Y(Z) = F(Z^{(0)}) + \sum_{i=1}^q \frac{\partial f(Z^{(0)})}{\partial z_i} (Z_i - Z_i^{(0)}) + \frac{1}{2!} \sum_{i=1}^{q-1} \sum_{j=1}^q \frac{\partial^2 f(Z^{(0)})}{\partial z_i \partial z_j} (Z_i - Z_i^{(0)})(Z_j - Z_j^{(0)}) + \sum_{i=1}^q \frac{\partial^2 f(Z^{(0)})}{\partial z_i^2} (Z_i - (0)) \tag{7}$$

For convenience, the point  $Z^0$  can be taken as the origin without loss in generality of the formulation and thus:

$$Z_1^{(0)} = Z_2^{(0)} = Z_3^{(0)} = \dots = Z_q^{(0)} = 0 \tag{8}$$

Let:

$$b_0 = F(0), b_i = \frac{\partial F(0)}{\partial z_i}, b_{ij} = \frac{\partial^2 F(0)}{2i \partial z_i \partial z_j}, b_{ii} = \frac{\partial^2 F(0)}{2i \partial z_i^2} \tag{9}$$

Substituting equation (6) into equation (3) gives:

$$Y(Z) = b_0 + \sum_{i=1}^q b_i Z_i + \sum_{i \leq j \leq q} b_{ij} Z_i Z_j + \sum_{i=1}^q b_{ii} Z_i^2 \tag{7}$$

Multiplying equation (3) by  $b_0$  gives the expression:

$$b_0 = b_0 Z_1 + b_0 Z_2 + \dots + b_0 Z_q \tag{8}$$

Multiplying equation (3) successively by  $Z_1, Z_2 \dots Z_q$  and rearranging, gives respectively:

$$\begin{aligned} Z_1^2 &= Z_1 - Z_1 Z_2 - \dots + Z_1 Z_q \\ Z_2^2 &= Z_2 - Z_1 Z_2 - \dots - Z_2 Z_q \\ Z_q^2 &= Z_q - Z_1 Z_q - \dots + Z_{(q-1)} \end{aligned} \tag{9}$$

Substituting Equations (5) and (6) into Equation (7) and simplifying yields:

$$Y(Z) = \sum_{i=1}^q \beta_i Z_i + \sum_{i \leq j \leq q} \beta_{ij} Z_i Z_j \tag{10}$$

Where:

$$\beta_i = b_0 + b_i \dots + b_{ii} \tag{11}$$

$$\beta_{ij} = b_{ij} - b_{ii} - b_{ij} \tag{12}$$

Equation (8) is Osadebe’s regression model equation. It is defined if the unknown constant coefficients,  $\beta_i$  and  $\beta_{ij}$  are uniquely determined. If the number of constituents, q, is 4, and the degree of the polynomial, m, is 2, the number of coefficients, N is now the same as that for the Scheffe’s (4,2) model given by:

$$N = C_m^{(q+m-1)} = C_m^{(4+2-1)} = 10 \tag{13}$$

$$N = \frac{(q+m-1)!}{M! (\llbracket q+m-1 \rrbracket - M)!} = \frac{(q+m-1)!}{m! (q-1)!} = \frac{(4+2-1)!}{2! (4-1)!} = \frac{5!}{2! 3!} = 10$$

### 2.1.1 Coefficients of Osadebe’s Regression Equation

The least number of experimental runs or independent responses necessary to determine the coefficients of the Osadebe’s regression coefficients is N. Let  $y^{(k)}$  be the response at point k and the vector corresponding to the set of component proportions (predictors) at point k be  $y^{(k)}$ .

That is:

$$Z^{(k)} = (Z_1^{(k)}, Z_2^{(k)}, \dots, Z_q^{(k)}) \tag{14}$$

Substituting gives:

$$Y^{(k)} = \sum_{i=1}^q \beta_i Z_i^{(k)} + \sum_{i \leq j \leq q} \beta_{ij} Z_i^{(k)} Z_j^{(k)} \tag{15}$$

Where k = 1, 2, ... N

Substituting the predictor vectors at each of the N observation points successively into Equation (15) gives a set of N linear algebraic equations which can be written in matrix form as:

$$Z \beta = Y \tag{16}$$

Where:

$\beta$  is a vector whose elements are the estimates of the regression coefficients:

$$\begin{bmatrix} \beta_1 \\ \beta_2 \\ \vdots \\ \beta_{10} \end{bmatrix} = \begin{bmatrix} Z_1^{(1)}, Z_1^{(2)}, \dots, & Z_1^{(10)} \\ & Z_2^{(1)}, & Z_2^{(2)}, \dots, Z_2^{(10)}, \\ Z_3^{(1)} Z_4^{(1)}, & Z_3^{(2)}, Z_4^{(3)} \dots, & Z_3^{(10)} Z_4^{(10)} \end{bmatrix} \begin{bmatrix} y(1) \\ y(2) \\ \vdots \\ y(10) \end{bmatrix}$$

### 2.1.2 Osadebe’s Method

$$Z_1 + Z_2 + \dots + Z_q = \sum_{i=1}^q Z_i = 1 \tag{17}$$

Where q is the number of mixture components and  $Z_i$  the proportion of the components in the mixture.

$Z_1$  = Water/Cement Ratio

$Z_2$  = Binder (OPC and RHA)

$Z_3$  = Fine aggregates (Sand)

$Z_4$  = Coarse Aggregates (Granite)

Osadebe assumed that the response Y is continuous and differentiable with respect to its predictors and can be expanded in the neighbourhood of a chosen point  $Z_0$  using Taylor’s series.  $Z(0) = (Z_1^{(0)}, Z_2^{(0)}, \dots, Z_q^{(0)})^r$

$$(18)$$

$$Y(Z) = \sum_{m=0}^q F^m(Z)^{(0)} (Z_i - Z^{(0)}) \tag{19}$$

Expanding to second order:

$$Y(Z) = F(Z^{(0)}) + \sum_{i=1}^q \frac{\partial f(Z^{(0)})}{\partial z_i} (Z_i - Z^{(0)}) + \frac{1}{2!} \sum_{i=1}^{q-1} \sum_{i=1}^q \frac{\partial^2 f(Z^{(0)})}{\partial z_i \partial z_i} (Z_i - Z_i^{(0)}) (Z_i - Z_i^{(0)}) + \sum_{i=1}^q \frac{\partial^2 f(Z^{(0)})}{\partial z_i} (Z_i - (0)) \tag{20}$$

For convenience, the point  $Z^0$  can be taken as the origin without loss in generality of the formulation and thus:

$$Z_1^{(0)} = Z_1^{(0)} + Z_2^{(0)} + Z_3^{(0)} + \dots + Z_q^{(0)} = 0 \tag{21}$$

Let:

$$b_0 = F(0), b_i = \frac{\partial F(0)}{\partial z_i}, b_{ij} = \frac{\partial^2 F(0)}{2i \partial z_i \partial j}, b_{ii} = \frac{\partial^2 F(0)}{2i \partial z_i^2} \tag{22}$$

Substituting equation (13) into Equation (22) into Equation (17) gives:

$$Y(Z) = b_0 + \sum_{i=1}^q b_i Z_i + \sum_{i \leq j \leq q} b_{ij} Z_i Z_j + \sum_{i=1}^q b_{ii} Z_i^2 \tag{23}$$

Multiplying Equation (3.19) by  $b_0$  gives the expression:

$$b_0 = b_0 Z_1 + b_0 Z_2 + \dots + b_0 Z_q \tag{24}$$

Multiplying Equation (17) by  $Z_1, Z_2 \dots Z_q$  and rearranging gives respectively:

$$\begin{aligned} Z_1^2 &= Z_1 - Z_1 Z_2 - \dots + Z_1 Z_q \\ Z_2^2 &= Z_2 - Z_1 Z_2 - \dots - Z_2 Z_q \\ Z_q^2 &= Z_1 - Z_1 Z_q - \dots - Z_{(q-1)} \end{aligned} \tag{25}$$

Substituting Equations (21) and (17) into Equation (24) and simplifying yields

$$Y(Z) = \sum_{i=1}^q \beta_i Z_i + \sum_{i \leq j \leq q} \beta_{ij} Z_i Z_j \tag{26}$$

Where

$$\beta_i = b_0 + b_i \dots + b_{ii} \tag{27}$$

$$\beta_{ij} = b_{ij} - b_{ii} - b_{ij} \tag{28}$$

Osadebe’s regression model equation is defined if the unknown constant coefficients,  $\beta_i$  and  $\beta_{ij}$  are uniquely determined. If the number of constituents,  $q$ , is 6, and the degree of the polynomial,  $m$ , is 2 then the regression equation is given as:

$$Y = \beta_1Z_1 + \beta_2Z_2 + \beta_3Z_3 + \beta_4Z_4 + \beta_5Z_5 + \beta_6Z_6 + \beta_{12}Z_1Z_2 + \beta_{13}Z_1Z_3 + \beta_{14}Z_1Z_4 + \beta_{15}Z_1Z_5 + \beta_{16}Z_1Z_6 + \beta_{23}Z_2Z_3 + \beta_{24}Z_2Z_4 + \beta_{25}Z_2Z_5 + \beta_{26}Z_2Z_6 + \beta_{34}Z_3Z_4 + \beta_{35}Z_3Z_5 + \beta_{36}Z_3Z_6 + \beta_{45}Z_4Z_5 + \beta_{46}Z_4Z_6 \quad (29)$$

Therefore, Equation (29) is the mathematical model based on Osadebe’s second degree regression method.

**2.1.3 Actual and Pseudo Components**

The requirement of the simplex as given in Equation (1) makes it impossible to utilize the conventional concrete mixes at any given water-cement ratio, requiring a transformation of the actual components to meet this requirement. Table 1 below gives the actual ( $Z_i$ ) and Pseudo ( $X_i$ ) components for Osadebe’s (4,2) Simplex Lattice.

Table 1: Actual ( $Z_i$ ) and Pseudo ( $X_i$ ) components for Osadebe’s (4,2) Simplex Lattice

PSEUDO COMPONENTS					RESPONSE COMPONENT	COMPONENT’S FRACTION			
S/N	X <sub>1</sub>	X <sub>2</sub>	X <sub>3</sub>	X <sub>4</sub>		Z <sub>1</sub>	Z <sub>2</sub>	Z <sub>3</sub>	Z <sub>4</sub>
1	1	0	0	0	Y <sub>1</sub>	0.08	0.229885	0.229885	0.45977
2	0	1	0	0	Y <sub>2</sub>	0.074	0.16835	0.252525	0.505051
3	0	0	1	0	Y <sub>3</sub>	0.07	0.155039	0.310078	0.465116
4	0	0	0	1	Y <sub>4</sub>	0.048	0.095238	0.285714	0.571429
5	0.5	0.5	0	0	Y <sub>12</sub>	0.058	0.13459	0.269179	0.538358
6	0.5	0	0.5	0	Y <sub>13</sub>	0.053	0.111359	0.278396	0.556793
7	0.5	0	0	0.5	Y <sub>14</sub>	0.044	0.086881	0.347524	0.521286
8	0	0.5	0.5	0	Y <sub>23</sub>	0.035	0.107181	0.321543	0.535906
9	0	0.5	0	0.5	Y <sub>24</sub>	0.064	0.116959	0.233918	0.584795
10	0	0	0.5	0.5	Y <sub>34</sub>	0.059	0.09901	0.247525	0.594059
<b>CONTROL</b>									
11	0.5	0.25	0.25	0	C <sub>1</sub>	0.121	0.21978	0.21978	0.43956
12	0.25	0.25	0.25	0.25	C <sub>2</sub>	0.098	0.245902	0.245902	0.491803
13	0	0.25	0.25	0.5	C <sub>3</sub>	0.059	0.134409	0.268817	0.537634
14	0	0.25	0	0.75	C <sub>4</sub>	0.056	0.277778	0.277778	0.555556
15	0.75	0	0.25	0	C <sub>5</sub>	0.038	0.096154	0.288462	0.576923
16	0	0.5	0.25	0.25	C <sub>6</sub>	0.038	0.306212	0.306212	0.568679
17	0.25	0	0.5	0.25	C <sub>7</sub>	0.028	0.080972	0.323887	0.566802
18	0.75	0.25	0	0	C <sub>8</sub>	0.038	0.333087	0.333087	0.555144
19	0	0.75	0.25	0	C <sub>9</sub>	0.035	0.072046	0.345821	0.54755
20	0	0.4	0.4	0.2	C <sub>10</sub>	0.032	0.345543	0.345543	0.552868

Table 2: Mix ratios and Components fractions

MIX RATIOS					COMPONENT’S FRACTION			
S/N	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	S <sub>4</sub>	Z <sub>1</sub>	Z <sub>2</sub>	Z <sub>3</sub>	Z <sub>4</sub>
1	0.35	1	1	2	0.08	0.229885	0.229885	0.45977

2	0.44	1	1.5	3	0.074	0.16835	0.252525	0.505051
3	0.45	1	2	3	0.07	0.155039	0.310078	0.465116
4	0.5	1	3	6	0.048	0.095238	0.285714	0.571429
5	0.43	1	2	4	0.058	0.13459	0.269179	0.538358
6	0.5	1	2.5	5	0.053	0.111359	0.278396	0.556793
7	0.43	1	4	6	0.044	0.086881	0.347524	0.521286
8	0.48	1	3	5	0.035	0.107181	0.321543	0.535906
9	0.51	1	2	5	0.064	0.116959	0.233918	0.584795
10	0.33	1	2.5	6	0.059	0.09901	0.247525	0.594059
<b>CONTROL</b>								
11	0.55	1	1	2	0.121	0.21978	0.21978	0.43956
12	0.6	1	1.5	3	0.098	0.245902	0.245902	0.491803
13	0.44	1	2	4	0.059	0.134409	0.268817	0.537634
14	0.5	1	2.5	5	0.056	0.277778	0.277778	0.555556
15	0.4	1	3	6	0.038	0.096154	0.288462	0.576923
16	0.43	1	3.5	6.5	0.038	0.306212	0.306212	0.568679
17	0.35	1	4	7	0.028	0.080972	0.323887	0.566802
18	0.51	1	4.5	7.5	0.038	0.333087	0.333087	0.555144
19	0.48	1	4.8	7.6	0.035	0.072046	0.345821	0.54755
20	0.47	1	5	8	0.032	0.345543	0.345543	0.552868

The design matrix as shown in Table 1 above for the  $X_i$  experimental points are called “Pseudo-components” and the  $Z_i$  are the actual experimental components.  $X = AZ$  (30)

Where A is the inverse of Z matrix and  $Z = AX^T$  (31)

Where A is the inverse of Z matrix,  $X^T$  is the transpose of matrix X.

Table 3: Table of Z based on Table 1 above

S/N	Z <sub>1</sub>	Z <sub>2</sub>	Z <sub>3</sub>	Z <sub>4</sub>	Z <sub>1</sub> Z <sub>2</sub>	Z <sub>1</sub> Z <sub>3</sub>	Z <sub>1</sub> Z <sub>4</sub>	Z <sub>2</sub> Z <sub>3</sub>	Z <sub>2</sub> Z <sub>4</sub>	Z <sub>3</sub> Z <sub>4</sub>
1	0.08	0.23	0.23	0.46	0.0184	0.0184	0.0368	0.0529	0.1058	0.1058
2	0.074	0.17	0.25	0.50	0.01258	0.0185	0.037	0.0425	0.085	0.125
3	0.07	0.15	0.31	0.46	0.0105	0.0217	0.0322	0.0465	0.069	0.1426
4	0.048	0.09	0.29	0.57	0.00432	0.01392	0.02736	0.0261	0.0513	0.1653
5	0.058	0.13	0.27	0.54	0.00754	0.01566	0.03132	0.0351	0.0702	0.1458
6	0.053	0.11	0.28	0.56	0.00583	0.01484	0.02968	0.0308	0.0616	0.1568
7	0.044	0.09	0.35	0.52	0.00396	0.0154	0.02288	0.0315	0.0468	0.182
8	0.035	0.11	0.32	0.54	0.00385	0.0112	0.0189	0.0352	0.0594	0.1728
9	0.064	0.12	0.23	0.58	0.00768	0.01472	0.03712	0.0276	0.0696	0.1334
10	0.059	0.10	0.25	0.59	0.0059	0.01475	0.03481	0.025	0.059	0.1475

Table 4: A – MATRIX

-455.2052666	1231.517063	-329.5748234	1451.381393	1520.989399	-2951.096174	-242.3070516	189.0269454	-898.5654534	498.8569095
28.7378845	-74.17043571	-150.5895161	272.009771	1355.244197	-1495.259042	79.06907765	-62.22066845	-598.5258808	649.5471997
31.4292578	-120.8119741	52.31786573	-60.59243082	-164.4715106	183.659049	36.15497648	-7.831935186	229.871365	-178.8325261
16.49078415	-60.57761478	40.20793539	-1.699017758	-131.3955939	151.7695847	-20.98871224	1.403439453	108.7568777	-103.0241121
630.5140751	-1169.460543	1136.478253	-2694.600553	-9001.388201	10812.93239	-85.03428736	55.70317468	3987.521238	-3703.865421
533.527126	-1801.678994	555.4710208	-528.1650934	-1340.705199	3923.218799	-64.10675484	-733.6523825	1615.968522	-2169.188493
395.0617582	-928.5083578	41.42664627	-2023.903241	-336.5379614	1317.532051	558.2372404	-35.45072095	-211.0309414	1207.228613
-74.77219454	275.3029098	161.0875805	-642.211443	-1309.61652	1137.259042	-152.8427479	324.4615608	-19.7915436	296.2371682
-59.24098412	89.85381071	87.47532632	-92.89319842	-1116.013127	1476.504624	-62.98148708	-45.80747567	740.2713048	-1018.698351
-92.07247351	368.2259919	-188.6576047	128.777518	519.0654225	-643.3258078	-4.841902355	17.06642128	-623.4819767	519.5055037

Table 5: X-MATRIX

1.0E+00	3.0E-13	4.5E-13	1.4E-12	1.5E-14	3.4E-14	7.5E-14	6.4E-14	1.6E-13	2.6E-13
-7.1E-15	1.0E+00	-5.7E-14	-1.1E-13	-1.3E-15	-1.8E-15	-1.1E-14	-1.8E-14	-2.8E-14	-7.1E-14
-1.8E-15	0.0E+00	1.0E+00	2.8E-14	4.4E-16	8.9E-16	1.8E-15	8.9E-16	1.8E-15	7.1E-15
-2.7E-15	-1.8E-15	-3.6E-15	1.0E+00	0.0E+00	-2.2E-16	-4.4E-16	0.0E+00	-8.9E-16	-5.3E-15
-3.4E-13	-3.4E-13	-1.3E-12	-2.3E-12	1.0E+00	-6.4E-14	-1.1E-13	-8.5E-14	-2.6E-13	-3.4E-13
-4.3E-14	-1.1E-13	0.0E+00	2.3E-13	-3.6E-15	1.0E+00	-1.4E-14	-2.1E-14	-1.4E-14	0.0E+00
1.4E-14	1.4E-14	1.1E-13	0.0E+00	2.7E-15	1.1E-14	1.0E+00	1.4E-14	5.7E-14	1.4E-13
-7.1E-15	-3.6E-15	4.3E-14	2.8E-14	4.4E-16	4.4E-15	1.8E-15	1.0E+00	0.0E+00	7.1E-15
-1.4E-14	0.0E+00	2.8E-14	0.0E+00	-8.9E-16	-3.6E-15	-7.1E-15	0.0E+00	1.0E+00	0.0E+00
3.6E-15	-7.1E-15	-2.8E-14	-1.1E-13	-1.8E-15	-1.8E-15	-3.6E-15	-3.6E-15	-1.8E-14	1.0E+00

Table 6: Matrix of X – Transpose

1.00E+00	-7.11E-15	-1.78E-15	-2.66E-15	-3.41E-13	-4.26E-14	1.42E-14	-7.11E-15	-1.42E-14	3.55E-15
2.98E-13	1.00E+00	0.00E+00	-1.78E-15	-3.41E-13	-1.14E-13	1.42E-14	-3.55E-15	0.00E+00	-7.11E-15
4.55E-13	-5.68E-14	1.00E+00	-3.55E-15	-1.25E-12	0.00E+00	1.14E-13	4.26E-14	2.84E-14	-2.84E-14
1.42E-12	-1.14E-13	2.84E-14	1.00E+00	-2.27E-12	2.27E-13	0.00E+00	2.84E-14	0.00E+00	-1.14E-13
1.51E-14	-1.33E-15	4.44E-16	0.00E+00	1.00E+00	-3.55E-15	2.66E-15	4.44E-16	-8.88E-16	-1.78E-15
3.38E-14	-1.78E-15	8.88E-16	-2.22E-16	-6.39E-14	1.00E+00	1.07E-14	4.44E-15	-3.55E-15	-1.78E-15
7.46E-14	-1.07E-14	1.78E-15	-4.44E-16	-1.14E-13	-1.42E-14	1.00E+00	1.78E-15	-7.11E-15	-3.55E-15
6.39E-14	-1.78E-14	8.88E-16	0.00E+00	-8.53E-14	-2.13E-14	1.42E-14	1.00E+00	0.00E+00	-3.55E-15
1.60E-13	-2.84E-14	1.78E-15	-8.88E-16	-2.56E-13	-1.42E-14	5.68E-14	0.00E+00	1.00E+00	-1.78E-14
2.56E-13	-7.11E-14	7.11E-15	-5.33E-15	-3.41E-13	0.00E+00	1.42E-13	7.11E-15	0.00E+00	1.00E+00

Table 7: Z - MATRIX

-455.2053	1231.5171	-329.5748	1451.3814	1520.9894	-2951.0962	-242.3071	189.0269	-898.5655	498.8569
28.7379	-74.1704	-150.5895	272.0098	1355.2442	-1495.2590	79.0691	-62.2207	-598.5259	649.5472
31.4293	-120.8120	52.3179	-60.5924	-164.4715	183.6590	36.1550	-7.8319	229.8714	-178.8325
16.4908	-60.5776	40.2079	-1.6990	-131.3956	151.7696	-20.9887	1.4034	108.7569	-103.0241
630.5141	-1169.4605	1136.4783	-2694.6006	-9001.3882	10812.9324	-85.0343	55.7032	3987.5212	-3703.8654



533.5271	-1801.6790	555.4710	-528.1651	-1340.7052	3923.2188	-64.1068	-733.6524	1615.9685	-2169.1885
395.0618	-928.5084	41.4266	-2023.9032	-336.5380	1317.5321	558.2372	-35.4507	-211.0309	1207.2286
-74.7722	275.3029	161.0876	-642.2114	-1309.6165	1137.2590	-152.8427	324.4616	-19.7915	296.2372
-59.2410	89.8538	87.4753	-92.8932	-1116.0131	1476.5046	-62.9815	-45.8075	740.2713	-1018.6984
-92.0725	368.2260	-188.6576	128.7775	519.0654	-643.3258	-4.8419	17.0664	-623.4820	519.5055

RESPONSES		REGRESSION COEFFICIENTS
Y <sub>1</sub>	42.37	49880.88029
Y <sub>2</sub>	35.00	19056.25884
Y <sub>3</sub>	32.89	-4524.982663
Y <sub>4</sub>	24.51	-2307.113416
Y <sub>12</sub>	20.95	-152307.2228
Y <sub>13</sub>	15.17	-55556.10739
Y <sub>14</sub>	43.375	-32556.01398
Y <sub>23</sub>	35.525	-12610.26213
Y <sub>24</sub>	33.385	-18182.54649
Y <sub>34</sub>	24.88	12903.1295

### III. RESULTS AND DISCUSSION

The laboratory responses for the twenty design points for the compressive strength are as presented in the table below. Two replicate experimental observations were conducted for each of the points, and of the twenty points, ten are control points. Table 8 also presents the mean values computed from the replicate compressive strength values.

Table 8: Results of Compressive strength test (Laboratory Responses)

Exp. No. (N)	Repetition	Response	Point	$\sum_{i=1}^n Y_i$	$\bar{Y} = \frac{(\sum_{i=1}^n Y_i)}{n}$
1	A	42.80	Y <sub>1</sub>	85.47	42.37
	B	42.67			
2	A	35.20	Y <sub>2</sub>	70.00	35.00
	B	34.80			
3	A	32.22	Y <sub>3</sub>	65.78	32.89
	B	33.56			
4	A	23.87	Y <sub>4</sub>	49.03	24.51
	B	25.16			
5	A	21.78	Y <sub>12</sub>	41.91	20.95
	B	20.13			
6	A	15.24	Y <sub>13</sub>	30.35	15.17
	B	15.11			

7	A	44.08	Y <sub>14</sub>	86.75	43.375
	B	42.67			
8	A	37.52	Y <sub>23</sub>	71.05	35.525
	B	33.52			
9	A	29.21	Y <sub>24</sub>	66.77	33.385
	B	37.56			
10	A	25.88	Y <sub>34</sub>	49.76	24.88
	B	23.88			
11	A	20.91	Y <sub>C1</sub>	42.54	21.27
	B	21.63			
12	A	13.89	Y <sub>C2</sub>	30.80	15.4
	B	16.91			
13	A	42.67	Y <sub>C3</sub>	88.03	44.015
	B	45.36			
14	A	35.30	Y <sub>C4</sub>	72.10	36.05
	B	36.80			
15	A	33.39	Y <sub>C5</sub>	67.75	33.875
	B	34.36			
16	A	26.06	Y <sub>C6</sub>	50.50	25.25
	B	24.44			
17	A	20.19	Y <sub>C7</sub>	43.17	21.585
	B	22.98			
18	A	16.00	Y <sub>C8</sub>	31.26	15.63
	B	15.26			
19	A	19.68	Y <sub>C9</sub>	41.91	20.955
	B	22.23			
20	A	14.24	Y <sub>C10</sub>	30.35	15.175
	B	16.11			

From the regression equation given in equation 29:

$$Y = \beta_1 Z_1 + \beta_2 Z_2 + \beta_3 Z_3 + \beta_4 Z_4 + \beta_5 Z_5 + \beta_6 Z_6 + \beta_{12} Z_1 Z_2 + \beta_{13} Z_1 Z_3 + \beta_{14} Z_1 Z_4 + \beta_{15} Z_1 Z_5 + \beta_{16} Z_1 Z_6 + \beta_{23} Z_2 Z_3 + \beta_{24} Z_2 Z_4 + \beta_{25} Z_2 Z_5 + \beta_{26} Z_2 Z_6 + \beta_{34} Z_3 Z_4 + \beta_{35} Z_3 Z_5 + \beta_{36} Z_3 Z_6 + \beta_{45} Z_4 Z_5 + \beta_{46} Z_4 Z_6$$

The predictive responses from the model are as tabulated below:

MODEL RESPONSE SYMBOL	RESPONSE FROM PREDICTIVE MODEL
Y <sub>m1</sub>	42.4
Y <sub>m2</sub>	35.0
Y <sub>m3</sub>	32.9
Y <sub>m4</sub>	24.5

$Y_{m5}$	20.9
$Y_{m6}$	15.2
$Y_{m7}$	43.4
$Y_{m8}$	35.5
$Y_{m9}$	33.4
$Y_{m10}$	24.9

**Testing model adequacy**

The t-test was the tool utilized in assessing the adequacy of the model. The two hypotheses of emphasis were that:

- (1). There is no significant difference between the experimental and predicted compressive strength values of the MS-RHA concrete, at 95% accuracy, for the null hypothesis ( $h_0$ )
- (2). There is a significant difference between the experimental and predicted values of the compressive strength of MR-RHA concrete at 95% accuracy, for the alternate hypothesis ( $h_i$ ).

Let  $Y_E$  represent experimental responses,  $Y_M$  be model responses, and  $N$  be the number of observations, hence:

$$D_i = Y_E - Y_M$$

Given that:  $D_A$  (mean of difference  $Y_E$  and  $Y_M$ ) =  $\frac{\sum D_i}{N}$  (32)

$$S^2 \text{ (Variance of difference of } D_i \text{ and } D_A) = \frac{\sum(D_A - D_i)^2}{N-1}$$
 (33)

$$t_{calculated} = \frac{D_A \times N^{0.5}}{s}$$
 (34)

Results are as tabulated below:

Table 9: Student t-test for the optimization model

Control points	$Y_E$	$Y_M$	$D_i = Y_E - Y_M$	$D_A - D_i$	$(D_A - D_i)^2$
C1	42.37	42.40	-0.03	-0.03	0.0009
C2	35.00	35.00	0.00	-0.06	0.0036
C3	32.89	32.90	-0.01	-0.05	0.0025
C4	24.51	24.50	0.01	-0.07	0.0049
C5	20.95	20.90	0.05	-0.11	0.0121
C6	15.17	15.20	-0.03	-0.03	0.0009
C7	43.37	43.40	-0.03	-0.03	0.0009
C8	35.52	35.50	0.02	-0.08	0.0064
C9	33.38	33.40	-0.02	-0.04	0.0016
C10	24.88	24.90	-0.02	-0.04	0.0016
$\sum D_i$			<b>-0.06</b>	$\sum (D_A - D_i)^2$	<b>0.0354</b>

From Equations (32) to (34):

$$D_A = \frac{\sum D_i}{N} = \frac{-0.06}{10} = -0.006$$

$$S^2 = \frac{\sum(D_A - D_i)^2}{N-1} = \frac{0.0354}{10-1} = 0.00393 \therefore s = 0.0627$$

$$t_{calculated} = \frac{D_A \times N^{0.5}}{S} = \frac{-0.006 \times 10^{0.5}}{0.0627} = -0.303$$

Allowable total variation in t-test:

Degree of Freedom = N – 1 = 9

5% significance for two-tailed test = 2.5% = 0.025

∴ 100% – 2.5% = 97.5% = 0.975

From t-table (see Appendix A),

Allowable total variation in t-test =  $t_{(0.975, N-1)} = t_{(0.975, 9)} = 2.262$

Since  $t_{calculated} < t_{table}$ , we accept the null hypothesis and reject the alternate hypothesis.

#### IV. CONCLUSION

On the strength of the research results, it can be concluded that:

1. RHA and MS can simultaneously replace OPC in concrete.

2. The Osadebe’s mathematical model can be used as a predictive tool for RHA – MS concrete compressive strength.
3. The highest compressive strength predicted in this work is 35.0N/mm<sup>2</sup> corresponding to a water/cement ratio of 0.55 in a mix ratio of 0.55:1:1:2 for a 10% replacement of OPC with 5% each of RHA and MS.
4. The compressive strength predictions ranged from 35.0N/mm<sup>2</sup> to 15.2N/mm<sup>2</sup>, indicating that the RHA-MS concrete can be used as structural as well as mass concrete.
5. Cost saving of 10% can be achieved for OPC in concrete works.
6. Furthermore, it has been established from this work that structural concrete can be achieved from a multivariant binder using more natural occurring and eco-friendly admixtures while maintaining the same strength and ensuring environmental sustainability.

#### APPENDIX A

t Table

cum. prob one-tail two-tails	<i>t</i> .50	<i>t</i> .75	<i>t</i> .80	<i>t</i> .85	<i>t</i> .90	<i>t</i> .95	<i>t</i> .975	<i>t</i> .99			
			<i>t</i> .995		<i>t</i> .999		<i>t</i> .9995				
	0.50	0.25	0.20	0.15	0.10	0.05	0.025	0.01	0.005	0.001	0.0005
	1.00	0.50	0.40	0.30	0.20	0.10	0.05	0.02	0.01	0.002	0.001
df											
1	0.000	1.000	1.376	1.963	3.078	6.314	12.71	31.82	63.66	318.31	636.62
2	0.000	0.816	1.061	1.386	1.886	2.920	4.303	6.965	9.925	22.327	31.599
3	0.000	0.765	0.978	1.250	1.638	2.353	3.182	4.541	5.841	10.215	12.924
4	0.000	0.741	0.941	1.190	1.533	2.132	2.776	3.747	4.604	7.173	8.610
6	0.000	0.718	0.906	1.134	1.440	1.943	2.447	3.143	3.707	5.208	5.959
7	0.000	0.711	0.896	1.119	1.415	1.895	2.365	2.998	3.499	4.785	5.408
8	0.000	0.706	0.889	1.108	1.397	1.860	2.306	2.896	3.355	4.501	5.041
9	0.000	0.703	0.883	1.100	1.383	1.833	2.262	2.821	3.250	4.297	4.781
11	0.000	0.697	0.876	1.088	1.363	1.796	2.201	2.718	3.106	4.025	4.437
12	0.000	0.695	0.873	1.083	1.356	1.782	2.179	2.681	3.055	3.930	4.318
13	0.000	0.694	0.870	1.079	1.350	1.771	2.160	2.650	3.012	3.852	4.221
14	0.000	0.692	0.868	1.076	1.345	1.761	2.145	2.624	2.977	3.787	4.140

16	0.000	0.690	0.865	1.071	1.337	1.746	2.120	2.583	2.921	3.686	4.015
17	0.000	0.689	0.863	1.069	1.333	1.740	2.110	2.567	2.898	3.646	3.965
18	0.000	0.688	0.862	1.067	1.330	1.734	2.101	2.552	2.878	3.610	3.922
19	0.000	0.688	0.861	1.066	1.328	1.729	2.093	2.539	2.861	3.579	3.883
21	0.000	0.686	0.859	1.063	1.323	1.721	2.080	2.518	2.831	3.527	3.819
22	0.000	0.686	0.858	1.061	1.321	1.717	2.074	2.508	2.819	3.505	3.792
23	0.000	0.685	0.858	1.060	1.319	1.714	2.069	2.500	2.807	3.485	3.768
24	0.000	0.685	0.857	1.059	1.318	1.711	2.064	2.492	2.797	3.467	3.745
26	0.000	0.684	0.856	1.058	1.315	1.706	2.056	2.479	2.779	3.435	3.707
27	0.000	0.684	0.855	1.057	1.314	1.703	2.052	2.473	2.771	3.421	3.690
28	0.000	0.683	0.855	1.056	1.313	1.701	2.048	2.467	2.763	3.408	3.674
29	0.000	0.683	0.854	1.055	1.311	1.699	2.045	2.462	2.756	3.396	3.659
40	0.000	0.681	0.851	1.050	1.303	1.684	2.021	2.423	2.704	3.307	3.551
60	0.000	0.679	0.848	1.045	1.296	1.671	2.000	2.390	2.660	3.232	3.460
80	0.000	0.678	0.846	1.043	1.292	1.664	1.990	2.374	2.639	3.195	3.416
100	0.000	0.677	0.845	1.042	1.290	1.660	1.984	2.364	2.626	3.174	3.390
z	0.000	0.674	0.842	1.036	1.282	1.645	1.960	2.326	2.576	3.090	3.291
	0%	50%	60%	70%	80%	90%	95%	98%	99%	99.8%	99.9%
	<b>Confidence Level</b>										

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## Environmental Policy of Solid Urban Waste and the Socio-Environmental Impacts in Baturité, Ceará, Brazil

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Received: 20 Jul 2022,

Received in revised form: 05 Aug 2022,

Accepted: 10 Aug 2022,

Available online: 15 Aug 2022

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**Keywords—** Urban Solid Waste. Environmental Policy. Garbage Dump. Baturité-CE.

**Abstract—** The research had as its primary objective to understand, from the socio-environmental perspective, the limits, and possibilities of the dynamics of solid urban waste treatment in the municipality. Methodologically, this research study is an exploratory case study, of a basic nature with a qualitative approach. For data collection the techniques of direct observation and non-directive interview were applied to collectors/ dwellers of the municipal dump of Baturité-CE. As for the analysis techniques, content analysis and socio-historical contextual narrative discourse were used. As conclusive results, the study found that the collectors / residents live in a situation of socio-economic and environmental vulnerability, without having a collective organization to support them, including the absence of municipal government in relation to support these professional collectors of urban solid waste in general and in the locus of the research, specifically.

## I. INTRODUCTION

Currently consumerism has become a constant practice in capitalist society. The way of life based on the growing propensity to consume, mostly superfluous, due to its symbolic meaning to achieve a need for pleasure, are often induced by a mass communication: media system means that has characteristics of reaching at the same time many receivers, starting from a single sender disseminating information to the high degree of consumption.

Following this reasoning, we observe that the increase in population leads to a large mass of people consuming in high quantities, products with no durability potential accommodated in long life containers. The "leftovers" from this unbridled consumption accumulate without consumers being concerned about their destination, causing an excessive generation of Urban Solid Waste - USW's. In the municipalities, this problem is crystal clear, since. "Waste generation is directly proportional to the total income of the municipality, i.e., the larger the city and the higher the income, the more waste will be produced by them" [1].

However, we can affirm that, whether in large or small cities, the increase in the generation of SUW's, as well as the absence of specific places, separated from the population centers, that present prerequisites for the disposal of these residues, avoiding and/or reducing the great contamination of soils, water resources, and air, has become a problem of great administrative repercussion.

In the municipality of Baturité the presence of open-air garbage is constant. To the people, the garbage dump is a place that many of us would never pass by, not

even close, because it is a place where we can't go anywhere else - smelly and horrendous. There are miserable people, poor wretches, underprivileged people, and other adjectives that people use when referring to those who deal with garbage. These stereotypes are based on prejudice and have perpetuated errors of judgment for many years, which only contribute to ineffective communication and personal relationships.

Based on this premise, many municipalities in Brazil, such as Baturité, in the state of Ceará, present situations of negative socio-environmental impacts, associated with anthropological actions related to USW's, for not having adequate management and management for their waste. Therefore, it is essential to alert both the municipal government and the population of this municipality to reflect on our attitudes towards the natural environment and the "garbage" that is produced.

The problems arising from the lack of proper attention to the USW's, are easily attributed to the demographic growth, the lack of awareness and environmental education of the population as well as visitors to the Maciço de Baturité; to the detriment of the conservation of the natural environment, have made these factors aggravating this problem.

It is necessary to show society the garbage scenario, where those people are inserted, the subhuman working conditions, housing, health, in the sense of public power support, and their perspectives for improvement of this environment. What do these waste pickers think about their working conditions? Why don't they look for another way to survive without depending on the absurd scenario



that those ramps are?

Since this is a theme related to our reality, the impacts that these dumps cause are the result of an absent and poorly managed public policy, resulting in a vulnerable situation for the collectors' way of life in that region.

In turn, both the government and the population, in general, need to assume their responsibilities regarding the minimization of this problem, from the public instance, yes, with programs of Environmental Education - EE consequent and concrete actions of management and proper waste management. Thus, such research was characterized in the search to understand and deepen the study on RSU's, sought the investigation beyond the consultations of documents from the competent bodies in the three spheres: Federal, State and Municipal - ABNT 10004/2004 Brazilian Standard; PNRS; PERS; PNEA; PDR<sub>Maciço</sub>; PPA<sub>Maciço</sub>; Organic Law, PA the City of Baturité-Ceará.

## II. THEORETICAL AND METHODOLOGICAL PROCEDURES

At the current juncture, Baturité has not yet realized what public policy dictates. And the elaboration of the PRRS of the Massif has not been properly accomplished. It should be noted that Baturité receives SUW's from neighboring municipalities, deposited in the open-air dump.

The environmental actions officially proposed by the municipality - see Municipal Organic Law; Law 160/2001; Law 1.221/2003; Law 1.615/2013, and PDR, 2004 - are not known by the population, therefore, without the necessary resonance in society. In fact, the proposals of the municipal government in "practice" still do not mean "public policy," since the "public" is not aware of them.

Thus, it is expected that the public authorities - schools - civil associations, and society in general, invest in environmental practices that can concretely minimize the impacts resulting from the lack of socio-environmental awareness of the population, as stipulated in law 1.221/2003.

The Ágape Institute counts on partnerships with small companies and the active participation of young people from schools and the community in general, besides building a bridge with Unilab. The educational action of the institution focuses on the development of social work in the environmental area through lectures, courses and workshops involving the theme, technical guidance for the realization of EE, especially in the APA Baturité; activities that, primarily, would be the responsibility of the public authorities.

There is also in the municipality the AACEMB - Associação dos Agentes de Endemias do Maciço de

Baturité, which is a private association, founded in 2012, which develops, for example, the sustainable project of recycling materials, turning them into art. The project works with reusing tires, turning them into trash cans or plant pots; pet bottles that become vases... among others. All the products are displayed in public spaces, in the city squares, to be sold as income for the project's logistics, and to count on several partners: merchants and people from the community.

These examples demonstrate the need to rethink what has been done so far and what needs to be changed for the transformations necessary to maintain and improve the natural environment to happen in practice.

According to [2] the waste collectors are "people condemned to live at the margins of the capitalist accumulation system", being seen as non-citizens, unnecessary to the system: they do not produce, do not consume, and are still "stigmatized by the fact that the marginality and precariousness" of their living conditions are interpreted as an individual will not to work, and not as an imposition of the increasingly selective and exclusionary productive system.

Thus, these professionals are marked by precariousness, prejudice, and devaluation.

For [3] they are "careless-looking" people who, literally, live inside the garbage.

These are provocative views, for exposing in a public way, poverty. Misery. Socially deprived subjects, placed at the margin. Since ancient times they have been surviving on the leftovers of those who consume and discard what they consider useless, being called garbage (solid waste), in contemporary times. These stereotypes are based on prejudices that, for many years, have perpetuated errors of judgment that only contribute to ineffective communication and social-political relations.

In this context, they find themselves in the garbage dump, where they perform their labor as an act of resistance to the exclusion and insecurity caused by the "transformations of the globalized but unfair world", forcing them to live in a situation of extreme vulnerability. They are people who have been unemployed for a long time, come from the agricultural and cattle raising sectors, former prisoners, and/or come from places of extreme poverty, and are on the verge of indigence. As a rule, they have little or no schooling, or no professional training.

[3], further states that:

The collectors of the Dump recognize that their working conditions are precarious, considering the lack of

personal protective equipment, the lack of a suitable place to work, such as covered sheds, which makes it difficult to work in the afternoon, due to sun exposure. At night, there is no lighting, and, in periods of rain, they end up working inside humidity.

For [4] the work performed by the collectors is considered precarious, due to inadequate conditions, with a high degree of danger and unhealthiness, without social recognition, with risks that are often irreversible to health, and with a total absence of labor guarantees.

[5] affirms that the Industrial Revolution, in the XVIII century, allowed the development of several industries, giving rise to new material artifacts and increasing the generation of several types of waste,

[...] with emphasis on industrial or synthetic products; products bought, used, and discarded; demanding increasing amounts of raw materials, subtracted from nature; many of them non-renewable; and the large increase in their chemical compositions, which are now very diverse, making their natural degradation and reabsorption difficult. Many of them have a short time of use, as is the case of batteries, electro-electronic products, and the most varied packaging, notably, polymeric packaging, such as plastic and plastic-cellulose.

This confirms that since the Industrial Revolution human actions in relation to consumption have been unrestrained, increasing, uncontrollably, the production of waste with final disposal in an inadequate way where everything ends up in the dump.

For the author, all human activities - anthropic - produce residues that induce enormous difficulties at the time of their treatment and final disposal. Therefore, there is a major problem at hand: municipal governments depend on the resources involved, as high investments are required, to remunerate people; training and qualification, as well as for the purchase of equipment and the cost of the RS's management system.

However, it is the municipality that generates the waste that must take responsibility for the production and final disposal of the garbage. The photographic records and the interviews with the garbage collectors show that the municipality must fulfill its role according to what is stated in the legislation, involving the whole society to do its part in a shared manner.

[6] explains that such a process enables a uniform and harmonious development among all stakeholders, to achieve the proposed objectives, appropriate to the needs and characteristics of each community. For this to occur, it is necessary dedication to think about the planning model and establish strategies to execute and program controls in the action that will be developed.

Another fact, facing the socio-environmental issue, is the continuous burning of garbage, preventing the reuse of these materials, because their sale as waste is compromised. The materials cited by the collectors as good and considered as profitable are plastic bottles, rubber, iron, and other materials such as - "the melissa", aluminum and dry plastic.

After a rough, urgent, competitive selection with their "peers"; the collectors in their "homes" make a "finer" selection of what really has value and will to provide them with a livelihood. It is necessary to emphasize that all this work is also developed among various materials of inflammable compositions, with constant burning of garbage, making it very difficult to handle the selection of materials that make it possible to generate income. Some waste pickers don't know or don't want to understand these processes that can harm their health. They are subjected to intense heat, both from exposure to the sun and the heat that is expelled from the ground because of the burning and decomposition of the garbage.

During the interviews at the dump, we witnessed waste pickers collecting waste "for recycling" in the center of the dump without any working conditions and without any safety. This happens because the waste arrives mixed and they must get there "on the ramp" - as they say - practically diving into the garbage, to pick up everything that seems to fit them. And, after a tiring day, they think about what might come the next day, so that they can start again another process of waste separation. The pickers are not concerned about whether they are sharing the scenery with the garbage, their concern lies in their ability to collect as much garbage as can be stacked.

We observe many discarded tires, which becomes a serious environmental problem. Even though they are classified as inert, they are undesirable residues from the environmental point of view. When discarded in rivers and lakes, they can contribute to silting and flooding. When they

are burned, they produce extremely toxic emissions, due to the presence of substances that contain dioxins and furans.

When disposed of inappropriately, for example, in landfills, they allow water to accumulate inside and can contribute to the proliferation of mosquitoes that transmit dengue and cholera. The glass rejects are quite visible on the ramp, and that their decomposition takes a long time to deteriorate. It is known that the composition of glass is resistant enough to understand that it is not reabsorbed by nature. The lifetime of this material is 4,000 years to disintegrate by erosion and/or action of chemical agents [7].

In the methodological scope, this work aims to address, qualitatively, a case study. It is characterized by understanding from the socio-environmental perspective, the limits, and possibilities of the dynamics of treatment of solid urban waste in the city of Baturité- Ceará. To delineate the way of life of the collectors/landfill dwellers, and to observe how the issue of environmental education of the municipality of Baturité- Ceará is today.

The methodological strategies employed for the development of this research follow the scientific method proper to the empirical-formal sciences. The method is understood as scientific the strategic paths used to investigate a research object in a systematic way through theory, methodology and peculiar technical procedures, adopted and accepted by the academic-scientific community [8]; [9].

As for the objectives, this study is of exploratory nature, because, in addition to exploring a concrete and verified reality, exploring specific facts, enabling the familiarization of the theme from the specific and scientifically studied contents. Exploratory research seeks to provide "greater familiarity with the problem, with a view to making it more explicit" [10]; [8].

It is worth mentioning that the field diary was very useful for noting details and curiosities during the research. A field diary is a complex instrument that allows the detailing of information, observations and reflections suggested during the research or moment observed [11].

Regarding the technical procedure adopted, the case study, we inform that the case chosen, among many others, were the socio-environmental impacts from solid urban waste from the dump of the city of Baturité, State of Ceará. According to [12] this procedure corresponds to an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between the phenomenon and the context are not clearly defined.

Thus, the case study was structured with the use of individual interviews, guided by a semi-structured script

and direct observation, as techniques for collecting data and information. According to [13], in the individual interview, the interviewer structures a script that will serve as a guide so that he can get the answer that reflects the position of the interviewee and that helps him to answer the investigated problem.

Therefore, we investigated the destination of the garbage generated and collected in the municipality, to find out where and how this waste is disposed of by the competent body. A survey of the environmental agencies and their attributions was also carried out.

These techniques were important because the data analysis and treatment were supported in a qualitative way and presented through discursive language. About the treatment, the techniques of content analysis were applied, in which it was carried out comparative reading of the quotes from the research subjects and contextualized sociohistorical discourse analysis. The results obtained with the interview were evaluated in parallel to the notes made in the field diary instrument during the investigative process.

The field research was carried out at the dump of Baturité located near the margins of the CE-021 that connects the CE-060 to the other municipalities of the Massif. It is approximately 3 km away from the municipal center.

### III. RESULTS AND DISCUSSION

The results observed during the visits to the dump were transcribed and analyzed according to the mentioned approach and correlated to the characterization of the socio-environmental impacts caused by the garbage in the interviewees' daily lives, as well as in the surrounding environment.

Especially, with the waste pickers, we analyzed the occupational risks, their perspectives for improvement, among others, focusing on the discourse of those subjects.

The first impact that distressed us was the sequence of several trash chutes and a lot of smoke all the time, making it impossible to be present at the site.

The collectors are forced to live with this pollution, with health risks: respiratory, lung, and, mainly, eye problems due to the gases that are eliminated by burning the garbage.

When we entered the dump, there were scavengers in the middle of the ramps collecting waste, i.e., their livelihood, all without PPE. We took photographs with the permission of the waste pickers, and we registered clippings of the place that caught our attention to assess the social and environmental context of those involved in the activity of

waste collection. In addition, we conducted interviews that took place at various stages and during visits to the research site.

Initially, the research sought to know the profile of the collectors and through it, we obtained information from the subjects from their free speech. Thus, it was delineated from: sex, age, place of birth, education, marital status, place of residence, type and conditions of housing, how long they have been performing this professional activity, type of recyclable material, the most profitable and individual income, where they collect this material, receive any benefit, have ever acquired any disease, suffered any kind of verbal or physical violence, ever suffered prejudice, have children and if they are involved in the collection activities, if they are associated with any cooperative, if they have support from public authorities or the community.

For the socioeconomic characterization, the first point detected is that 70% of the interviewees were male and 30% were female (Figure 1-A). All inhabiting shacks in recyclables, especially flammable ones, in the dump itself. Regarding the age of the waste pickers interviewed, we observed that a percentage of 40% of the waste pickers are between 28 and 38 years old (Figure 1-B).

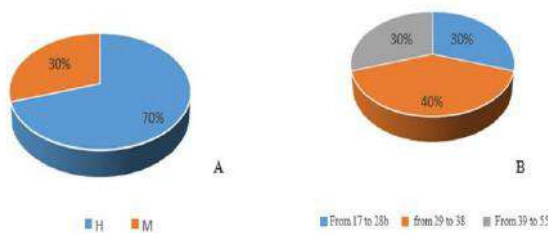


Fig. 1: A - n° of interviewees per gender. B - age range of the waste pickers at the dump.

Source: Elaborated from the interviews with the catadores

As for the pickers' place of birth, it was found that 74% are children of Baturité, and most were residents of the Candeia district - a rural area of the municipality - while 26% were from Quixadá (Figure 2-A). Regarding the collectors' schooling, it was found that 70% can neither read nor write, while 20% only know the name, but cannot read, and 10% have incomplete elementary school education (Figure 2-B).

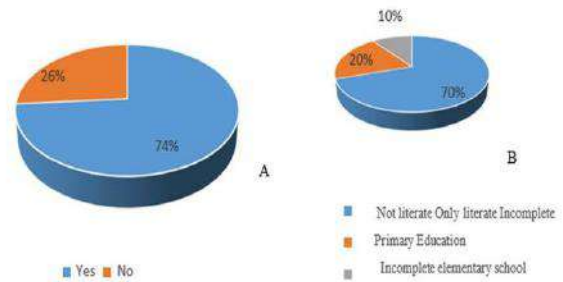


Fig. 2: A - Place of birth. B - Education of the collectors.

Source: Elaborated from the interviews with the catadores

As far as the place where the interviewees live is concerned, they sleep at their own workplace, that is, at the garbage dump - in a shack built out of tin foil collected on site (Figure 3).



Fig. 3: Home of the garbage collectors.

Source: Personal archive.

According to the reports, there are two residents who live in Candeia and return to their homes on weekends or on days that are pre-established by them. According to them, "the house there" is made of mud, and they all justify staying directly in the shack "because nobody invades and takes the space". They don't have bathrooms for their special needs, no running water - they buy water - and no energy. Inside their houses the temperature is very hot, because the walls are made of tin, the partitions are made of cloth and most of them sleep on the floor on a mattress.

Figure 4 demonstrates how long they have been practicing the collection activity at the dump. With 80% stating that they work with waste picking/inhabit the site in a range of ten to seventeen years; the remaining 20% claim to have been in the waste picking activity for five to nine years and reported that they "accompanied their mother" - who has been there the longest, since childhood. The pickers who have lived the longest, say that they have been picking

up trash since the first dumpsite that appeared in the municipality and that when they rented another piece of land, they came in search of their livelihood. "At first it was difficult because it was far from home," but with sometime later they began to make their shacks to store the recycled materials and then "it was staying" until it became a fixed dwelling.

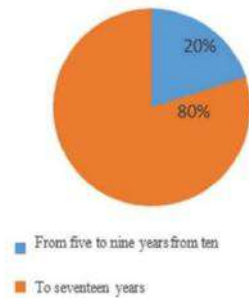


Fig. 4: Length of time working as a garbage collector.

Source: Elaborated from the interviews with the catadores.

As for the materials collected for sale, most "prefer" aluminum, melissa (characterized by various types of rubber, e.g., slippers), thick plastic (characterized by packaging, mainly of hygiene and cleaning products, e.g., shampoo bottles), PET (characterized by soda and oil packaging), iron and copper scrap, and glass. There is a predilection for aluminum because of the price paid, but this "little has come locally", therefore, the collection depends on what is available now, only the cardboard is not collected because of the organic mixture that ends up damaging it for recycling or burning.

Since everyone works, individually - "here the couple is uno!" - some claim to get, monthly, "half of a minimum wage." Others even "exceed this", earning about R\$ 500.00 per month. The value obtained from the sale of the materials is insufficient to support their families. The waste pickers have no fixed buyer, they sell their material according to the arrival of different buyers and for "unfair prices".

It was noticed that the average income they claim to take from the dump, depends on the pace and what "garbage" arrives, the more garbage, the higher the income. A few believe that it is enough, because they have assistance from the family scholarship, but most do not receive any benefit. Waste collection is done at their own workplace, at the garbage dump. And they do the separation-recycling in the shack where they live.

When asked about health problems due to their frequent contact with garbage, they said that "no serious

illnesses", but most said they suffer from headaches, fevers, stomach aches, coughs, and flu, which are constant, "due to exposure to the sun". Only one resident said he had an operation for an ulcer.

When asked if they have suffered verbal or physical violence because of their conditions, the majority said yes. The total of the interviewees claim that they suffer both verbal and physical violence, because of the "disputes", for example, about the dumpsters of the

garbage. Currently, they have had to organize themselves so as not to have more fights, separated by cities, about the origin of the garbage. For this, some of the interviewees reported that there was an agreement among them, in the municipal forum, to divide the collection days for each picker/ resident.

As for suffering prejudice, 90% of the interviewees consider that when they say they "work at the dump," many "people" suggest another job, but at the same time, they answer "I think it's better to be at the dump than somewhere else. The other 10%, say that yes, they have suffered when they say that they work at the "ramp" now of some purchase in certain stores, in the "credit issue" (Figure 5). When asked if they had children and if they are involved in the collection activities, most said that they do not involve children in the collection, but sometimes some from the neighborhoods show up to "make mischief".

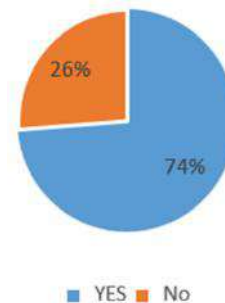


Fig. 5: Prejudice suffered for simply being known as a waste picker

Source: Elaborated from the interviews with the catadores

The interviewees affirmed that there is no cooperative. Some believe that individual work becomes more profitable; if they had a "cooperative, it wouldn't work because some can rely on each other's work" and prefer to go it alone. When asked how important the selective collection in a cooperative was, most answered that it would be "a delay of life".

The prospects of these collectors are minimal because they claim that at the dump "nothing ever changes", they always say that they are used to this situation. About

the support offered by the public authorities or the community to the class of collectors, they say that they are forgotten, that there is a lack of support and that they have never received visits from doctors, health agents, and much less from Social Action.

It is worth noting that the process of urban occupation and the use of rudimentary techniques by agriculture have contributed to the degradation of natural resources. This is contributing to the reduction of the planting areas, resulting in a decrease in the productivity of the agricultural sector, which is one of the pillars of the region's economy, occupying a large part of the active labor force [14]; [15].

Baturité, through the municipal law No. 1.615/2013, which provides for the Multi-Year Plan - PPA of the municipality for the period 2014-2017, with strategic basis focused on the improvement and quality of life of the population, provided for 2017 the end of the open dump. And guided: Improve the conditions of infrastructure, urban planning, basic sanitation, essential services, providing residents with the appropriate habitability and displacements and urban development in a rational and balanced manner. The plan intended to promote the practice of environmental protection and preservation [16].

The municipal law n° 1.160/2001 - Environmental Policy of the Municipality of Baturité - propounds, for the exercise of its constitutional competence and in the terms of the Organic Law, that it will be responsible for the creation of means, instruments, and mechanisms that ensure effectiveness in the implementation and control of policies, programs, and projects related to the environment (Article 3°):

- XI - To ensure the environmental sanitation in Baturité, in a broad way, covering the aspects of water supply, sanitary sewage, collection, treatment and final disposal of solid residues, drainage, sanitary education, incineration of hospital residues, among others; XIII - To ensure permanently the environmental education as an instrument of awareness, citizenship formation in all levels and age groups.

In this way, it proposes to guarantee to the citizens a better quality of life for the exercise of citizenship in general, establishing its principles, objectives, and instruments, emphasizing the responsibilities of the

government. This law also deals with the management and destination of solid and semi-solid waste, which must follow a technical approach with differentiated collection and integrated treatment.

For this collection to be properly separated, an integrated waste transportation system is required. The public authority is responsible for a technical study, prepared by the competent municipal agency and approved by the Municipal Council of Environment and Urban Development (Article 43°, §3°). In this way, the municipality must seek appropriate technologies that are less costly to implement and operate; maintenance; in minimizing health risks; and to the wellbeing of the community and environmental quality.

On the other hand, the traffic of garbage collection vehicles should be avoided, especially the loads composed of by-products or hazardous materials through permanent preservation areas, as well as the transit of trucks through densely populated areas (Article 43°, § 4°). Regarding reuse, the pruning's, and remains of trees, whenever possible, will be transformed into charcoal for certain companies such as: bakeries, potteries, and ceramics (Article 43°, § 3°).

According to the referred law, the Executive Branch shall maintain a system of selective collection of garbage, with separation of waste at its origin, into two distinct classes - inorganic waste and organic waste - aiming at its recycling (Article 44°). Under these perspectives, the competent body will maintain the collection of dry residues and they will be independently transported for recycling purposes, and the wet residues will be collected and forwarded for final disposal.

Consequently, the municipality may be committing an infraction by omission with what is proposed in PERS in its articles 51 to 53, by not having a survey of possible contamination of the water table in the locations of its dumps [17].

Thus, the agencies responsible for enforcement, together with civil society, should act effectively to seek ways to manage the RSU's of Baturité, with responsibilities and efficiency suitable for environmental protection.

To comply with this legislation, the Baturité City Hall, aiming to encourage shared responsibility with the population, seeks a partnership with the Education and Sports Secretariat, understanding that formal education can contribute to attitudes that aim to improve society's quality of life.

Consequently, he sanctioned a new law No. 1.221/2003, which provides for environmental education in schools of the Municipal Education Network. Thus, EE gains prominence in the school network, bringing a

proposal to stimulate students to defend and preserve the environment for present and future generations, emphasizing the curriculum composition (Article 1°).

The Municipal Department of Education and Sports is responsible for the adequacy of programmatic content and interdisciplinarity of the school curriculum, in accordance with the law No. 9.795, 1999 (Article, 4°). Thus, the programmatic content relating to EE has an instructional and educational character, without, however, failing students (Article, 3°). This demonstrates a timid concern of the government with learning and deepening the concepts of Environmental Education, enabling sensitization of students to change their attitudes and behaviors habits and performance of sustainable actions in society. Moreover, the law does not present indications for a continuous or even punctual practice, such as the organization of environmental fairs and social projects in schools involving the community.

Among the strategic areas, the "Area-Program 5" - Regional Human Support Infrastructure, focusing on the intervention "Sanitary Sewage with the elaboration of the Massif Regional Plan of Sanitary Sewage/PRES MACIÇO and recovery and expansion of the sanitary sewage systems (networks and simplified systems) of the Massif" stands out as relevant because it deals with SR's. Still on the intervention of the regional development plan, it discusses the elaboration of the Regional Plan of RS's of the Massif/PRRS MACIÇO and implementation of the regionalized system of collection and destination of garbage in the Massif [18].

Starting from the intervention on the SR's of the PDR, the city of Baturité, would participate, with other municipalities in the region, in a public consortium based on the Federal Law No. 11.107/2005 for the creation of a regional landfill [19]. This consortium was formed in 2007, through AMSA aiming at the management and administration; associated public services, for the construction, maintenance, and management of the regional sanitary landfill, located at the headquarters of the municipality of Baturité.

#### IV. CONCLUSION

After the investigative process undertaken in this research including: the field visits, the contact with the catadores/waste pickers, the informal relationship during the visits, and the analysis of the documents, it was possible to have a comprehensive view of the management situation of the USW in Baturité and of the situation of those subjects inserted in the dump.

It was also observed that the waste pickers are in a situation of social vulnerability. They live in a state of extreme need. They live in the most unhealthy and dangerous conditions possible. They live in the same place where they work, without any sanitary conditions. They live and coexist with garbage. Their "survival" is determined, solely and exclusively, by the materials that they collect from that environment and that can be recycled and sold; even if the "market value" is not at all adequate, as is their income. However, we can see that this is one way, if not the only way, found to deal with the capitalist and consumerist society. For this is how the waste pickers find a way to insert themselves into it, a way to establish themselves socially and in the labor market, even if in a cruel way.

The study also allowed us to conclude that, among the difficulties encountered by the collectors of the garbage dump, the lack of water and energy in that environment, and the lack of attention to health by the public authorities and the subjects themselves, due to the problems that arise from the presence of the garbage, with its various vectors, stand out.

Still on the financial aspect, besides leading them to a lack of income for an adequate support for the family, they face great difficulties for not having a fixed buyer, being at the mercy of a buyer who "dictates the rules of the market".

It is worth pointing out that the insecurity of living in a shed on their own site is not the only one of this situation. Much worse is not being able to leave for a long time, lest they be invaded by others.

It is obvious that the lack of organization of the subjects and the absence of the municipal public power in minimally organizing and valuing them, leads the collectors/residents to face several social and environmental problems for living together with the garbage, showing that men and women in full productive life, degrade themselves, together with the garbage they survive on.

It is also necessary to say that this proposal is only the "initial step" of a journey that, starting by getting it right, should be continued with more in-depth studies on the environmental issue involving both the municipality of Baturité and the other municipalities of the Maciço de Baturité Region, State of Ceará in Brazil.

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## Quality of Life of Military Policemen in a Western Amazon State in Times of the Covid-19 Pandemic

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Received: 18 Jul 2022,

Received in revised form: 06 Aug 2022,

Accepted: 11 Aug 2022,

Available online: 16 Aug 2022

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**Keywords—** *Quality of life, Covid-19, military police, Pandemic, Rondônia.*

**Abstract—** *Objective: To analyze the quality of life of active military police in a state in the Western Amazon during the Covid-19 pandemic. Methodology. This is a descriptive, cross-sectional field study, with a convenience sample, non-probabilistic and with a quantitative focus, with 358 active PMs in the PMRO. A self-report questionnaire was used to collect sociodemographic data and health conditions. To assess QOL, the WHOQOL-Bref questionnaire was used, consisting of 26 questions related to the physical, psychological, social relationships and environment domains and their facets. Results: Analyzing the sociodemographic characteristics, the age variable obtained (39.21 ± 6.41) years and (61.17%) of the PMs were less than 40 years old. The variable length of service was (15.44 ± 7.64) and (78.21%) of the police officers had less than 20 years of experience in the police service. The working hours obtained (6.87 ± 2.04) and (29.10 ± 80.79) days away from work due to NCDs or Covid-19. In terms of education, (52.79%) have a college degree, (69.27%) are married, (47.49%) are warrant officers and sergeants with an income between 5 and 7 minimum wages, (49.44%) work 6 daily hours, (43.02%) were removed from the service due to CNCD and (34.08%) due to Covid-19. The general quality of life obtained an average of (15.21 ± 2.00). Among the WHOQOL-Bref domains, the highest score was for the psychological domain (16.01 ± 2.11) and the lowest for the environment (14.20 ± 2.28) and the self-assessment of QOL was (14, 97 ± 2.69). Conclusion: The quality of life has satisfactory levels, despite chronic health conditions and the*

*multidimensional character of quality of life, with (76.8%) of the PMs evaluating their QOL as very good and good and (65.8%) being very satisfied or satisfied with their health, with the highest scores in the social relationships domain and the lowest in the environment domain. For the facets, the highest scores were for mobility, self-esteem, sexual activity and the lowest scores were for negative feelings, dependence on medication or treatment, and finally, pain and discomfort, data that are corroborated by the self-report of NCDs and Covid-19.*

## I. INTRODUCTION

Currently, the occupational and working conditions of military police officers (PMs) have been identified as high risk for health, due to the specificity of police work and more recently because they are responsible for social control and restriction of the movement of people. Action aimed at addressing the impacts caused by Covid-19. The PMs work daily in ostensive/preventive policing, in the preservation of public order and with the arrival of the coronavirus pandemic, these public agents are directly involved in the fight and control of the Covid-19 pandemic. Nevertheless, this recent pandemic phenomenon has caused health aggravation, generated concerns in the work environment, absences from the service, mortality and reducing the quality of life of this class of workers.

For the military police, the high risk for infection by Covid-19 is associated with direct contact with the population, confined and crowded environments. In this sense, the new work dynamics during the pandemic period may have been a risk factor for physical and mental health, physical inactivity and the contagion by Covid-19. Furthermore, professionals working in public security are individuals prone to developing cardiometabolic and psychological pathologies whose main causes are physical inactivity and stress [1].

According to Arroyo [2] in a study with police officers from São Paulo, he found that the military police may have their health compromised, due to the fact that the night shift and extra shifts lead to loss of sleep and an increase in tobacco consumption. For the author, the work activity of the MPs is one of the most exhausting and stressful, because within the barracks there is a high professional demand, combined with the increase in daily violence, working conditions, professional technical preparation and insufficient personal help, representing an imminent danger to the emotional and mental health of these individuals [3]. These public security activities demand a degree of physical and mental exhaustion of these servers, contributing to the decline of physical and mental health, and in contrast, these subjects seek a better quality of life. In this regard, social changes have influenced the individual and collective health of

individuals and physical activity has become an important modulating tool for health and quality of life [4].

Nowadays, the search for quality of life (QOL) is increasingly in vogue, due to the Covid-19 pandemic that affected the entire world population. However, during this period of pandemic, a significant portion of the population was infected by the coronavirus and another portion lost their loved ones, affecting mental health and consequently the quality of life. In addition, even during this pandemic period, all people seek to seek a harmonious balance between physical and mental. Therefore, QOL “involves a complex interaction of biological, economic, social, cultural and lifestyle factors” [5]. This set of individual and collective parameters that provide health and well-being is fundamental for people's quality of life. Furthermore, in the field of public health, especially related to the impacts involving work issues within the barracks, the specific scientific literature on the military police theme encompasses specific work situations in the performance of their functions [6]; [7]; [8]; [9]; [10] and [11].

According to Nahas [12] the quality of life is the human condition resulting from a set of individual and socio-environmental parameters, modifiable or not, that characterize the conditions in which the human being lives. On the other hand, according to Barbanti [13] quality of life is a “general positive feeling and enthusiasm for life, without fatigue from routine activities. It is closely linked to the standard of living”. For Rodrigues [5], the term quality of life is being implemented in the work environment, where workers dedicate much of their time, however these individuals seek a more satisfactory quality of life in the place where they work.

For Zimmermann [14] “its estimate can guide the planning, evaluation and implementation of health technologies and policies”. This preventive behavior or balance can also be called a healthy lifestyle, which must be present in everyday life with family, friends, at work and in leisure time, however the pressures and demands of everyday life create stressful environments. Studies have “expanded the relevance of aspects, living conditions and lifestyles, especially when the concern is with aspects of promotion, health protection and risk prevention” [15].

However, for the improvement of the lifestyle, there must be behavioral changes in the habits of life and care of professionals and specialists in the areas of health.

Currently, the Covid-19 pandemic has contributed to the deterioration of the quality of life of individuals. In this light, Alvarenga et al., [16] aimed to evaluate the perception of quality of life of 35 teachers of both sexes from public and private schools during the Covid-19 pandemic. The WHOQOL-Bref was used as a research instrument, applied virtually through the Google Forms platform. The results found show the physical domain with 70.7 points, the psychological domain with 68.2 points, the social domain with 64.5 points and the environment domain with 64.9. The study concluded that the majority of the investigated teachers have suffered with the aspect of quality of life, with the social domain being the most affected.

Regarding the quality of life of military police officers, research is still scarce, however, there is evidence of high rates of illness, due to physical inactivity, sedentary lifestyle and irregular habits, which have contributed to the emergence of Non-Communicable Chronic Diseases (CNCD) and worsening of quality of life. life in this specific population [15]; [6]. However, the quality of life construct in military personnel is a contemporary approach, which takes into account several dimensions that are closely intertwined with health, professional, work and daily activities in the military environment. In this context, the “quality of life of military police officers is more related to social and psychological factors”[17].

However, the “work dynamics of police officers face some aspects that are essential for the promotion of quality of life”, as they are constantly away from the service due to various diseases derived from their professional activity [11]. In modern societies, work occupies a large part of human life, establishing in these workplaces a daily coexistence, dedication of strength, efforts and energy, but the work overload associated with inadequate conditions can compromise the health of these workers [15]. For Minayo et al., [10] the quality of life “can be influenced as a result of working conditions, such as long working hours, few hours of sleep and pressure on activity, which is common within the military police”. In this step, “the search for QOL is much sought after, as it is not only associated with the professional's well-being in the work environment, but with physical, mental and social health” [18]. In the professional environment, QOL is not just to provide the health and safety of the worker, it must contain occupational health or risk prevention actions focused on increasing the effectiveness and productivity of professionals, both in civil corporations and in military

institutions. , being a combination of actions by state entities, community, individuals and the health system [18]; [19]. In this sense, the measurement of quality of life within the military institution seems to be adequate, given that this diagnosis can result in improvements in institutional policies for the acquisition of new proposals for intervention in the health/disease process, as well as, in prevention actions, treatment and rehabilitation of these public safety professionals [20].

The main causes that make it difficult to improve the quality of life derive from the very specificity of the profession, with sleep deprivation during the work shift, rigid hierarchy, ergonomic factors, stress, daily living with violence and risk of death [11]. The lifestyle adopted by the military police, precarious working conditions and factors that generate stress, due to the constant risk of life, cause damage to health, as well as the dynamics of work itself, confronts some aspects that are essential. for the promotion of quality of life [6]; [7]; [8]; [9]; [10] and [11]. In this way, the quality of life “can be influenced as a result of working conditions, such as long working hours, few hours of sleep and pressure on activity, which is common within the military police” [10]. For the authors, the main causes that make it difficult to improve quality of life derive from the very specificity of the profession, with sleep deprivation during the work shift, rigid hierarchy, ergonomic factors, stress, daily living with violence and risk of death.

This stressful characteristic of being always in constant attention and alert during the service and in everyday life can be a risk factor to the health of military police, so that QOL, health conditions and lifestyle can be negatively affected [21]. These public security workers are different from the majority of the population, as they are subjected to highly stressful situations, especially living with violence and the risk of death, the workload and working conditions, and stress [20]. For the authors, the causes of diseases derive from work activities that caused harmful effects and produced intrinsic and extrinsic changes in relation to QOL, such as: social, political, economic and behavioral changes. On the other hand, programs to improve the health and quality of life of military companies or corporations “would benefit from a healthier workforce, lower absenteeism/turnover, fewer accidents, lower healthcare costs, higher productivity, better image and, finally, an improvement in the environment” [19].

Notably, inside the barracks, the military police have a reduced quality of life, due to their attributions and specificity of the profession. In this context, Oliveira and Quemelo [20] evaluated the quality of life of 262 military

police officers, using the SF-36 questionnaire, which is a multidimensional instrument consisting of 36 items, encompassed in eight domains. The results showed that (82.4%) of the police officers were male and (17.5%) were female, with a mean age of  $37 \pm 7$  years. In the study, the general average of  $70.7 \pm 20.2$  points for quality of life, while the general health status was  $60.8 \pm 17.0$ , which points to the need for interventions regarding this aspect to improve and promote the health of these workers.

Arroyo [3] investigated the quality of life of 506 military police officers belonging to the Interior Police Command 5th region (CRP-5) of the State of São Paulo. It was a population-based cross-sectional study of military police officers. The instrument called WHOQOL-Bref was used for the study. The results showed that (81.82%) of the military police rated their quality of life as good or very good and (8.30%) were very dissatisfied or dissatisfied with their health. The study concluded that the lowest quality of life score was for the Environment domain with 62.21 points and compromised financial resources, recreation and leisure, physical environment, sleep and rest facets.

Another important study was carried out by Souza Filho et al., [17] which aimed to investigate the perception of quality of life of military police officers in the metropolitan region of Belo Horizonte. For the study, 316 male police officers from the operational area with a mean age of ( $36.68 \pm 7.07$ ) years were selected. The subjects answered the WHOQOL-Bref questionnaire. The Spearman's-Rho correlation test was performed with a significance level of  $p \leq 0.05$  and adequate internal consistency for the WHOQOL-Bref ( $\alpha = 0.833$ ). The results for the social and psychological domains obtained the highest scores when compared to the physical and environment domains. The study concludes that the perception of QOL of PMs in Belo Horizonte is more associated with factors involving psychosocial domains.

In this sense, studies carried out with 533 employees of the police force and the army corps emergency response service in a German-speaking urban area, northwest Switzerland (71.1% men), who completed a battery of self-report questionnaires, assessing stress, exercise, perceived fitness and health. The results showed that increased stress was associated with poor health and increased fitness was associated with reduced stress. Thus, it was evidenced in the final considerations that exercise and physical conditioning can contribute significantly to a healthy life, thriving workforce that takes less sick leave and feels better prepared to deal with chronic stress [22].

Silva et al., [23] conducted studies to investigate the relationship between quality of life, health, physical

activity, occupation, body composition and sociodemographic characteristics of military police officers in Santa Catarina-Brazil. A total of 302 PMs from the metropolitan region participated in the study, randomly selected through a simple draw and who met the eligibility criteria. Data were collected using the WHOQOL-Bref-short version and the IPAQ – long version, in addition to a spreadsheet on sociodemographic, anthropometric, occupational and health variables. It was found that the majority of PMs are married, educated and with an average of 36.6 years of age and 15.1 years of police work and have a good perception of quality of life. They have above-recommended levels of physical activity, are in the recommended weight range and are in good health. It is concluded that there are associations of quality of life with physical leisure activities, height and marital status.

Another study conducted by Araújo et al., [24] aimed to evaluate the relationship between the level of physical activity and the anthropometric profile, perception of quality of life and mental health in military police officers in the State of Sergipe (PM/SE). Cross-sectional study that included 30 male military police officers, aged between 28 and 40 years. The pedometer was used as a research instrument for four days and later questionnaires were answered (demographic, anthropometric, occupational data, IPAQ short version, WHOQOL, anxiety, depression and stress scale). The study revealed a prevalence of (70%) active police officers and no symptoms for problems that affect mental health, while (66.67%) reported good perception and quality of life and (70%) were satisfied with their health. There was a correlation of PAL with stress on the day of work and on the first day off with quality of life indicators and a correlation of the activity level of the first day off with the Physical domains ( $R=0.411$ ;  $p<0.05$ ) and of the Environment ( $R=0.511$ ;  $p<0.05$ ). In the final considerations, good levels of mental health were evidenced. As for the PAL, a positive relationship between the day of work and the stress variable was observed. There were positive relationships between the activity level of the first day off and the Physical and Environment domains regarding quality of life.

Brasil and Lourenção [25] evaluated the quality of life through a cross-sectional study with 289 military police officers belonging to the 16th Battalion in the interior of the State of São Paulo. The instrument used was the WHOQOL-Bref. Of those investigated, (93.43%) were male and the prevalent age group was between 30 and 45 years of age. Most police officers, that is, (80%) rated their quality of life as good or very good, (10%) were very dissatisfied, (1.4%) were dissatisfied (8%) with their health. The quality of life scores ranged between 60.88 and

72.52, the lowest for the environment. Therefore, the study concluded that the military police officers analyzed showed commitment to factors related to the Environment domain, requiring improvements in the environmental conditions of the place where they are inserted, financial resources and transport, in addition to the environment at home.

Arroyo, Borges and Lourenção [3] carried out a cross-sectional study with military police officers of both sexes, from the CRP-5 of the State of São Paulo. For this, the objective was to evaluate the quality of life of military police officers and compare with the variables gender, time of professional activity, shift and workload. The instrument for collecting sociodemographic data and the WHOQOL-Bref and statistical analysis, according to the model provided by the WHOQOL Group. The results showed that most police officers were male (88.7%), median age of 36 years and more than 10 years of police work. Therefore, it was concluded that the investigated military police have a good or very good quality of life and are satisfied with their health.

Therefore, the specific literature points out unfavorable health and working conditions for military police officers, given the long and strenuous working hours [10], small police force [27]; [15], constant psychosocial problems [9] and [10], unsanitary police unit infrastructure [15], insufficient physical activity level [8]; [26], high incidence of sick leave [27], double working hours [2]; [3]; [25], societal and institutional pressures for results [2]; [3]; [25], in addition to outdated technologies, equipment and work materials compared to criminals. Although there is still no consensus, due to the various instruments used to assess physical activity levels, health conditions and quality of life of military police officers in different regions of Brazil.

Surveys carried out by Gonçalves [27] with the human resources sector of the Military Police of the State of Rondônia showed a small number of staff, different scales, few rest periods and double working hours, contributing to the overload at work and resulting in the physical and psychological exhaustion, in order to negatively influence the quality of life of military police officers. This workload, insufficient physical activity, sleep deprivation during work, rigid hierarchy, ergonomic factors, stress, daily living with violence and risk of death, have particular characteristics and are closely related to work [9] and [11]. Thus, suffering from the stress resulting from extensive work activities that overload police work can negatively influence health and quality of life. Thus, due to the peculiarities of the police function, physical activity should be adopted as a tool to alleviate these tensions in the work environment. However, due to these

particularities, it is certain that the investigated military police do not practice any regular program of physical activity inside the barracks. In this vein, Benedet [9] states that the Military Police are the most numerous in terms of human resources compared to other public security institutions and their agents are exposed to various deleterious effects on health, such as: physical and mental trauma and more likely to be at risk of death. According to Batista [28] a significant number of military police officers still have high rates of body fat in the central region, which has contributed to pressures in the work environment, a high proportion of psychological problems, risks of death, physical traumas, affecting significantly the health and quality of life of these individuals. Other factors such as hierarchy and rigid discipline, psychic pressures suffered inside the barracks, also cause harmful effects on health, due to illness through psychic disorders and mental suffering, which are related to professional practice, because, when exposed to these traumatic events and everyday violence, these professionals suffer serious consequences to their health and quality of life [9] and [12].

The general objective of the study was to analyze the quality of life of active military police in a State of the Western Amazon in times of a Covid-19 pandemic, using the questionnaire The World Health Organization Quality of Life (WHOQOL - Bref).

## II. METHODOLOGICAL PROCEDURES

### 2.1 Characteristics of the study

This is a descriptive, cross-sectional field study with a convenience sample, non-probabilistic and with a quantitative approach.

### 2.2 Population and sampling

About 410 printed questionnaires were distributed, as there is a considerable loss at the time of return. However, to minimize these losses, this researcher personally monitored and guided the individuals participating in the study, regarding the best way to fill out the instruments. After analyzing the returned questionnaires, there was a sample loss of 12.5% that were misplaced, were filled out incorrectly or subjects did not record their signatures in the TCLE. Female PMs and all those who did not consent to participate in the study were excluded from the sample, in addition to individuals who were on vacation, on leave for health treatment or on various missions outside their units. At the end, the sample consisted of 358 male PMs belonging to the active force of the PMRO, having between 1 and 32 years of police service, who voluntarily participated in the study. Sample was calculated according to the following statistical

formula [29]:

N –Population size; e –margin of error (percentage expressed in decimals);

z – z-score z (95% = 1.96). The z score is the number of standard deviations that a given proportion deviates from the mean. The sample size was based on the population size with a confidence level of 95% and a margin of error of 5%. [29].

$$\text{Tamanho da amostra} = \frac{\frac{z^2 \times p(1-p)}{e^2}}{1 + \left(\frac{z^2 \times p(1-p)}{e^2 N}\right)}$$

### 2.3 Data collection instruments

To assess QOL, an instrument called WHOQOL-Bref [30] was used; [31]; [32]. The WHOQOL-Bref was chosen for the following reasons: they are reliable and free, they are internationally accepted and used, they allow quantitative assessment of variables, they have sufficient psychometric consistency, are widely used by health professionals, have good reliability and are validated for the Brazilian population [30]; [31]; [32].

#### 2.3.1 Sociodemographic variables and health conditions.

Military police officers answered a questionnaire to assess sociodemographic and occupational variables (age, marital status, income, graduation or post, education, length of service and hours worked per day) and health conditions and NCDs or Covid-19. Military police officers who perform administrative service work between 6 and 8 hours a day. In order to calculate the hours worked by those police officers who work on a regular duty schedule of 12x24/12x72, the average number of services during the month was computed, multiplied by the number of hours worked per day of service, divided by the 30 days of the month. It was added up according to the following formula: Average of 13 monthly services x 12 hours worked/30 days of the month, that is, 156 h/month/30 days/month = 5.2 hours of average per day. For computing the hours worked, the hours prior to the service were not taken into account, where the police officer arrives in advance to prepare the vehicle, check equipment and weapons used during the service, as well as the hours that exceed the passage of service, due to those who are in the act or registering the act. In addition, the hours in which the military police are available to justice and appear before the court as a witness, victim or as a conductor of occurrence to ratify the arrest of criminals were not computed.

#### 2.3.2 Quality of life assessment

Quality of life was assessed using a simplified

instrument called WHOQOL – Bref. This instrument consists of 26 questions, two general questions about the general quality of life and a subdivision of the other facets/domains: physical, psychological, social relationships and environment, preserving the last 24 facets of the original domain (WHOQOL-100) [31]; [32]; [33]. The answers follow a Likert scale from 1 to 5, the higher the score, the better the quality of life, allowing to measure attitudes and know the degree of conformity of

the interviewee with any proposed statement [30]; [31]; [32]. This instrument is generic and self-administered, it was developed in a cross-cultural perspective to collect data on QOL, being available in more than 40 countries”, including validated for the Brazilian population [31]; [32]; [33]. According to Ferentz [31]; the choice of indicators to measure quality of life will depend on which study area will be linked. For the author, the quality of life assessment instrument was standardized by the WHO as a way of enabling the comparison of results between different situations, sectors or regions. Therefore, there are five official methods to measure the population's quality of life, namely: the WHOQOL-100, WHOQOL-Bref (abbreviated), WHOQOL-HIV, WHOQOL-SRPB and WHOQOL-OLD (for the elderly) [31]; [32]; [33].

The WHOQOL-Bref questionnaire has been validated in over 20 countries. In Brazil, the version was developed by the Federal University of Rio Grande do Sul (UFRGS) located in Rio Grande do Sul. The Portuguese version of this instrument allows comparing studies carried out in different regions [31]. Multidisciplinary studies can be an important tool for state entities to analyze the impact of public policies on the population's health conditions, cultural, socioeconomic and psychological aspects [32]. For the study with PMs from Rondônia, we will use the simplified version of the WHOQOL-Bref [32]. The instrument is the most suitable to be applied to PMs, due to the specificity of routine and work activities inside the barracks.

Table 1 Demonstration of domains and facets: physical, psychological, social relationships and environment and general quality of life of the WHOQOL – Bref.

Domains	WHOQOL
Physicist	Pain and discomfort; energy and activities of everyday life; depend
Psychological	positive feeling; think, learn, conc appearance; negative feelings;

	spirituality – religion/personal beliefs
<b>Social relationships</b>	Personal relationships; sexual activity; social support
<b>Environment</b>	Physical security and protection; environment at home; financial resources; health and social care: availability and quality; opportunities to acquire new information and skills; participation in recreation/leisure opportunities
<b>General</b>	Perception of quality of life; health satisfaction

Source: Adapted from Ferentz [31]; Fleck [34].

The WHOQOL – Bref results are indicated in percentage (%), being from 0 to 100 points, the higher the percentage, that is, closer to 100, the better the quality of life of individuals [33]. The data were analyzed by a tool, developed from the Microsoft Excel software, directed to the calculation of scores and descriptive statistics of the WHOQOL-Bref instrument - following the syntax proposed by the WHOQOL Group, allowing to perform WHOQOL-Bref applications without needing to use from the SPSS software [33]. In this sense, this study used this tool that allows tabulating the data, calculating the descriptive statistics of the sample (average, standard deviation, minimum and maximum of the physical, psychological, social relations, environment and general domains), leaving the researcher only tabulate the collected data and the calculations of scores and statistics all in an automated way [31].

**2.4. Procedures**

For data collection, the 2-way informed consent and previously selected and validated questionnaires were provided to the volunteer police officer.

**2.5. Ethical aspects**

All subjects were previously informed about the objectives and type of research, who participated voluntarily and formalized the free and informed consent term (ICF) in writing to the technical manager. The protocol and all consent forms were previously approved by the Research Ethics Committee (CEP). All research followed the procedures of Operational Norm n° 001/2013, Resolution 466/2012 Resolution 510/2016 both from the National Health Council (CNS) for research carried out with animals and humans.

**2.6. Statistical Treatment**

For the tabulation of sociodemographic data and the level of physical activity, the EXCEL spreadsheet was used. For the statistical treatment, the BioEstat 5.0 software was used, where the Mean, Standard Deviation, Frequency and Percentage (%) were calculated through descriptive statistics. For the data on quality of life, the

benefit and proposed by Pedroso et al., [33] was used, which was simulated in the SPSS software, performing the calculation, social support and descriptive statistics in an automated way.

**III. RESULTS AND DISCUSSION**

A total of 410 instruments were distributed and of 358 met the eligibility criteria. Data collection was carried out between September and December 2021.

**3.1 Sociodemographic data and occupational conditions of military police officers in Rondônia.**

Regarding sociodemographic characteristics, these were collected using a specific instrument, with emphasis on male military police officers and active members of the PMRO, with a total of (n=358/100%) of the investigated sample. Of the police officers investigated, the age variable had the mean (39.21 ± 6.41) years of age. This finding is superior to data from military police officers from Tocantins who obtained (25.5 ± 3.60) years of age [26], from the region of Araçatuba/SP who obtained (36.8 ± 7.1) years of age [17] and lower than the findings from the City of Floriano/PI, which was (46.39 ± 4.25) years old [35]. Regarding the variable length of service in the corporation, the average was (15.44 ± 7.64) years of age for the sample. Therefore, the Rondônia study is inferior to the findings of Neta et al., [35] who were in (26.74 ± 2.33) and Batista [28] who found for the operational and administrative group (18 .06 ± 5.54 and 17.25 ± 6.83) years of police service, respectively. In the study in Rondônia, most of the military police officers analyzed, that is, (61.17%) were under 40 years of age and (78.21%) of the police officers had less than 20 years of experience in the police service. However, the minority of police officers were in the age group above 40 years and above 20 years of police service. In addition, it was characterized in the study that the military police of Rondônia are in the middle age and also in the middle of their professional careers.

Regarding the training of PMs in Rondônia, (52.79%) have higher education courses, including Specialization and Masters. Regarding this variable, the study in Rondonia differs from the findings by Silva et al., [23] in Santa Catarina, which was (28.5%) of police officers with higher education and the study in Alagoas, which found a percentage of (5.4%) of PMs with higher education [36]. Regarding education, most of the subjects studied had a higher education and a minority had a high school education, inferring that Rondonian police officers are highly qualified. However, these data show that Rondônia's military police are one of the most qualified

public security workers in the country. Concerning the marital status of the military police in Rondônia, (69.27%) are married, similar to the findings of Gonçalves et al., [27] in the 10th Battalion of Miguel Pereira and Paty do Alferes and higher than that found in Alagoas, which identified about (67.6%) of married police officers [36] and found in Santa Catarina that was (57.9%) of married military police officers, with marital status associated with better quality of life [23].

Regarding the ranks and degrees of military police, most (47.49%) are from the ranks of warrant officers and sergeants and earn between 5 and 7 minimum wages, (42.46%) are from the ranks of corporals and soldiers and have as an average salary of approximately up to 4 minimum wages, (6.70%) are in the ranks of junior or intermediate officers and earn between 8 and 10 minimum wages, while (3.35%) of the officers are of the upper echelon and earn above 11 minimum wages. The higher rate in the ranks of warrant officers and sergeants is due to the constant promotions for these cadres, which also raises the salary range of these servers. On the other hand, the lower the rank or rank of the military police officer, there is an impact on their income. These data differ from the studies with PMs from São Paulo that found (10.9%) of warrant officers and sergeants and (70.1%) of corporals and soldiers [3]; [25] and salary income differs from PMs in Alagoas where (90.9%) receives between 2 and 5 minimum wages and only (8.1%) earns more than 5 minimum wages [36]. However, when comparing the salary range of Rondonian PMs with other state military corporations, this income range is one of the lowest in the country, behind 23 other military police corporations. This low salary range imposes on Rondonian police officers the search for a second income (beak), increasing the incidence of hours worked, leaving little time for physical activity, which has contributed to low physical condition, increased body weight, high level of stress and further worsening the quality of life.

The working hours of the military police officers investigated was ( $6.87 \pm 2.04$ ) hours per day and ( $29.10 \pm 80.79$ ) days away from work due to various NCDs and Covid-19. From this point of view, the vast majority of the subjects analyzed, that is, (49.44%) work an average of 6 hours a day in the corporation. On the other hand, just over (20%) of the individuals work in 12x24/72 shifts. Thus, police work in shifts has as its main harmful factor to health, the constant periods of alert and changes in sleep during the duty shift. This type of work can compromise the health and quality of life of military police officers, as there is an increase in tobacco consumption and loss of sleep at night [3]; [25]. The causes of absence from service due to physical and mental health problems among the

military police were around 29 days of absence. These data found are superior to the studies by Oliveira [37] who identified that (21.02%) of the analyzed police officers were away for at least 1 day from work in the last year, that is, much lower than the studies in Rondônia. These questions point out how important social, demographic and labor factors are in maintaining health and quality of life [38]. In the study, a prevalence of (48.32%) of CNCD was observed in the investigated police officers. Therefore, the data from our studies are superior to those found by Paiva et al., [39], where they observed that (28%) of the police officers studied had some type of chronic disease, including arterial hypertension, herniated disc and diabetes. It was noted in the research instrument that (34.08%) of the investigated policemen contracted COVID-19 between 2020 and 2021.

### 3.2 Quality of life of military police officers in Rondônia.

Quality of life was assessed using the WHOQOL-Bref instrument validated for the Brazilian adult population in five domains: physical, psychological, social relationships, environment and general quality of life. The classification of the military police officers surveyed for the physical domain was 71.37, the psychological domain 75.03, for social relationships it was 74.76, the environment domain was 63.67, while the general quality of life was 70.04, with the highest scores for the psychological domain, social relationships and the lowest scores for the environment and physical domains. Therefore, the study with military police officers from Rondônia differs from the studies carried out during the coronavirus pandemic by Alvarenga et al., [16] with teachers who identified the highest scores for the physical and psychological domain and the lowest for the social and environment domain.

*Table 2 – WHOQOL-Bref domains (physical, psychological, social relationships, environment and total quality of life) of military police officers in Rondônia. Study data - 2021*

DOMAINS	QOL
Phycis	71.37
Psychological	75.03
Social relationships	74.76
Environment	63.77
TOTAL	70.04

*Table 3: Facets of the WHOQOL-Bref of the PMs of Rondônia. Study data - 2021*



<b>FACETS WHOQOL</b>	<b>QOL</b>	
<b>pain and discomfort</b>	<b>30.52</b>	<p>dissatisfied or dissatisfied with their health [17]. The military police officers from Rondônia also revealed, when asked how they evaluate their quality of life, the study confirmed that (76.8%) evaluate their QOL as very good and good and (3.36%) understand QOL as very bad and bad. The findings from Rondônia differ to a lesser extent than the data found in São Paulo, where (81.8%) of police officers in São Paulo rate their QOL as very good and good and (4.3%) as very bad and bad [3], as well as the findings with police officers in Belo Horizonte [17], where (80.7%) said they rate their QOL as very good and good and (3.5%) rate their QOL as very bad and bad. The findings of our study show us the impacts caused by the current pandemic crisis of COVID-19 that devastated the military police of Rondônia, corroborating the decrease in the perception of health and quality of life of these individuals.</p> <p>When performing the analysis of the domains, the physical domain of the WHOQOL-Bref of the Military Police of Rondônia presented a score of 71.37 points and for the pain and discomfort facets the percentage was 30.52 points and for the treatment dependence facet or medication, the score was 27.30 points. In this aspect, when comparing the data from the questionnaire prepared by the authors of the study, with the data from the WHOQOL-Bref, it was characterized that the physical domain was significantly affected, which can be observed in the percentage of individuals who indicated various diseases of the bone system and musculoskeletal injuries. The results presented in this study corroborate the findings of other studies with the population of military and military police who found low back, spine and neck pain, spinal injuries, knee and ankle injuries, joint dislocations, arm and leg fractures, tendinitis and bursitis, mild pain, of moderate and severe intensity [10]; [40]; [41]. Although the findings show that individuals depend on medication or medical treatment, this does not prevent them from carrying out their daily activities. In this aspect, there is an indication of good physical health and, consequently, a good quality of life in relation to the physical domain and investigated facets. In addition, most military police officers are satisfied with their physical health, despite feeling pain, discomfort or discomfort manifested in the instrument itself and also in the WHOQOL-Bref. Data that are corroborated by studies by Alvarenga et al [16] with teachers during the Covid-19 pandemic who reported that they are satisfied with their physical health, despite some pain or discomfort, this does not prevent them from performing activities daily, showing little need for medical treatment, being an indication of a good quality of life.</p> <p>For the psychological domain related to the mental health of the PMs from Rondônia surveyed, the</p>
<b>energy and fatigue</b>	<b>69.83</b>	
<b>sleep and rest</b>	<b>62.78</b>	
<b>Mobility</b>	<b>83.03</b>	
<b>everyday life activities</b>	<b>68.72</b>	
<b>Dependence on medication or treatments</b>	<b>27.30</b>	
<b>work capacity</b>	<b>73.04</b>	
<b>positive feelings</b>	<b>68.05</b>	
<b>Thinking, learning, memory and concentration</b>	<b>65.01</b>	
<b>Self esteem</b>	<b>83.78</b>	
<b>Body image and appearance</b>	<b>81.22</b>	
<b>negative feelings</b>	<b>24.86</b>	
<b>Spirituality/religion/personal beliefs</b>	<b>77.04</b>	
<b>Personal relationships</b>	<b>75.14</b>	
<b>Personal support and support</b>	<b>69.41</b>	
<b>sexual activity</b>	<b>79.75</b>	
<b>Physical security and protection</b>	<b>69.59</b>	
<b>home environment</b>	<b>73.25</b>	
<b>Financial resources</b>	<b>49.37</b>	
<b>Health care</b>	<b>57.82</b>	
<b>New information and skills</b>	<b>66.06</b>	
<b>recreation and leisure</b>	<b>60.15</b>	
<b>physical environment</b>	<b>59.78</b>	
<b>Transport</b>	<b>74.30</b>	
<b>Self-Assessment of Quality of Life</b>	<b>68.53</b>	

In the present study, the highest scores were for self-esteem with 83.78; for mobility it was 83.03 and body image and appearance 81.22. On the other hand, the lowest scores were for pain and discomfort with 30.52, dependence on medication or treatment with 27.30 and for negative feelings with 24.86 points.

Regarding quality of life, the police were asked if they were satisfied with their health, and (65.8%) responded that they were very satisfied or satisfied with their health and (12.1%) were very dissatisfied or dissatisfied. The findings differ from the São Paulo study that found (75.7%) of military police officers very satisfied or satisfied and (8.3%) dissatisfied or dissatisfied with their health [3] and from the studies of the metropolitan region of Belo Horizonte that (82, 6%) of PMs are very satisfied or satisfied with their health and (6.1%) are very

data found were quite positive, despite the problems faced by the police during the Covid-19 pandemic. This domain evaluated the psychological capacity of military police officers to face the challenges inherent to their profession, as well as the ability to deal with stressors, caused by the coronavirus pandemic and which led these professionals to a very high level of stress. However, when asked how often you have negative feelings, such as: bad mood, despair, anxiety and depression, (13.64%) of military police officers reported that they often, very often and always have negative feelings. From this perspective, affected mental health is one of the possible side effects of Social Distancing caused by the Covid-19 pandemic [42].

When performing the analysis of the psychological domain, it was around 75.03 percentage points and for negative feelings, the WHOQOL-Bref facets of the present study identified 24.86 points, although the investigated military police had a self-esteem of 83.78 and positive feelings with a percentage of 68 points. However, such findings during the coronavirus pandemic confront higher levels of negative feelings, although there is good satisfaction with the health and general quality of life of military police officers. These studies corroborate the specific literature, as most of the individuals analyzed were happy with their physical and mental health and also reported a good perception of quality of life [2]; [3]; [25]. Although these professionals have reported a good perception of health and quality of life, it seems reasonable to believe that the perception of these individuals in relation to highly exhausting working conditions and high levels of stress generate negative impacts and cause several physical health problems. and mental that are imbricated in the very essence of the police profession.

For the social relationships of military police officers from Rondônia, the results of the WHOQOL-Bref were 74.76 points for this specific domain composed of the facets personal relationships, sexual activity and support and social support. The Rondônia study is corroborated by other studies also with military police, such as the State of São Paulo, which found the percentage of 75.05, 75.1 points respectively [2]; [3]; [25] and the study of the State of Santa Catarina that obtained 75.0 points for personal relationships [23]. These Findings show that the score is the second highest in the investigated domains. Therefore, it can be inferred that the restriction of circulation, social isolation and work carried out at home-office caused by the Covid-19 pandemic influenced the longer contact time with family members, strengthening social and support relationships at work and at home. In addition, for this analyzed domain, the most prominent point was the self-esteem facet of the military police officers in Rondônia, which obtained a higher percentage in relation to the other

facets.

In the environment domain, a score of 63.67 points was found. The findings of our study are superior to studies carried out with police officers in São Paulo, which found scores of 62.20; 60.88 and 62.21 points respectively [2]; [3]; [25], to the findings in Tocantins, which was 55.50 points for police officers with more than two years of career [26] and in Santa Catarina, which found scores of 53.1 for the environment domain [23]. In view of this, it can be inferred that the differences found in relation to studies with São Paulo military police [2]; [3]; [25], from Tocantins [26] and from Santa Catarina [23] were due to the characteristics that make up the State of Rondônia, where there is still an environment with a favorable climate, little pollution, low noise levels and lower rates of violence compared to other Brazilian capitals. These peculiar aspects, combined with the low industrialization of the State and the production of renewable energy with the construction of the Santo Antônio and Jirau hydroelectric plants, reflected in a better quality of life for the military police of Rondônia. These aspects contributed to a better general quality of life with a total index of 70.04 points for these individuals. Therefore, the general assessment of the quality of life of military police officers from Rondônia is similar to the study carried out in Araçatuba-SP, where individuals obtained an overall average of 70.7 points, although the instrument used differs from that used in our study [20].

These data found refer to the conditions of military police officers inside the barracks, in relation to their perception of housing conditions, places where they live, security and violence, quality of urban and private transport, access to leisure options and opportunity for tourist trips. Such findings for the environment domain represent the reality of most military police officers investigated during the Covid-19 pandemic period. The arrival of Covid-19 impacted health conditions, as well as access to leisure options and opportunities for local and tourist trips that were suspended due to the social isolation imposed by the authorities as a way of mitigating the disease. For the facet that analyzes transport, the score was 74.30 points. This score can be explained by the fact that public transport in the Capital of the State of Rondônia is of poor quality and in some municipal locations it does not even exist. This forces the military police to have their own vehicle, which leads them to have greater satisfaction with the means of transport. On the other hand, in relation to financial resources, the score was 49.37 points. This facet can be easily explained, given that the income range of Rondonian police officers is one of the worst in Brazil, however, in relation to housing and home environment, it is still possible for individuals to have access to housing in

more centralized locations, due to the lower price of rents and real estate compared to the great centers of the country.

Regarding the recreation and leisure facet, the score was 60.15 points. This facet can be explained, due to the lower risk faced by the military police during their breaks from service, they still have better access to recreation and leisure in squares, parks, sightseeing in the region, fishing, among others. All this corroborates for a better perception of the quality of life in this facet. With regard to access to information, nowadays with the boom of the technological era and digital media, military police officers have greater access to various digital information tools, which influences the aspects of data collection, information and fact checking. Therefore, the findings of this study highlight the impacts of the pandemic on the group of military police officers, due to the isolation and social distancing measures implemented by the government of Rondonia, as well as the specificity of police work in this period in an attempt to mitigate the contagion by Covid-19.

#### IV. CONCLUSION

With regard to sociodemographic characteristics and occupational conditions, it was found that most individuals are less than 40 years old and have less than 20 years of police service in the corporation and, predominantly, have a higher education level, are married, have warrants and sergeants and earn between 5 and 7 minimum wages. The vast majority of police officers work 6 hours a day and have already been removed from the service, due to being carriers of CNCND and were also infected by Covid-19.

Regarding the health conditions indicated in the self-report instrument, the highest prevalence of diseases that affected Rondonian military police officers between the years 2020-2021 are related to the infection by Covid-19 with (34.8%) of the infected police officers, followed by musculoskeletal diseases (16.58%) and psychosomatic diseases (14.80%). From this point of view, the investigated military police are getting sick in the best productive age group, bringing a huge amount of damage to these individuals, their families, to the military corporation and increasing public health expenses for the State of Rondônia. Therefore, the low PAL, NCDs and Covid-19 reported here contributed to momentarily worsening the quality of life of PMs. However, it is still too early to present conclusive results on the influence of Covid-19 on the levels of physical activity, on health and on the worsening of the quality of life of military police officers.

Therefore, the quality of life of military police officers in Rondônia has satisfactory levels, despite chronic health conditions, demonstrating through self-report and the multidimensional character of quality of life, with the highest scores in the social relationships domain and the lowest in the environment domain. In this sense, (76.8%) of the military police officers evaluate their quality of life as very good and good and (65.8%) answered that they are very satisfied or satisfied with their health. On the other hand, the highest scores were for the facets mobility, self-esteem, sexual activity and the lowest scores were for the facets of negative feelings, dependence on medication or treatment, and finally, pain and discomfort, data that are corroborated by the self-report of CNCND and Covid-19 highlighted in the research instruments.

Therefore, there is a need for more aggressive public policies on the part of the military institution to promote physical activity inside the barracks and contribute to improving the health and quality of life of its employees, including police officers who are diagnosed with NCDs and those who were positive and are cured of Covid-19. On the other hand, epidemiological studies with the population of military police, sciences applied to sport and physical exercise prove the benefits of daily physical activity to minimize sedentary behavior, reducing the incidence of NCDs and infectious diseases, such as Covid-19. In addition, high levels of physical activity is an important non-pharmacological tool for the prevention, restoration and maintenance of health and the quality of life of military police officers.

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# A Timeline of the Risk Field: Bridging Fundamental Achievements and Modern Research

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Received: 05 Aug 2022,

Received in revised form: 08 Aug 2022,

Accepted: 09 Aug 2022,

Available online: 16 Aug 2022

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**Keywords**— risk; risk analysis; risk  
science; uncertainty.

**Abstract**— An evolutionary, diverse, and complex path of the risk conceptualization has been built along with the history of mankind. The current understanding and the variety of methods available to deal with risk and uncertainty are linked to the achievements made by several academics and researchers in the past. However, very little of the risk analysis literature has attempt to explicitly bridge or recognize this fundamental construction for organizational and research purposes. This conceptual paper presents the results of a literature research in a timeline framework. The significant accomplishments that collaborated to the modern knowledge in the field of risk are organized in five distinct phases and their connections to modern research topics are discussed. The aim is to provide a condensed but comprehensive overview of the foundations and evolution of the risk field and link the different conceptual paths that currently exist in risk analysis research. The present paper contributes to a systemic view of the risk discipline, which we believe will be a helpful review from which academy and industry readers would benefit.

## I. INTRODUCTION

Risk analysis practices have been performed since the beginning of civilization. Some researchers affirm that the oldest strategy for coping with risk is insurance, a societal risk management strategy <sup>[1]</sup>. Others believe that the risk notion appeared with man's fascination with games of chance, the very essence of risk-taking <sup>[2]</sup>, that seems to be nearly as old as man himself (e.g., findings of relics related to a dice game Astragali in many archaeological digs) <sup>[3,4]</sup>.

Though the notion of risk existed before the concept became linguistically or mathematically defined, there is no conclusive agreement about its origin. Authors denominate risk as a problematic conceptual phenomenon due to its many views in metaphysic, epistemic and moral contexts with no common understanding and obscure

origin <sup>[5,6]</sup>. The philosophical issues of risk research <sup>[7]</sup> are challenging topics permanently in debate <sup>[8-12]</sup>. Therefore, proper academic risk discipline with educational programs, journals, research groups, societies, and scientific events had emerged <sup>[8,9,13]</sup>.

There is an astonishing volume of literature covering the risk and uncertainty topics, and it seems to be present in all disciplinary fields. However, fundamental matters of risk and uncertainty are mostly addressed in dedicated chapters or book introductions from related disciplines (e.g., probability theory, decision theory, social sciences) but not often in research papers.

The inspiring book of Peter Bernstein <sup>[2]</sup> gives an interesting portrait of the evolution of the risk concept up to 1960. It provides a broad view about the historical

achievements but, as the author highlights, the theme is presented using a conceptualization of risk focusing on quantification, rationalism, and probability, using either frequentist or subjective interpretations.

Covello and Mumpower<sup>[3]</sup> focused on the “neglected period” of risk analysis and risk management, the years before the 20th century, when probability theory emerged and tools for quantitative risk analyses were developed. Althaus<sup>[5]</sup> classifies the risk concepts in a disciplinary perspective using the economic conceptualization of risk. Though other authors have used this classification in the study of risk theory (e.g.,<sup>[14,15]</sup>), some authors affirm that it lacks precision<sup>[16]</sup>.

In<sup>[16]</sup>, the author uses an approach called “thought-constructed development paths” to review the definition and meanings of the concept of risk. Nine risk definition categories are presented to encompass the many definitions of this subject in the literature. The author concludes that in the past two decades, there has been “a shift from rather narrow perspectives based on probabilities to ways of thinking which highlight events, consequences and uncertainties”. Although comprehensive, it missed a historical contextualization of the leading proponents of the risk concepts considered in the classification.

Aven<sup>[13]</sup> reviews the principles and methods proposed at the beginning of the XXI Century, focusing on the fundamental ideas that form generic risk research. The author recognizes that the selection of ideas reported in his manuscript has “bias toward rather recent papers and the areas of interest of the author”. Carayannis et. al,<sup>[17]</sup> provides distinction of five “risk management Eras” with briefly describing some historical accomplishments. However, it lacks connecting current research with past achievements.

The present paper provides an organized timeline with the main collaborators to the risk discipline in a phase division structure. It distinguishes the main conceptualizations of risk developed throughout history in a unified, comprehensive, and neutral view of the risk discipline. The aim is to provide fundamental knowledge and their connection to the modern risk research from which academy or industry practitioners can strength the decision-making and policy formation for RD&E management structures.

The structure of this paper is as follows. We present the method used to perform this conceptual research and the approach to developing the risk timeline in Section II. Section III presents the research findings following the proposed fundamental risk phases. Section IV outlines discussions about some modern risk research and their

connections with the timeline and our view about the risk field. Section V concludes this paper with lessons learned and future topics of research.

## II. RESEARCH METHOD AND TIMELINE DEVELOPMENT

This conceptual paper consists of an extensive literature research. The review began broadly, searching for review articles and generic (classic) books related to the risk topic (e.g.,<sup>[2,4,18-20]</sup>). Additional relevant articles were identified in papers references using snowballing backward and forward approaches<sup>[21]</sup> (i.e., citation tracking) and browsing in specialized journals covering risk and related disciplines. Also, search strings from the area of study was performed to retrieve relevant articles from the databases of Scopus and Web of Science.

The timeline shown in Figure 1 was built from an interactive process of reading-collecting (database formation), cross-checking (information verification), selecting (prioritizing most relevant data), and organizing the most reliable information from different sources in a chronological order. The names of the main collaborators, their nationality, approximate date of publication, and short title of the achievement made to the risk field are shown in a standard form. When mention is made in the text, we use the name of the collaborator and the date of publication to make it easier to find each author in the timeline.

Prioritizing data was simultaneously conducted with phasing formation process. We acknowledge that other authors could be added to the timeline, but consciousness and sticking to the objective of the paper is mandatory. Therefore, criteria on higher impact to each philosophical current (i.e., different risk conceptualization) was applied and the most important developments were selected to form the timeline.

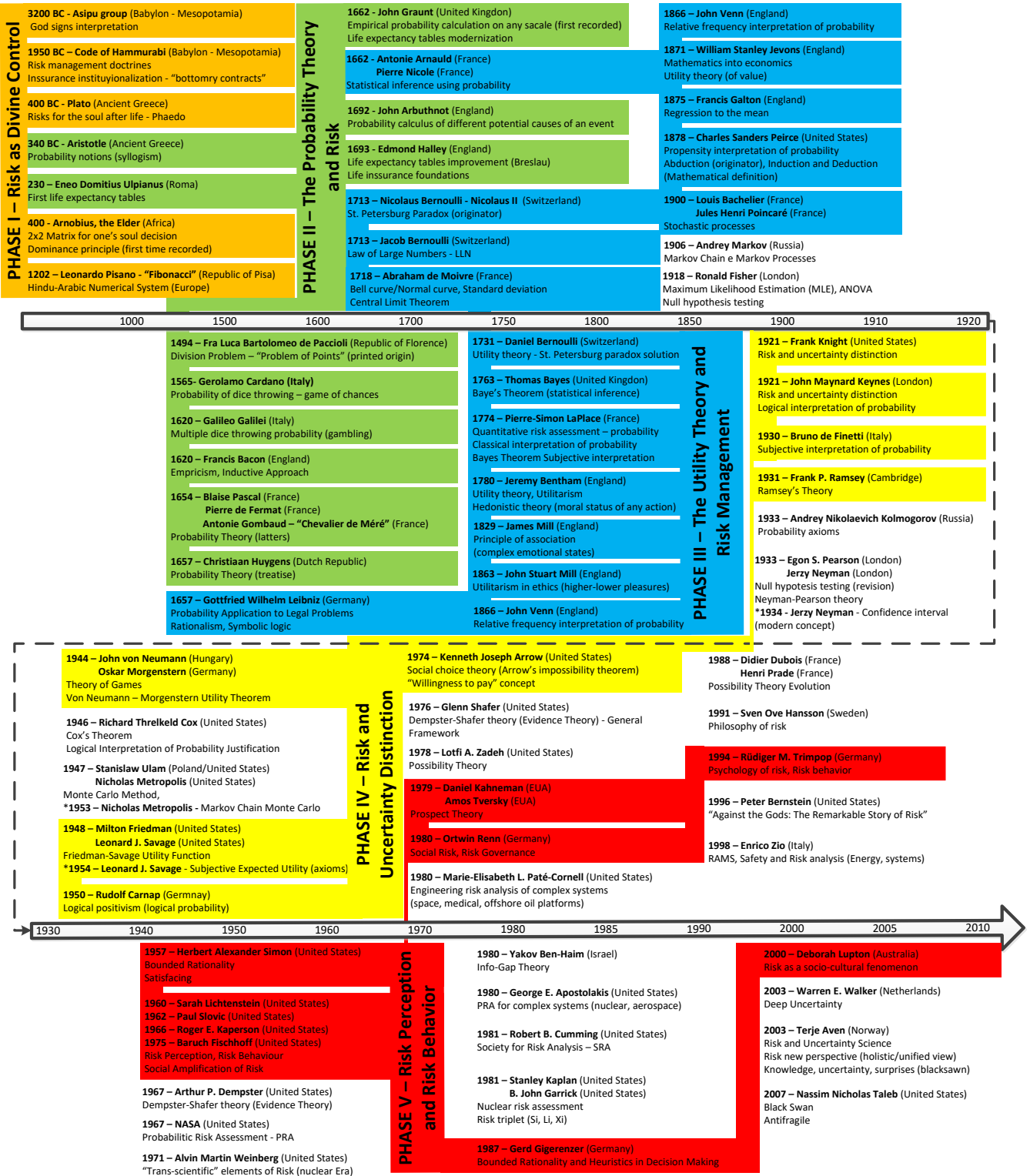


Fig. 1. The Risk History Timeline and Phase Division.



### III. PHASES IN THE EVOLUTION OF THE CONCEPT OF RISK

We defined five distinct phases that organize the history of risk according to the risk fundamental conceptualizations defined over time. The proposed phases are not chronologically straightforward and do not include the utmost modern risk authors cited in the discussion topic. The phase division should not be understood necessarily as progression or an improvement view of risk fundamentals since there is no definitive or proven right conceptualization of risk broadly accepted in the research community.

Risk as Divine Control phase (phase I) embodies the collaborators from an epoch where the society notion of risk was based on the Divine will, people had no choice towards their future, and the uncertainty idea did not exist. The phase named probability theory and risk (phase II) comprise the precursors and the acknowledged discoverers of the probability concept. Emphasizing this revolutionary theory that made humans believe in having the power of controlling the future by mastering risks. Risk management consolidation and utility theory phase (phase III) encompass the achievements that made possible the capitalist system and the first ideas that people's interests are reflected in decision making, the fundamental essence of utility theory. The risk and uncertainty concepts distinction phase (phase IV) is characterized by the recognition that there are limitations in the normal law and the strengthening of subjectivism (degree of belief). The perception of risk and risk behavior phase (phase V) is marked by the rationality behavior questioning and the appearance of several theories in the psychology field to understand human behavior in the decision-making process.

#### 2.1 Phase I: Risk as Divine Control

The **Asipu Group - 3200 B.C.** is recognized as the first recorded instance of risk analysis practitioners<sup>[3,6]</sup>. The group was part of the ancient Babylon civilization and served as consultants for risky and uncertain decisions<sup>[3]</sup>. They identified the problem and the alternative actions, collected data of possible outcomes by interpreting the gods' signs, and recommended the most favorable alternative with certainty, confidence, and authority<sup>[6]</sup>.

According to **Rüdiger Trimpop – 1994**<sup>[6]</sup>, other ancient traces of the risk notion are found in the **Code of Hammurabi - 1950 B.C.** It established several risk management doctrines within 282 clauses in the code and laid out the basis for the institutionalization of insurance by formalizing the concept of *bottomry* in maritime contracts on vessels and cargoes<sup>[2]</sup>.

Even though concerns about risks had evolved, an important change just came to happen with the rise and spread of Christianity. **Peter Bernstein – 1996**<sup>[2]</sup> suggests that the single God with well-defined purposes and intentions to the future changed the humans notion of risk, the future became a matter of moral behavior and faith. Then, Christians focused their curiosity on what would happen in the afterlife.

Although the afterlife subject had already been thought by philosophers in the past, it remained as will and control of the Divine. According to Covello and Mumpower<sup>[3]</sup>, **Plato - 400 B.C.** included several discussion treatises about afterlife in *Phaedo*. In the monograph *Against the Pagans*, **Arnobius the Elder – 400 A.D.** proposed a 2x2 matrix for the decisions affecting one's soul according to Christianity acceptance and God's existence<sup>[3,6]</sup>. Arnobius' argument marks the first recorded appearance of the *dominance principle*, a heuristic for making decisions under risk and uncertainty<sup>[3]</sup>.

Centuries later, in the context of the cultural shocks caused by the Crusades, the handwritten book *Liber Abaci* authored by **Leonardo Pisano – 1202** (i.e., *Fibonacci*), came to be known as the introduction of the Hindu-Arabic numbering system to the western world<sup>[2]</sup>. The written calculation fostered abstract thinking and enhanced mental capabilities of humans, considered essential basis for realist and constructivist philosophical perspectives<sup>[11]</sup> of the risk discipline, and general science development.

#### 2.2 Phase II: The Probability Theory and Risk

Besides probability is widely acknowledged as a mathematical concept, its discovery is a landmark for the risk field. Phase II encompasses the emergence of the probability theory and the beginning of changing at the Divine assignment of risk, during the Renaissance and Protestant Reformation after 1300<sup>[2]</sup>.

The nature of probability had been thought by Greeks through the word *eikos*, the old Talmudic Jewish philosophers may have come closer to quantifying it<sup>[2]</sup>. Still, the probability theory was formally defined only in the 17th century and even later associated with risk, in an epoch that society was shifting its culture from mysticism to science and logic<sup>[3]</sup>.

The book *Liber de Ludo Aleae* written by **Gerolamo Cardano – 1565** (posthumously published in 1663) introduced the notion of chances with dice-throwing experiments, but the meaning of risk still remained related to the gut view of probability, with no connection to measurement<sup>[2,18]</sup>. **Galileo Galilei – 1620**, aware the achievements made from Cardano, also concluded about the frequency of various outcomes with dice throwing, but lost interest in the subject<sup>[2]</sup>.

Around the same time, the philosopher of science **Francis Bacon – 1620** authored the book *Novum Organum* with the pioneering scientific method of empiricism [22,23]. It confronted the dominant deductive approach, as established by **Aristotle – 340 B.C.** in the work *Organon* (i.e., a treatise on logic and syllogism [22]). Bacon's work defined rules for a scientific method where inductive reasoning can generate scientific knowledge in a non-metaphysical approach (i.e., *eliminative induction* [24]). By acknowledging inductive reasoning as a scientific method, Bacon suggests that reason exists beyond the mythologies and religions. Consequently, it awakened the epistemological potential of human mind leading to an explosion of knowledge, innovation, and growth in science [25].

In this context, **Chevalier de Méré - 1654** invited the famed French mathematician **Blaise Pascal - 1654** to solve the “*problem of the points*”, the stakes division in an unfinished game of *balla*, suggested by **Luca Paccioli - 1494** in the book *Summa de Arithmetica*. Pascal turned for help to **Pierre de Fermat – 1654**, and the outcome of this collaboration led to the development of the theory of probability [2,18,19,26].

Few years later than Pascal and Fermat letters about probability, **Christiaan Huygens – 1657** independently published his treatise on probability in the book *Calculations in Games of Chance* [26]. **John Arbuthnot – 1692** translated Huygens' publication and added generalizations on dicing games results in the book *Of the Laws of Chance* [27] what made Huygens being recognized as another originator of the probability theory.

With probability theory, quantified decisions and forecasts to the future became possible [26]. First, defining expected outcomes in games of chance and gradually to other applications, created a disruption for decision-making based on the degree of belief. Bernstein [2] provides an interesting view of the two sides of probability, one looking at the future, meaning the degree of belief of an opinion (i.e., the gut view, known as epistemological) and the other interpreting the past, concerned with what we actually know from experience.

After the games of chances, the mortality tables and life expectancy observations were the second formal application of the probability theory, fulfilling a large temporal gap in this topic since the **Eneo Domitius Ulpianus – 230** life tables [3]. The businessman **John Graunt – 1662**, acknowledged as the founder of the science of statistics together with William Petty [2,19], made the first recorded attempt to calculate empirical probabilities of life expectancy tables of London city in his

publication *Natural and Political Observations Made Upon the Bills of Mortality*.

Although Graunt failed to generalize conclusions from the statistics available [2], he acknowledged that sampling is an essential part to predict about the future, a crucial topic to the risk field. **Edmund Halley - 1693** published an advanced probability analysis of mortality and births for the city of Breslaw in the book *Transactions*. This work allowed the insurance annuities calculation [6] and is considered the foundation of the modern life insurance system. However, the notion of risk management only effectively emerged when society could believe that they were free agents and had some influence in the outcomes of actions, according to their choices [2].

### 2.3 Phase III: The Utility Theory and Risk Management

Phase III addresses the risk management consolidation and the development of the *Utility Theory*, an alternative to explain human choices beyond probabilities. **Antoine Arnauld** and **Pierre Nicole – 1662**, brought the probability subject into evidence in the book *La Logique ou L'art de Penser*. They suggested a process for developing hypothesis from a set of facts (i.e., known today as statistical inference) and pioneering included the strength of desire for a particular outcome in the decision-making [18].

Among other accomplishments, the eight celebrated mathematicians from the *Bernoulli* family shown in Figure 2 had established fundamental theories related to the risk field. Advised by **Gottfried Wilhelm Leibniz – 1657**, that a “finite number of experiments would inevitably be too small a sample for an exact calculation of nature's intentions” [28], **Jacob Bernoulli - 1713** considered the linkages between probability and the quality of information for the first time in the book *Ars Conjectandi* (posthumously published by his nephew Nicolaus II) [2]. Jacob admits that “unless we can assume that the past is a reliable guide to the future”, an estimate of probability after the fact is impossible. Jacob concludes that whatever data is chosen to analyze, it is only a fragment of reality, and the quality of data is crucial for generalization [2,18].

The theorem *Law of Large Numbers – LNN* [18] proposed by Jacob for calculating probabilities a posteriori states that increasing the number of trials, the probability of the observed average to reach the true average will correspondingly increase, within some stated amount of error, no matter how small. This was the first fundamental theory about the limitations using probability to measure past events (i.e., the relative frequency interpretation of probability), which was later advanced by John Venn – 1866 in *The Logic of Chance*.

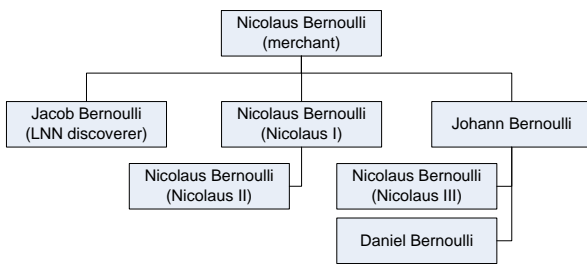


Fig. 2. The parental tree of the Bernoulli mathematicians related to the risk field.

The prominent statement that “satisfaction resulting from any increase in wealth being inversely proportionate to the quantity of goods previously possessed” was introduced by *Daniel Bernoulli* – 1731 in a paper titled *Specimen Theoriae Novae de Mensura Sortis*. This conclusion came to be the first systematic process to explain how most people make choices and reach decisions using the fundamental idea of utility in the sense of desirability or satisfaction<sup>[2]</sup> - “the value of an item must not be based on its price, but rather on the utility that it yields”<sup>[29]</sup>. The solution of the *St. Petersburg Paradox* (suggested by his cousin *Nicolaus II* – 1713)<sup>[30]</sup> came to be the most famous example of proving his point.

Daniel Bernoulli criticized the dominant approach of *expected value* to explain decision-making choices since it completely ignored the decision-maker (i.e., the value assigned to each possible outcome in a decision under uncertainty). He concluded that even when probabilities are known, rational decision-makers will try to maximize expected utility rather than the expected value.

When searching if observations comprise a sufficiently representative sample of the universe, *Abraham de Moivre* – 1718 suggested the structure of the *normal distribution* (i.e., the *bell curve*) and defined the concept of standard deviation in the book *The Doctrine of Chances*<sup>[2,18,28]</sup>. Today, we recognize de Moivre proposals as the core principle for risk management systems.

By investigating the inverse problem of Jacob Bernoulli (i.e., *inverse probability*), *Thomas Bayes* - 1763 made a striking advance in statistics through an experiment with a billiard table. He defined a systematic way to use new information to revise probabilities based on old data (i.e., to compare posterior probability with the priors) in his famous book *Essay Towards Solving A Problem In the Doctrine of Chances*. The possibility to modifying a probability based on the accumulation of new information opened a philosophical discussion about uncertainty, which at that point was still unknown.

*Pierre-Simon LaPlace* – 1774 interpreted Bayes original theorem in a subjective view by modifying it to infer distribution parameters instead of searching for the probability of random variables. He published his advances in *Mémoire sur la probabilité des causes par les événements* and later in *Essai philosophique sur les probabilités*<sup>[28]</sup> and made Bayes theorem famous as the originator of the Bayesian inference. The conversion of the Bayes original theorem made possible to predict a probability distribution for a future outcome using a subjective interpretation. It assumes that the same pattern from a prior distribution would be followed, defining a fixed state of belief or state of knowledge.

According to Bernstein<sup>[2]</sup>, the utility concept only became a paradigm of choice when Economists incorporated the concept in the late 18th century. *Jeremy Bentham* - 1780, the founder of modern *utilitarianism*, reinterpreted utility as a property in any object that tends to produce benefit, advantage, pleasure, good, or happiness. What he called *felicific calculus*<sup>[31]</sup> in the book *An Introduction to the Principles of Morals and Legislation*. Later, the son of *James Mill* - 1829 (i.e., Bentham’s collaborator) named *John Stuart Mill* – 1863 modified and expanded the utilitarianism to a more liberal conception. Stuart Mill introduced a moral agent who maximized global happiness (i.e., pleasure over pain - “*The greatest happiness principle*”) and separated the pleasures into higher and lower forms<sup>[32]</sup>. *William Stanley Jevons* - 1871 enhanced the utility concept and believed he solved the value problem (i.e., value-laden characteristics<sup>[16,33,34]</sup>) with his publication *The Theory of Political Economy*.

The industrial revolution made a great impulse to quantification trend and scientific research growth<sup>[2]</sup>. The experience with sweet peas (*Quincunx II*) led *Francis Galton* - 1875 to propose a general principle that came to be known as the *Regression* or *Reversion to the Mean*. “This is the tendency of the ideal mean filial type to depart from the parental type, reverting to what may be roughly and perhaps fairly described as the average ancestral type”<sup>[35]</sup>. Although Galton recognized that nature sometimes fails to regress to the mean, several methods are fundamentally grounded in this principle creating a direct relation to the meaning of risk (e.g., to predict tendency in the investment field).

*Henri Poincaré* - 1900 and his student *Louis Bachelier* attempted to explain why empirical frequencies approximately reproduce mathematical frequencies (i.e., distributions are not far from the *Normal Law*<sup>[36]</sup>). They recognized that sometimes there is not enough information to apply the laws of probability and concluded it was impossible to acknowledge with certainty how good a

sample is. This conclusion is acknowledged as the *Laplacian principle of insufficient reason*, a necessary convention for determining the value of the probability when information is missing. In this situation, they suggested to fall back on inductive reasoning and try to guess the odds using the "method of arbitrary functions" developed by Poincaré [2,37].

#### 2.4 Phase IV: Risk and Uncertainty Distinction

The phase IV addresses the risk and uncertainty distinction in the Economics field and the beginning of research on how human beings recognize and respond to probability, risk management, and decision-making, arising the dilemma of measurement versus degree of belief in the rational perspective.

In the post First-World War, problems could no more be faced using strict quantified rationalism and probability under the Normal Law behavior [2]. **Frank Knight - 1921** quotes in his book *Risk, Uncertainty and Profit*: "Uncertainty must be taken in a sense radically distinct from the familiar notion of Risk, from which it has never been properly separated" [38]. Knight's proposition confronted the theory of certainty and regulation by the laws of probability [39]. He defined the term apodeictic certainty to group and characterize the events which objective probability could be assigned ("publicly verifiable" [40]) and rejected the probability assignment for other types of events.

**John Maynard Keynes - 1921** published two important books addressing risk-related content in distinct moments of the history. In 1921, the book *A Treatise on Probability* explored the meaning and applications of probability. Keynes proposed the distinction of risk and uncertainty in contrast to what is definable and undefinable [41] and concluded that Galton's peapod analogy using *Regression Towards the Mean* and *Normal Law*, applies to nature but it is irrelevant to human activities [2]. Keynes advocated that objective probability does not exist: "It is not, that is to say, subject to human caprice – but our ignorance denies us the certainty of knowing what that probability is; we can only fall back on estimates". Then, Keynes suggests that: "we pass from the options of theorists to the experience of practical men" [41,42].

In 1937 Keynes published the book *The General Theory* with the explicit notion that uncertainty is unknown: "By uncertain knowledge... I do not mean merely to distinguish what is known for certain from what is only probable... there is no scientific basis on which to form any calculable probability whatever. We simply do not know" [43]. Keynes advocated the logical interpretation of probability [33], earlier originated by Bernard Bolzano's

publication *Wissenschaftslehre* (1837) and further developed by **Rudolf Carnap - 1950** years later [44].

Motivated by the difficulties and limitations of the empiricist philosophy, the subjective interpretation of probability resurgence came from the 1930s with the philosophers **Frank Plumpton Ramsey - 1931** (i.e., *coherence principle*) and statistician **Bruno de Finetti - 1930** (i.e., *betting interpretation*). However, it was only widely restated with the publication *The Foundations of Statistics* from **Leonard Savage - 1948/1954** [18,33,44,45].

The old belief that people would know all the information and that certainty would prevail had vanished with the World Wars, opening the opportunity for risk management research [2]. Nobel laureate **Kenneth Joseph Arrow - 1974** (i.e., inventor of modern *social choice theory*) focused to understand how people made decisions under uncertainty and how humans behave with their decisions [46]. Arrow developed the "*impossibility theorem*", stating that although individuals may have preferences, groups do not. The "social choice" is governed by a single global societal preference order (i.e., the social welfare function) resulting from the set of individual preferences [46,47].

**John von Neumann - 1944** and **Oskar Morgenstern - 1944** made significant progress in understanding risk and uncertainty in the *Theory of Games*. Their book *Theory of Games and Economic Behavior*, represented a disruption from earlier efforts to incorporate mathematics into decision-making [48]. In essence, the theory consists of two or more elements trying to maximize their utility simultaneously, each aware of the other's concerns. That is, uncertainty lies in the intentions of the others [48,49]. This approach follows the classical model of rationality, assuming that people clearly understand and constantly apply their preferences [2,6].

The Game theory induced many ideas and applications, strengthening the rationalist view for governing risk and maximizing utility [5]. However, the rationalist triumph had a dramatic break in the early 1970s with the research works criticizing the rational behavior principle.

#### 2.5 Phase V: The Risk Perception and Risk Behavior

Phase V addresses the rationality questioning period. Although discussions had emerged in the 1960s and the world had changed in so many forms, this is still an open research topic. The rational perspective believes that humans make decisions following a pattern of behavior that enables predictability. On the other hand, Psychologists had proven that people are prone to distortions during decision-making process [2,5].

**Herbert Alexander Simon - 1957** challenged the rationality perspective (i.e., main economics orthodoxy<sup>[50]</sup>) by suggesting the *theory of bounded rationality*. It assumes that human “computational abilities” and memory has limitations to absorbing and processing information to reach conclusions. Simon concluded that human intuition consists of a “subconscious pattern recognition” process. Then, he proposed a model in which the maximization of utility is replaced by *satisficing*<sup>[24]</sup>. It occurs when associations or patterns automatically retrieved in the mind (i.e., based on experiences stored in memory) satisfy the decision-maker goals. Simon did not consider intuition irrational, but a complementary cognitive mode<sup>[50]</sup> without a conscious analytical method<sup>[51]</sup>.

The research psychologists **Sarah Lichtenstein - 1960**, **Paul Slovic - 1962**, **Baruch Fishhoff - 1975**, and others developed the psychometric paradigm (i.e., pioneered by **Chauncey Starr**<sup>[52]</sup>) and introduced the notion of perceived risk<sup>[5,6,53-55]</sup>. These early research produced “*cognitive maps*” of hazards that explained how laypeople perceive risks but neglected individual differences in risk perception<sup>[56]</sup>. **Roger Kasperson – 1966**, **Ortwin Renn - 1980** and colleagues suggested the concept of social amplification of risk and demonstrated by empirical studies that hazardous events interact with psychological, social, institutional, and cultural processes in ways that can attenuate individual and social perceptions of risk<sup>[57,58]</sup>.

**Daniel Kahneman - 1979** and **Amos Tversky - 1979** made one of the most important contributions to risk management and uncertainty fields. They defined the *Prospect Theory* (2002 Nobel Prize winner) in a critique about the expected utility theory<sup>[5,59,60]</sup> while exploring the psychology of intuitive beliefs and choices under bounded rationality<sup>[61]</sup>. Some of their conclusions are summarized as follows:

- People display risk-aversion, and risk-seeking behaviour for the same choices put in different settings called a failure of invariance.
- People tend to ignore the common components of a problem and concentrate on each part in isolation.
- People have trouble recognizing how much information is enough and too much.
- People pay excessive attention to low-probability events accompanied by high drama and overlook routine events.
- People are not risk-averse; the major driving force is loss-aversion. People do not hate uncertainty, they hate losing.

Daniel Bernoulli advocated that the final wealth state (i.e., the “final state of endowment”) influences the value of a risky decision. However, Kahneman and Tversky had

proven that value is determined by attitudes with reference to gains or losses and dependent on a reference point<sup>[2]</sup>. Kahneman<sup>[61]</sup> calls it the Bernoulli’s error, that prevailed as the accepted understanding for 300 years.

Kahneman and Tversky<sup>[62]</sup> concluded that people use computational shortcuts and editing operations when faced with a complex problem. People rely on a limited number of heuristic principles (e.g., representativeness, availability, and anchoring<sup>[53,54]</sup>). Human mind automatically replace the complex mental effort by simpler judgmental operations (i.e., heuristics) that sometimes leads to severe and systematic errors (i.e., biases)<sup>[60,61]</sup>.

**Gerd Gigerenzer – 1987** proposed the fast and frugal heuristics program as an alternative theory to the heuristics and biases program (from Kahneman and Tversky). The fast and frugal heuristics relates to the ecological rationality, suggesting that humans develop a repertoire of cognitive strategies for solving judgment and decision tasks in an adaptative way (i.e., adaptative box). Differently from the heuristics and biases program, the fast and frugal heuristics does not rely only in the human cognitive architecture, it also addresses the environment structure (i.e., the pair of scissors from H. Simon)<sup>[63]</sup>.

The research about the flaws of the rational model made society realize that the risk perception, risk behavior and decision-making result from a complex interaction between conscious, subconscious, and emotional (internal) aspects constantly moderated by the environment and socio-cultural influences (see Deborah Lupton - 2000 and **Ortwin Renn - 1980**<sup>[64]</sup>).

#### IV. DISCUSSION AND RECENT RESEARCH

The risk field is wide-ranging, interdisciplinary and includes several philosophical issues in epistemology, philosophy of science and psychology topics. The distinction between know-how and know-that<sup>[13,65]</sup>, the meaning of knowledge as the “epistemically most justified beliefs”<sup>[66]</sup>, the risk field as a scientific discipline<sup>[8,10,67]</sup>, the influences of human cognitive system<sup>[61,68,69]</sup> and behavior<sup>[70-72]</sup>, and the implications of the probability interpretations<sup>[33,73]</sup> are some examples of the fundamental topics of research.

The tension between subjective (constructivism) and objective (realism) conceptualizations of risk is present in all the way through the history of risk field and numberless cited in the literature<sup>[74,75]</sup>.

The realist perspective acknowledges that risk events are produced by physical and natural processes in ways that can be objectively quantified<sup>[76]</sup>. Then, the technical estimates of risk constitute true representations of

observable events regardless of the beliefs of assessors <sup>[77]</sup>. In contrast, the constructivism perspective acknowledges that risk is inherently subjective and it does not exist independently of human minds and cultures <sup>[76]</sup>. In this perspective, decisions are mental constructions subject to degrees of belief and constantly moderated by socio-cultural influences <sup>[77]</sup>.

Next subsections introduce some of the recent advances in the risk field (since the 1950s) and discuss their links to the past achievements described in the paper.

#### 4.1 The Risk Field and Probability Theory

The risk concept is often linked to the probability concept due to the interpretation of chance <sup>[33]</sup>. Probability was the first way researchers encountered to understand the randomness nature of events in gambling. Although probability is a well-defined mathematical concept, it has philosophical limitations when used for measuring risk and uncertainty <sup>[78]</sup>. Fundamental issues often occurs due to the lack of consistency about probability interpretation as classical, frequentist, logical, or subjective <sup>[33,73]</sup>.

Several industries and engineering sectors (e.g., energy, transportation, aerospace, military, and construction) widely adopt Probabilistic Risk Analysis (PRA) techniques. PRA even became regulatory and normative in many of these fields to support decision-making <sup>[20,79]</sup>. However, its origin is often neglected.

PRA was first developed for safety goals but soon got widely adopted for other purposes. It formally originated in the aerospace sector at **NASA - 1967** <sup>[20,80]</sup> with the investigation of the Apollo testing accident <sup>[81]</sup>. However, PRA only proved to be an essential tool for assessing risks after 1979, with the Three Mile Island accident investigation <sup>[12,20,81]</sup>. Foundations of the PRA can be traced back to the first applications of probability as a measure of risk since the probability theory definition in the 17th century by Pascal, Fermat, and de Méré. However, it just became a reality due to the support and mathematical coherence provided by the axioms of probability established by **Andrey Nikolaevich Kolmogorov - 1933** and the computational modeling advances. **Alvin Weinberg - 1971**, **Marie-Elisabeth Paté-Cornell - 1980**, **George Apostolakis - 1980**, **Stanley Kaplan** and **John Garrick - 1981**, and **Enrico Zio - 1998** are also recognized by their important contributions to PRA in the context of engineering.

Most applications of PRA aim to support activities related to complex systems since they need for systematic ways to deal with reliability and safety, and often rely on the availability of great amount of data. Criticism of the probabilistic approaches to measure risk and uncertainty (i.e., often due to the philosophical orientation or

probability interpretation issues) triggered the development of non-probabilistic methods. Researchers argue against the use of PRA in situations with little knowledge to support the representation of uncertainty <sup>[82]</sup>. *Evidence Theory* also known as *Dempster-Shafer Theory* or *Theory of Belief Function* firstly introduced by **Arthur Dempster - 1967** and generalized by **Glenn Shafer - 1976** <sup>[83,84]</sup>, *Possibility Theory* developed by **Lotfi Zadeh - 1978** <sup>[85]</sup> and advanced by **Didier Dubois** and **Henri Pade - 1988**, and *Info-Gap Model* defined by **Yakov Ben-Haim - 1980** <sup>[86]</sup> are some of the non-probabilistic theories most adopted in the literature.

#### 4.2 The Uncertainty Era and Risk Governance

Judging uncertainty as part of risk characterization is only possible due to the uncertainty and risk distinction made by Knight and Keynes in the 1920s. Recent events faced by society and the way they have been predicted or surprised us emerged new challenges to risk research. **Nassim Nicholas Taleb - 2007** made the *black swan* concept <sup>[87]</sup> well-known and widely discussed in the risk field research. Through this concept, authors emphasized the need for evidencing knowledge and surprises in risk management approaches <sup>[13,88]</sup>. Some disciplines were already familiar with the idea of unknown-unknowns (i.e., one type of black swan <sup>[89]</sup>) well before getting popular <sup>[24]</sup>. However, extreme events such as climate disasters, terrorism, global pandemics, and economic crises incited the need for exploring how to deal with such risks (e.g., deep uncertainty).

The *deep uncertainty* concept <sup>[90]</sup> was popularized by **Warren Walker - 2003** in the academic environment (see <sup>[91-93]</sup> for precursors). Deep uncertainty research raised many questions about the efficacy of the traditional approaches for risk management and risk policy when decision-makers cannot agree upon appropriate models or how to represent uncertainty <sup>[94,95]</sup>. Authors concluded that deep uncertainty situations should be treated differently from "normal" situations <sup>[96,97]</sup>. Therefore, deep uncertainty and black swan research resulted new developments about precautionary, robustness, and resilience principles <sup>[98,99]</sup> for risk management, and new methods to deal with emerging risks (i.e., characterized by the weak knowledge related to known/unknown <sup>[13,100]</sup>).

In this context, we see similarities in the risk field history with the first attempts to explain the Normal Law flaws made by Poincaré. Francis Galton suggested a pattern of behavior for natural events with the bell curve, but the complex and random events resulted from the interactions between society and natural environment insistently proves its unteamed character. Then, researchers move back attentions to improve managing

strategies (i.e., risk governance). Ortwin Renn, one of the most influential researcher on the topic, defines risk governance as the various ways in which many actors of society respond in the context of risk-related decision-making, including systemic risks <sup>[101]</sup>. The risk governance research topic has been in debate <sup>[102,103]</sup> since its formalization in political science in 2001 as an opposite approach to the classical notion of risk assessment and risk management <sup>[104]</sup>.

**Terje Aven – 2003** is an important researcher of the risk field that advocate the science of risk with **Sven Ove Hansson - 1991** <sup>[9,66]</sup>. Aven presents a “new perspective” of risk based on knowledge (i.e., “epistemically most justified beliefs” <sup>[66]</sup>), scenarios, and surprises, in opposition to “narrow perspectives” (e.g., accurate risk predictions based on probability and expected values). Aven <sup>[88]</sup> advocates the need to focus on the aspects outside *Mediocristan* <sup>[87]</sup>, what Taleb refers to as *Extremistan*, which includes improved risk assessments, better capture of the knowledge dimension, adaptive and resilient thinking, and the antifragility characteristic <sup>[13,101,105]</sup>.

Aven is a strong supporter for a unified vocabulary and fundamental principles definition as the basic pillar of the risk science in the context of the Society for Risk Analysis – SRA (i.e., founded by **Robert Cumming – 1981** and others <sup>[106]</sup>). These efforts seek to allow communication between the specific knowledge areas in a common language of risk <sup>[9,13,34,66]</sup>.

#### 4.3 The Dynamic and Computational Methods for Risk Analysis

Current general research focuses on dynamic and real-time risk management rather than static or traditional risk assessment <sup>[13,107]</sup>. These methods have been possible with the improvement of the fully integrated data systems, computational capability, sensors technology, prognostic techniques, and programming strategies (e.g., AI <sup>[9,107,108]</sup>, blockchain <sup>[109]</sup>).

The origin of computational aid for risk analysis can be traced back to *Monte Carlo Method* (MCM) development by **Stanislaw Ulam – 1947**, during the development of the first electronic computer ENIAC <sup>[110]</sup>. The MCM allowed statistical sampling to estimate uncertainties before testing and made disruptive advances in hypothesis testing and design of experiments (i.e., the core of inductive reasoning), since first developments by **Ronald Fisher – 1918**, **Egon Pearson** and **Jerzy Neyman - 1933**.

Other remarkable achievement led by **Nicolas Metropolis – 1947/1953** was the *Markov Chain Monte Carlo* (MCMC) algorithm <sup>[111]</sup>. The MCMC merges MCM and the *Markov Chain Theory* developed by **Andrey**

**Markov – 1906**, and the algorithm improvements (e.g., combined with *Gibbs sampler*, *Metropolis-Hastings* <sup>[112]</sup>) have been extensively applied for estimating posterior distributions using Bayesian inference to model dependence within samples in dynamic analysis <sup>[111,113]</sup>.

The Bayesian inference using MCM and MCMC relates back to the Bayes Theorem interpretation made by Laplace. From this point, posterior probability with a prior distribution for unknown parameters became possible, assuming that the same behavior is maintained. Similar subjective interpretation of probability as a degree of belief supports the *Cox theorem* introduced by **Richard Cox – 1946**. It establishes a set of conditions under which abstract reasoning (i.e., degrees of plausibility, belief, confidence, credibility) is equivalent or isomorphic to probability theory <sup>[114]</sup>.

Strongly related to the risk analysis is the inference process consists in moving from premises to logical conclusions. Current knowledge recognizes three types of logical reasoning: induction, deduction, and abduction. For **Charles Sanders Peirce – 1878**, the scientific method involves a spiral interplay among the reasoning methods (i.e., abduction – creating hypotheses, deduction – inferring what should be the case, and induction – testing hypotheses) <sup>[115]</sup>. Though reasoning categories are conceptually and mathematically well-defined, the mapping process for risk conceptualization is not straightforward, mainly due to human factors.

## V. CONCLUSION

This paper elaborated on the main achievements made by academics, philosophers and researchers that shaped the risk field (knowledge area) and the different risk conceptualizations advocated so far. It provides a general overview of the risk discipline in a condensed form and suggests a logical separation of the collaborators according to the risk conceptualization they advanced.

A timeline with a phase division guides the paper content and summarizes the results from an extensive literature review. The timeline dates to the first acknowledged practices of risk analysis in the ancient civilization up to the contemporary research. We address the revolutionary transitions of the risk conceptualization along the history and the knowledge building blocks achieved by researchers up to the most recent research topics.

Links are built between the past and modern research topics to highlight the importance to understanding the origins of the current methods for risk analysis. It is acknowledged that the remarkable collaborators to the risk

field from our time will only be recognized in the future as the risk field continuously evolve. From the extent and the continual research about the fundamental pillars and philosophical issues addressed, we acknowledge that the risk science has much more to evolve in a continuum path alongside the changes of the society.

We see further research from the presented review as discovering additional links among the contributions of the authors presented in the timeline since just few are briefly introduced in the paper. Future research should also focus on contributions to the risk field from philosophers of science, which is punctually covered in this paper.

### ACKNOWLEDGEMENTS

This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001.

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# Miguel Ferrante's *Seringal*: human exploitation and violence in Amazonian rubber plantations

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Received: 19 Jul 2022,

Received in revised form: 06 Aug 2022,

Accepted: 11 Aug 2022,

Available online: 16 Aug 2022

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**Keywords—** *Seringal* – Rubber-tappers,  
violence – exploitation – Miguel Ferrante

**Abstract—** In this article we explore the issue of violence and oppression suffered by rubber-tappers in the Amazonian rubber plantations, visible in Miguel Ferrante's novel *Seringal*. The novel is set in the Santa Rita rubber plantation in the interior of Acre, in the Brazilian Amazon, and reproduces the oppressive life of rubber tappers who work for the owner of the rubber plantation, the "colonel. "Always aiming at "profit and more profit" rubber plantation's owner exploits and enslaves the "seringueiros", taking violent actions against the poor workers. The novel also reveals the subhuman condition in which the women in the rubber plantation live, subject to rape and other sort of violence. Women are more deeply colonized and exploited than the rubber men. We argue that violence against women and workers today reflects violence in rubber plantations in the XX century. Scholars such as the thinker Frantz Fanon (1979) who wrote about colonization and Cristina Wolf (2001) who researches violence in the state of Acre, among others, support our argument.

## I. INTRODUCTION

We believe that studies on rubber plantations in the Brazilian Amazon remain very important and necessary as the region continues to be the scene of several conflicts: the exploitation of workers in favor of the wealth of a few is still a reality. In addition, violence against women, who were an object of consumption in the rubber plantations, still seems to be frequent in the Northern region of Brazil. Miguel Ferrante's work is not so recognized as it is the novel *A Selva* by Ferreira de Castro, but it contains several elements that denounce the working conditions in the rubber plantations in the pan-Amazonia. Contextualized in Santa Rita Rubber Plantation, located in the Brazilian state of Acre, in the western Brazilian Amazon, the novel *The Seringal* presents a rubber plantation in the Amazon in the "second Rubber Cycle." There is a strong control of the boss

over a vast territory of the rubber plantation and everything that happens in it seems to suffer his influence. In this context we propose to discuss Miguel Ferrante's novel, focusing on the scenario of violence and exploitation of the human being.

## II. THE CONTEXT OF RUBBER PLANTATIONS IN THE BRAZILIAN AMAZON

The "new boom" of rubber production was motivated by the Second World War, which required rubber extracted from the Amazon rubber tree, since the allied countries could not buy the product from Malaysia. The alliance between Brazil and the United States clearly involved the interest of the United States in the Brazilian rubber. Thus, the two

countries formed a formal alliance under the Washington Agreement of March 1942. It was precisely in 1942 that a great drought occurred in the Brazilian Northeast. The government would then send the most suffering people to the Amazonian rubber plantations. Amazonia became the “Promised land” of those people who were almost starving in Northeast. President Getúlio Vargas recruited about thirty thousand “rubber soldiers” and thus began the migration of northeasterners to the Amazon.

Samuel Benchimol, a scholar who studied the rubber plantations in the Amazon, in his work *The romance of rubber battle* (1992) informs us that the migration of northeasterners to the place of rubber battle in the Amazon “developed during 1941-1942 and early 1943, in the traditional fashion with the flagellates and northeastern migrants, hit by the drought and or attracted by the rubber, in search of the Amazon and its high rivers” (BENCHIMOL, 1992, p. 227).

The appalling working conditions given to the workers shocked observers at the time; Most of the rubber tappers were illiterate and did not read the contract they signed with the owner of the rubber plantation (seringal). Thus, the rubber tappers lived in slavery condition, as the descendants of the “rubber soldiers” still claim today. Researcher Cristina Scheibe Woff relates violence in rubber plantations with violence against women today:

Violence was not one-way, it was not established in a type of relationship between the boss and the rubber tapper, for example. It circulated between relationships, a kind of language that many used and took on different forms. But what I could identify is that it almost always also had a gender character, especially linked to masculinity. (Wolf, 2011, p. 36).

With these considerations we can enter the novel *Seringal*, the fiction created by Miguel Ferrante, based on the history of rubber plantations. We propose to develop a reading centered on human and social issues

### III. THE SERINGAL BY MIGUEL FERRANTE

Ferrante's work describes the daily life of the rubber plantations as the paradise of the few people and the hell of many others, from the extraction of sap to the moment of rubber manufacturing. “The Santa Rita” rubber plantation is the main setting for the moving stories that end the centuries-old martyrdom of the Acre settlers, a martyrdom

that is repeated in hundreds of other shacks, where the tyranny of the rubber plantation owners reigns” (Ferrante, 2007, p. 10). The scenes suggests a cycle of violence imposed by the rubber tapper to guarantee his dominating position.

The narrative develops at the moment when the character named Toinho, who had recently become an orphan, arrives as a teenager at the headquarters of the Santa Rita rubber plantation, where his godfather was the rubber worker, a fact that initiates the character's perception of violence. One of the first impacts occurs, when the female character Paula, only 12 years old, his lover, was raped by Carlinhos, son of the mayor and godson of the colonel who owned the rubber plantation. Toinho comes to know a universe marked by violence, injustice and crimes. As it had been done with indigenous people before, it also began to be done with northeastern migrants:

He worked like an animal, day and night, traversing rubber-tree roads, cutting trees, collecting milk, sitting on the edge of the smoker, or breaking the chestnut urchins. He had deprived himself of many of the few things in his life. But the small balance in the boss's hands soon disappeared in an illness, in the purchase of medicine, a hammock, a piece of cloth (Ferrante, 2007, p.23).

In this scenario marked by the representation of the strength of the colonizing discourse, the author presents the violence generated by the reproduction of this same discourse, as an instrument of power to define and maintain the position of the one who utters it. The novel describes in detail the cycles of exploitation and perpetuation of violence from generation to generation. The rubber forest owners used to submit the workers to slavery, leaving them, without hope and with no perspectives to a better life.

His wife had died. The son grew up, stunted, stunted. Years and illnesses bury the dream, breaking its will [...]. And it stayed. Aging, almost blinded by the urucuri smoke, in the daily work of the smoker. [...] The chest tight with suffocating anguish, and the swollen liver. He walked bent over under the pains that tortured his entrails (Ferrante, 2007, p.23).

This discourse covers multiple violence which is engendered in the narrative, which presents throughout the plot, the naturalization of these sad experiences that strengthen a process of oppression. For Franz Fanon (1979), violence is this fuel that drives the colonial gear, experienced both physically and mentally. “It is violence in its raw state and it can only bow to greater violence” (FANON, 1979, p. 46).

The character Toinho, a rubber tapper under the command of the rubber owner, is well inserted in this world of violence from which he seems to be unable to get out.

Now Toinho is sixteen years old. He is already a man. Soon he will be in a “placement”, coming and going all his life along the same narrow rubber trail, in the disheartening ergastule of the forest, collecting and smoking the latex for Colonel Fábio Alencar, until his legs weaken, the diseases undermine his organism, the urucuri smoke blinding his eyes. And die one day as he lived, anonymously, forgetting gods and men (Ferrante, 2007, p. 21).

The protagonist, who already lived in a “colocação”<sup>1</sup>, with the death of his father, now is living under the roof of his godfather, Colonel Fábio Alencar. In this context Toinho comes to know a universe marked by violence in the face of an aggressive landscape that tones the anguish experienced in the “seringal.”:

“In the still landscape there is a gray tone of desolation and anguish. The immobilized air. Not a wing, the slightest breeze. Everything static, dying brutalized by the suffocating heat, under the dome of the sky” (p. 13).

The writer Miguel Ferrante (2007), describes the rubber plantation environment, as the underworld, a place of everlasting misery or an infernal region: “The hell of the igapós on the floodplains. The devilishly green forest, exuberant, oozing with sap, advancing dominating, enraged over the tent” (p. 23). Nature is described with characteristics of anguish, authority, related to the perpetuation of the miserable life of the rubber tapper that ends in a painful and undignified death.

<sup>1</sup> - Colocação –a little improvised house, built in the forest, it was made from wood and covered with straw in

The fiction *Seringal* reveals a lower world, an environment of affliction in the Amazonian rubber trees forest. It is a narrative which shows traces of naturalism when the stronger imposes violence on the weakest. The dominator, we could say, in this sense, the colonizer, responds to his desires and instincts and, in this way, is always seeking the advantage over the workers. Violence is manifested by the colonizing instinct that brutalizes the human being and causes fear to the victims. Toinho expresses this fear for the first time, when he is introduced to his godfather, the owner of the rubber plantation, Colonel Fábio Alencar:

Toinho, embarrassed, fearful, eyes fixed on the syringe shoe, asked for a blessing. [...] The boy remained motionless, lost in the confusion of strange fear. [...] He raised his hand in supplication, dumbfounded, struggling in vain to free the words strangled in his throat, while walking away like an automaton (Ferrante, 2007, p.17-18).

The violence in the Santa Rita rubber plantation is reflected on the gun, the firearm which was the instrument useful both to punish the said transgressors and to demonstrate the power of command. “The rifle was, then, the symbol of authority. There was no place for pity, for compromise. [...] The weak either succumbed or bowed, slavishly, to the law of the strong. There was no alternative.” (FERRANTE, 2007, p.38). This clearly reflects what Frantz Fanon argues in “Concerning Violence” from *The Wretched of the Earth*

In the colonial countries, on the contrary, the policeman and the soldier, by their immediate presence and their frequent and direct action maintain contact with the native and advise him by means of rifle butts and napalm not to budge. It is obvious here that the agents of government speak the language of pure force (FANON, 1979, p.38):

The Amazonian rubber plantation reveals itself to be a colonial context where one sees inequality, and “the immense difference of ways of life which never come to mask the human realities.” Dona Clara, the colonel's wife, wants to build a school for the children of the rubber plantation, and after so much insistence she got her husband's approval and then occurred the actual construction of the shed to receive students and teacher. The

order to offer shelter to the rubber tappers and their families.

methodology used by the teacher relied on the action of the paddle, an instrument to punish the mistakes made by the students in the evaluation of the lesson of the day, as well as screams and physical punishment added to the difficulty faced by the way into the woods, which were discouraging the disposition of the children.

In the beginning, it had been all that fuss, that eagerness to get to school right away. Soon, however, their enthusiasm died. They now go to classes under threats from their parents. Fearful and reluctant, lengthening their path as if to delay a punishment (Ferrante, 2007, p. 39)

Among the acts of violence experienced by Toinho, we highlight the case of Paula who suffered an outrageous violation of her body and then gradually languishes as a result of the rape. Without adequate medical care to treat the trauma, as indicated by Father José in a visit requested by the boy, she felt hopeless. A fact that leads the protagonist to question about the injustices and violence suffered in that world. And the understanding that he had about the figure of the colonel in front of the rubber plantation, as a leader who upheld justice, is slowly crumbling into painful perceptions of injustices that have been fraught with violence in that world which reminds us of Fanon's colonial world:

Then the colonized discovers that his life [...] is the same as the colonist's. He discovers that a settler's skin is not worth more than an indigenous skin. This Discovery produces an essential shake-up in the world. [...] Not only is his presence no longer intimidating, but I am ready to prepare such ambushes for him that within a short time he will have no other way out than to flee (Fanon, 1979, p.34).

The narrative tension increases when there is a double murder between the rubber tappers Chico Xavier and Clemente, motivated by their disputing a woman. This disagreement leads to a strong controversy and fight which resulted in a point-blank death. Later on, another death happened as punishment for the assassin rubber tapper, this death allowed by the colonel. At this moment, Toinho finds himself confused between the ideas of justice and violence

that are exposed to him, seeks in his friend Mané Lopes, a former rubber tapper from Santa Rita, for clarifications. However, he receives from his friend only words of servile submission to the colonel's orders, reproducing the colonizing discourse in terms of holding back thoughts that interrogate the commands of the owner of the rubber plantation. His friends is still blind to the need of justice for that place. Toinho is confused in this environment, and begins to reflect on whether to follow his fate, a whirlwind of questions invades his mind:

His heart troubled with contradictory emotions, his thought insisting on pulling away from the prayer that his lips utter and he pulling it, bringing it back, trying to concentrate, gazing anxiously at the crucifix. And horrified, he senses that that "thing" is taking possession of him. [...] An anguish digging into his chest, his head heavy, the contours blurring, the colors blurring. (Ferrante, 2007, p. 105).

The novel highlights a feeling of fear inherent in the rubber tapper, which manifested itself every time in the presence of the colonel: "Toinho was trembling before him. It was always like that when I had to talk to him. He had never managed to overcome the fear that his godfather inspired in him" (p.135). He becomes the colonel's slave and has ideas to escape this reality and seek a new destiny. It so happens that upon learning of Toinho's plans, Colonel Fábio expresses his denial:

Where to Go ? You were born here and here you will have to live. This is your world. Our world. Mine, yours, Raimundão's one. All's world.. We are attached to the earth, we are part of it. understand? [...] "You need to work to end these crazy ideas. I'll give you a 'placement'. (Ferrante, 2007, p. 136)

Once again we realize that the rubber tapper lives in a situation that reflects Fanon's ideas (1979). "For a colonized people the most essential value, because the most concrete, is first and foremost the land: the land which will bring them bread and, above all, dignity."(p.54)

Toinho maintains his fears regarding that fate determined by the godfather, as if agreeing with what was imposed on him would mean accepting all the violence and injustices witnessed and experienced by the protagonist.



The boy looks like a cornered animal, lost in grief, as if something has broken inside him and his mind is crumbling in the gears of dread. A frantic desire to scream, to throw himself into the shining waters of the Aquiri, to disappear. And the blurred, semi-conscious senses, holding him to the shreds of reality, warning him of danger, impelling him to seek help (Ferrante, 2017, p. 141).

This feeling provoked in the character a certain dose of revolt that had been fueled by the representation of domination in the figure of his godfather. Now with greater clarity and more certain of his ideas, he tried to break free from the “seringalista”, the owner of the plantation.

When the day arrived for Toinho's farewell, who, then, had a job to take care of and follow the same fate as his father, he felt his fear transformed into a feeling of revolt when he saw the colonel with "a relaxed expression of calm security, a firm gaze of an oppressor. “Toinho felt himself suddenly, enraptured by that gaze” (Ferrante, 2007. 159). And at that moment, as a way of freeing himself from the fear generated by the history of violence, which the colonel represented, and with the possession of a firearm, the representation of order and justice in the seringal, he shot the colonel, and then runs away towards the forest, in the Amazon jungle.:

From the depths of the past, the monotonous voices of rubber tappers emerged, chanting the blessed of the dead at his father's funeral. The hammock swaying to the cadenced rhythm of the porters' footsteps. The hollow sound of the earth falling on the body buried without the coffin. Paula's eyes looking at him, green and meek, through the shadows of death. [...] And the disturbing vision of Chico Xavier, tied to the post, the mouths of the wounds uttering words of blood... Trapped in the tangle of torturous ideas, he felt like a dog that the jaguar is chasing” (Ferrante, 2007). , p. 162).

The sudden reaction undertaken by the protagonist, reflected the desire to revolt against the oppression Toinho had experienced. And during the flight, he was presented with a momentary freedom that allowed him to enjoy a state of peace, overcoming the fears caused by a life of violence.

His eyes no longer saw the land buried in darkness. The ears no longer heard the angry voices, which were approaching. Alone, in front of himself, he felt invaded by an immense stillness, his heart freed from the chains of fear, stripped of anguish. As if all the suffering from seringal had gathered in himself. (Ferrante, 2007, p. 163)

Toinho resorted to the power endorsed by the firearm, and this decision gave opportunity, even if momentarily, to freedom that he desired, had been desiring for a long time.

#### IV. FINAL CONSIDERATIONS

We are aware that there are many studies on fictional and non fictional works related to rubber plantations and rubber tappers. We consider, however, that it is still extremely important to bring more studies and investigations into our discussions. As we explained at the beginning of this chapter, the exploitation of workers and slavery are still present in the Amazon. Behind the desire for profit of a few and the suffering of a large number of workers, who live in their skin the humiliation of working without any prospect of improvement, there is always a discourse that speaks of progress and development in the Amazon. Bringing for discussion a less explored work such as Miguel Ferrante's *Seringal* a work written from Acre perspective, may help us to understand better the literature produced in our environment. Although the author did not live in the rubber plantation itself, the author lived in the state of Acre and he is able to offer us in his work clear characteristics of a colonial world. By reading the novel one is reminded of Frantz Fanon's warning, when he affirms that “the colonized world is a world split in two” (1979, p 143), on the one hand, the privileged colonizers, on the other, the colonized, the damned of the land or “wretched of the earth.” Perhaps we can say that *O Seringal* represents this world divided in two: on the one hand, the rubber tapper and those closest to him, and on the other, the rubber tapper with all his tribulations: colonial violence was exercised for the dominating permanence. Another important theme which may be explored in the novel is the violence against women in the seringal. The novel invites the reader to reflect on issues such as misogyny, feminist studies or gender studies. This was not our aim for this article, but we probably feel invited to explore this on another occasion. It is worth mentioning that violence against women and workers today reflects violence in rubber plantations in the XX century. It is important to remember Cristina Wolf's

work (2001) which denounces violence in the state of Acre, especially violence against women.

Finally, the narrative presents the violence generated by the discourse and attitudes of the colonizer that can be well addressed with the help of post-colonial and decolonial theories that invite us to realize that in the Amazon the colonizers often come with the intention of producing “profit and more”. profit” regardless of the need to respect the others.

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# Association between Environmental Factors and Incidence of Diarrhea Among Toddlers in The Working Area of Ambal I Health Center, Kebumen, Center of Java, Indonesia

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Received: 20 Jul 2022; Received in revised form: 08 Jul 2022; Accepted: 12 Aug 2022; Available online: 18 Aug 2022

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**Abstract**— About 1.7 billion children suffer from diarrhea and diarrhea causes 525,000 toddlers died each year. In 2021 diarrhea in toddlers as much as 34.2% of 357 cases of diarrhea, and in the work area of Ambal I health center for the last 3 years cases of diarrhea in toddlers have not shown a decrease. The purpose of this study was to determine the association between environmental factors and the incidence of diarrhea in toddler in the working area of Ambal I Health Center in 2022. This type of research was analytic observational with a cross sectional approach. The population in this study were toddlers aged 12-59 months who lived in the working area of Ambal I Health Center, Ambal District, Kebumen Regency in 2022. The number of samples taken was 67 samples using the proportional random sampling method. The association test was carried out using the Chi-Square test. The results of this study indicate that there were no significant association between clean water sources ( $p=0.220$ ), faecal disposal facilities ( $p=0.717$ ), waste water disposal facilities ( $p=0.103$ ), waste disposal facilities ( $p=0.683$ ) and the type of floor of the house ( $p=0.610$ ) with the incidence of diarrhea in toddler. Environmental factors are not related to the incidence of toddler diarrhea in the working area of Ambal I Health Center, Kebumen, Center of Java, Indonesia in 2022.

**Keywords**— environment, diarrhea, toddler, Health Center.

## I. INTRODUCTION

Globally, children suffering from diarrheal diseases each year recorded approximately 1.7 billion and resulted in 525,000 toddlers died due to diarrhea. Toddlers are a vulnerable group which if exposed to diarrhea and do not get the right help can lead to death. Diarrheal diseases also play a major role in the case of malnutrition in toddler (WHO, 2017). The incidence of diarrheal disease in Indonesia at all ages amounted to 3.5% while in toddlers amounted to 6.7% (Christy, 2014).

Diarrheal diseases are caused by various influencing factors, namely environmental conditions, public health

services, behavior, nutrition, population, education, knowledge, social, economic and others. Diarrheal diseases themselves are caused by about 20-30% by Rotavirus viruses, by 20-30% by E. coli, by 1-2% by Shigella sp. and less than 1% by the parasite Entamoeba histolytica (Maidartati and Anggraeni, 2017).

Environmental factors are factors that have a crucial role in relation to the emergence of various diseases. Poor environmental conditions will also affect a person's health and make it easier for the person to be exposed to diseases such as diarrhea, malaria, measles, hepatitis, dengue hemorrhagic fever and so on, so that efforts are needed to improve the environment to eradicate infectious diseases

(Febrianti, 2019). These environmental factors can be seen from the presence of polluted clean water, poor environmental sanitation, poor hygiene and the use of latrines, cleanliness of dwellings that are not maintained and poor waste water disposal facilities (Fathia, 2015).

Research Yasin, et al (2018), states that there was an association between environmental factors (landfills, latrine types and drinking water sources) with diarrhea toddlers ( $p = 0.028$ ). Similar research conducted by Yustati (2021), it was found that there was a meaningful association between clean water facilities ( $p = 0.000$ ), latrine availability ( $p = 0.000$ ), and SPAL ( $p = 0.000$ ) with toddler diarrhea. Another study was conducted by Saputri & Astuti (2019) and it is known that the type of floor, the type of stool disposal and the source of drinking water are factors causing toddlers to suffer from diarrhea (OR = 4,035; OR = 4,218; OR = 5,716).

Based on preliminary studies and data from Ambal I Health Center, Ambal sub-district, Kebumen Regency, it is known that cases of diarrhea both among all ages and toddlers have decreased from previous years, but the decline has not been significant. Data from Ambal I Health Center showed that in 2021, as many as 34.2% or as many as 122 cases out of 357 cases of diarrhea in the working area of Ambal I Health Center were cases of diarrhea in toddlers.

Environmental health data according to Ambal I Health Center, Kebumen, Center of Java, Indonesia in 2021, namely the community has 93.2% coverage of clean water access, 95.9% coverage of access to healthy latrines, 93.1% coverage of clean water access, 83% coverage of Healthy Homes and the number of families who are still defecate in open as much as 1.5%.

According to preliminary studies that have been conducted, most people in the area of Ambal I Health Center still throw garbage directly on the ground and then burned as much as 100% (16 of 16 respondents), have clean water sources have not qualified as much as 37.5% (6 of 16 respondents), have latrines have not qualified as much as 56.3% (9 of 16 respondents), waste water disposal facilities have not qualified as much as 43.8% (7 of 16 respondents), and there are still 18.8% (3 of 16 respondents) whose floors are not waterproof.

Based on the above background, the researchers were interested in researching "Association Between Environmental Factors and Incidence of Diarrhea Among Under-Five Years Children in The Working Area of Ambal I Health Center, Kebumen, Center of Java, Indonesia in 2022".

## II. METHOD

This study was conducted in the working area of Ambal I Health Center, Kebumen, Center of Java, Indonesia in April – May 2022. The Ethical Clearance no 187/EA/KEPK-FKM2022 approval from Health Research Ethic Committee, Faculty of Public Health Diponegoro University. The research design used was a cross sectional study. The independent variables studied were clean water sources, fecal disposal facilities, waste water disposal facilities, garbage disposal facilities, and type of house floor, while the dependent variable studied was the incidence of diarrhea toddlers.

### 2.1 Population

The population used in this study was mothers who had toddlers aged 12 to 59 months in Ambal 1 Health Center working area in 2022. The population in this study amounted to 1656 toddlers.

### 2.2 Sample

Sampling was done by proportional random sampling. Sampling technique is used when the elements or members of a population is not uniform/ homogeneous and stratified proportionally (Sidik et. al., 2016). The number of samples is calculated using the formula according to Lemeshow et. al. (1991)

$$n = \frac{Nz^2p(1-p)}{d^2(N-1) + z^2p(1-p)}$$

Description,

$n$  = sample size

$N$  = large population

$z$  = Z value at  $\alpha=90\%$  ( $z = 1.96$ )

$p$  = proportion of diarrhea in toddlers (according to Oktariza et. al., (2018), the proportion of diarrhea in toddlers in Indonesia, amounting to 20% or 0.2)

$d$  = precision (10% or 0.1)

By using the formula above, it can be obtained the calculation of the minimum sample in this study of

$$n = \frac{1656 \cdot (1.96)^2 \cdot 0.2 \cdot (1 - 0.2)}{(0.1)^2 \cdot (1656 - 1) + (1.96)^2 \cdot (0.2) \cdot (1 - 0.2)}$$

$$n = 59,3 \approx 60$$

From the above calculation, obtained a minimum number of samples as many as 60 samples. Then do the calculation with an estimated drop out of 10% to obtain the number of samples as many as 67 samples. The results are then calculated proportions to get the number of samples per village.

Formula proportional random sampling (Ikrimah, 2018) :

$$n = \frac{\text{number of toddlers per village}}{\text{jumlah total balita total number of toddlers}} \times \text{number of samples}$$

Table 1. The number of samples per village in the working area of Ambal I Health Center Kebumen, Center of Java, Indonesia in 2022

No.	Village	Number of toddlers	Number of samples per village
1	Entak	111	4
2	Plempukankembaran	65	3
3	Kenoyojayan	82	3
4	Ambalresmi	172	7
5	Kaibonpetangkuran	123	5
6	Kaibon	121	4
7	Sumberjati	94	4
8	Blengorwetan	89	4
9	Blengorkulon	102	4
10	Benerwetan	79	3
11	Benerkulon	118	5
12	Ambalkliwonan	115	5
13	Pasarsenen	94	4
14	Pucangan	80	3
15	Ambalkebrek	66	3
16	Gondanglegi	145	6
<b>Total</b>		<b>1656</b>	<b>67</b>

### 2.3 Data analysis

The data analysis were univariate and bivariate analysis. Univariate analysis in the form of presentation of frequency distribution data on environmental factors, (clean water sources, fecal disposal facilities, waste water disposal facilities, garbage disposal facilities and type of house floor). Bivariate analysis presents data on the results of the association test using chi-square test between environmental factors and the incidence of toddler diarrhea.

## III. FINDINGS AND DISCUSSION

### 3.1 Overview of research sites

The working area of Ambal I Health Center is in Ambal Sub-District, Kebumen regency, Central Java. This area consists of 16 assisted villages namely Entak, Plempukankembaran, Kenoyojayan, Ambalresmi, Kaibonpetangkuran, Kaibon, Sumberjati, Blengorwetan, Blengorkulon, Benerwetan, Benerkulon, Ambalkliwonan,

Pasarsenen, Pucangan, Ambalkebrek and Gondanglegi. Geographically, this region is a lowland area with an average altitude of 7.5 meters above sea level and a total area of 35,490 km<sup>2</sup>. The smallest village area was Plempukankembaran village was 1.1 km<sup>2</sup> and the most extensive village area was Entak village which was 4.549 km<sup>2</sup>. Land use in the working area of Ambal I Health Center is 55% dry land consisting of residential building land and moorland, while the other 45% is paddy land.

The total population in the working area of the Ambal I Health Center in 2020 was 33,561 people where this number increased from the previous year, namely in 2019 which had a population of a total of 33,373 inhabitants. The distribution of the population is uneven, because the population concentration varies from village to village. The level of population density has increased in 2020 by 950 per 1 km<sup>2</sup> where previously it was 946 per 1 km<sup>2</sup> in 2019.

### 3.2 Univariate analysis

Univariate analysis aims to determine the frequency distribution of the variables used in this study. Distribution of characteristics of mothers and toddlers include mother's age, mother's education, mother's occupation, family income, toddler's age, toddler's gender, and toddler's

nutritional status while the sample characteristics include clean water sources, fecal disposal facilities, waste water disposal facilities, garbage disposal facilities and types of home floors and distribution of diarrhea frequency in the working area of Ambal I Health Center.

Table 2. Frequency distribution of mothers and toddler characteristics in the working area of Ambal I Health Center, Kebumen, Center of Java Indonesia, in 2022

No.	Mothers and toddler characteristics	Frequency (f)	%
1	Mother's age (year)		
	Mean	32,15	
	Minimum	20	-
	Maximum	47	
	Std. Deviation	6,165	
2	Mother's education		
	Low		
	Primary school	11	16,4
	Junior high school	33	49,3
	High		
	Senior high school	19	28,4
	Bachelor	4	6,0
3	Mother's occupation		
	Work		
	Farmer	3	4,5
	Trader	3	4,5
	Village apparatus	2	3,0
	Not Work		
	Housewife	59	88,1
4	Family income		
	< Regional minimum wage (RMW)	54	80,6
	≥ Regional minimum wage (RMW)	13	19,4
5	Toddler's age (Month)		
	Mean	30,93	
	Minimum	12	-
	Maximum	58	
	Std. Deviation	12,008	
6	Toddler's gender		
	Male	26	38,8
	Female	41	61,2
7	Toddler's nutritional status		

Mean	-0,67	
Minimum	-3,40	-
Maximum	2,13	
Std. Deviation	1,237	

Based on Table 2, it was known that of the 67 respondents of the study, the age of the mother who became the respondent was a minimum of 20 years and a maximum of 47 years, the majority of respondents' education is Junior High School (33 or 49.3%), the majority of respondents' jobs were housewives or not working (59 or 88.1%), the majority of respondents' family income was below regional minimum wage of Kebumen

Regency (54 or 80.6%), the age of respondents' toddlers was a minimum of 12 months and a maximum of 58 months, the majority of the gender of toddlers is female (41 or 61.2%) and the majority of the nutritional status of toddlers was good nutritional status as much as 56 (83.6%) with a minimum z-score value of -3.40 and a maximum of 2.13 and the standard deviation value of 1,237.

Table 3. The incidence of diarrhea in toddler in the working area of Ambal I Health Center Kebumen, Center of Java Indonesia, in 2022

No.	Incidence of diarrhea	Frequency (f)	%
1	Diarrhea	37	55,2
2	Not diarrhea	30	44,8

Based on table 3. it was known that toddlers who have diarrhea in the last 3 months are 37 (55.2%) cases, while toddlers who do not have diarrhea are 30 (44.8%) cases.

disposal facilities, garbage disposal facilities, and type of house floor) with the dependent variable (incidence of diarrhea toddlers) in the working area of Ambal I Health Center. Association analysis was performed using The Chi-Square test.

### 3.3 Bivariate analysis

Bivariate analysis in this study aims to determine the association between variables of environmental factors (clean water sources, fecal disposal facilities, waste water

Table 4. Test results of environmental factors that affect the incidence of diarrhea in toddler in the working area of Ambal I Health Center, Ambal District, Kebumen Regency in 2022

No.	Variables	Diarrhea		p - value	RP (95%CI)
		Yes	No		
1	Clean water sources				
	Unprotected	24 (61.5%)	15 (38.5%)	0.220	1.85 (0.69 – 4.94)
Protected	13 (46.4%)	15 (53.6%)			
2	Fecal disposal facilities				
	Unqualified	25 (56.8%)	19 (43.2%)	0.717	1.21 (0.44 – 3.32)
Qualified	12 (52.2%)	11 (47.8%)			
3	Waste water disposal facilities				
	Unprotected	30 (61.2%)	19 (38.8%)	0.103	2.48 (0.82 – 7.52)
Protected	7 (38.9%)	11 (6.1%)			
4	Garbage disposal facilities				
	Unqualified	35 (54.7%)	29 (45.3%)	0.683	0.60 (0.05 – 6.99)
Qualified	2 (66.7%)	1 (33.3%)			
5	Type of house floor				
	Not waterproof	8 (61.5%)	5 (38.5%)	0.610	1.38 (0.40 – 4.76)
Waterproof	29 (53.7%)	25 (46.3%)			

Table 4. showed that the results of the association test using Chi-Square Test between environmental factors (clean water sources, fecal disposal facilities, waste water disposal facilities, garbage disposal facilities, and type of house floor) with the incidence of diarrhea obtained p-value of more than 0.05 ( $p\text{-value} > 0.05$ ). This indicates that environmental factors do not have a meaningful association with the incidence of diarrhea in toddlers in Ambal I Health Center working area in 2022.

### 3.4 The association of clean water sources with the incidence of diarrhea

This study shows that of the 67 respondents studied there are respondents who have a protected source of clean water as many as 28 (41.8%) respondents, while respondents who have a source of clean water is not protected as many as 39 (58.2%) respondents. A protected source of clean water is when it is protected from the risk of contamination, such as water from pumps, Springs and boreholes and the distance between the water source and the fecal reservoir is more than 10 meters (Yasin, 2018). Unprotected sources of clean water because they are not protected from the risk of pollution, such as water from rivers, dug wells, and rainwater reservoirs and the distance of clean water sources with fecal reservoirs is less than 10 meters (Yasin, 2018). Respondents used drilled wells (45 or 67.2%) and dug wells (22 or 32.8%) as their source of clean water. Wells of respondents who meet the requirements of a distance of more than 10 meters from the reservoir of feces as many as 39 (58.2%), while others have a distance of less than 10 meters as many as 28 (41.8%) respondents.

There was a close association between water sources and sources of solid waste pollution and waste. The quality of clean water sources is influenced by the presence of pollution sources that are <10 meters away, such as household garbage disposal, latrine disposal, garbage disposal and animal cages. Various chemicals or microorganisms, especially pathogens of diarrheal diseases contained in wastewater or waste waste will flow and seep into the surrounding water sources. It will make clean water not good quality both in terms of biological, physical and chemical quality. The condition of such a water source if used for drinking water will certainly make water as a medium for the entry of pathogenic microorganisms into the body (Oktariza et.al., 2018).

The results showed that of the 67 respondents who use clean water sources are not protected there are 24 (61.5%) toddlers affected by diarrhea respondents while respondents who use clean water sources are protected there are 13(46.4%) toddlers affected by diarrhea.  $RP=1.85$ ,  $H_0$  was accepted, which means there was not

association between clean water sources and the incidence of diarrhea in toddler in the working area of Ambal I Health Center. The results of this study were in line with research conducted by Kamilla et al (2012).

The number of toddlers affected by diarrhea is higher in respondents who have unprotected clean water sources compared to respondents whose clean water sources are protected. This does not make the benchmark that clean water sources and the incidence of diarrhea toddlers have a significant association. This condition occurs because the clean water used as drinking water by the respondents is not consumed directly. Clean water taken from the well is then cooked/boiled until boiling and stored in a closed and clean place. Respondents who cook water before drinking as many as 63 (94%) people while the remaining 4 (6%) people do not cook drinking water. Boiling drinking water is related to the occurrence of diarrhea where boiling drinking water will reduce the contamination of germs in the water (Putra, 2014).

### 3.5 The association of fecal disposal facilities with the incidence of diarrhea

This study shows that of the 67 respondents studied there are respondents who have a means of disposal of feces qualified as many as 23 (34.3%) respondents, while respondents who have a means of disposal of feces do not qualify as many as 44 (65.7%) respondents. Qualified means of disposal of feces is if it has its own latrine, latrine has a septic tank with a distance of more than 10 meters with a source of clean water, the type of goose neck latrine, easy to maintain, and has a roof and wall building (Yasin, 2018; Oktariza, 2018). Means of disposal of feces respondents who do not meet the requirements due to the distance septic tank with a source of clean water less than 10 meters (28 or 41.8% of respondents) and do not have their own latrines (7 or 10.4% of respondents). Respondents who do not have their own latrines usually use latrines chapter brothers/hitchhiking as many as 2 (3.0%) respondents and chapter in the latrine as many as 5 (7.5%) respondents. The type of latrine used by respondents was goose neck as many as 62 (92.5%) units and *cubluk* (pit used as a toilet) as many as 5 (7.5%). Toddler habits of respondents when defecating in the toilet as many as 27 (40.3%) toddlers, while others defecate carelessly or not in the toilet as many as 40 (59.7%) toddlers.

Fecal disposal facilities with unqualified conditions can cause pollution of the surrounding environment, especially pollution due to human waste. Environment polluted by human feces, will result in increased transmission of diseases such as diarrheal diseases. The process of transmission of diarrheal diseases due to unqualified



means of disposal of feces is the bacteria that cause diarrhea that moves from feces to other people. It can occur through various media such as soil, water and insects which then contaminate food/ drinks (Sidhi et. al., 2016).

The results of this study showed that of the 67 respondents who use means of stool disposal does not meet the requirements there are as many as 25 (56.8%) toddlers affected by diarrhea respondents while respondents who use means of stool disposal meets the requirements there are as many as 12 (52.2%) toddlers affected by diarrhea respondents with a value of  $RP = 1.21$  so that  $H_0$  was accepted, which means there was not association between stool disposal facilities and the incidence of diarrhea in toddler. Means of feces disposal was not a risk factor for diarrhea in working area of Ambal I Health center. The result of this study was not in line with the research conducted by Yasin et al (2018) and Workie et.al (2019) which states that latrine conditions have a meaningful association with the incidence of diarrhea in toddlers.

Diarrhea in toddlers with unqualified means of stool disposal does have a higher number than diarrhea in toddlers with qualified means of stool disposal. This does not make the benchmark that the means of disposal of feces has a meaningful association with the incidence of diarrhea toddlers because as has been explained in theory H.L.Blum that health is influenced by 4 factors, not only environmental factors but other factors such as Behavior, Health Services and genetic (Saputri and Astuti, 2019). Diligent behavior of washing hands after pooping (67 or 100% of respondents wash their hands with soap after pooping or cleaning toddlers when finished pooping) can reduce the risk of diarrhea. One effective way that is easy to do to prevent disease transmission as early as possible is to wash your hands with soap because washing your hands can break the chain of disease transmission (Azhar et.al., 2014).

### **3.6 The association of wastewater disposal facilities with the incidence of diarrhea**

This study shows that of the 67 respondents studied, there are respondents who have protected wastewater disposal facilities, namely as many as 18 (26.9%) respondents, while respondents who have unprotected wastewater disposal facilities, namely as many as 49 (73.1%) respondents. Means of waste water disposal that meets the requirements is if the means is protected by pipes or cement (closed), does not contaminate surface water, is not infested by disease-causing insects, does not emit foul odors and does not flood/inundate the surrounding environment. Waste water disposal facilities are not protected because the facilities are made of

perforated soil and not covered so that it can pollute clean water and the surrounding environment (Nurnaningsih et.al., 2017).

Unprotected means of wastewater disposal can lead to pollution of the surrounding environment. This can make waste water disposal facilities as a medium of transmission of diarrheal diseases. The process of transmission of diarrheal diseases due to unprotected waste water disposal facilities is the bacteria that cause diarrhea that moves from waste water to other people. It can occur through various media such as water, soil and disease vectors which then contaminate food/ drinks. If someone eats/ drinks contaminated food / drink will cause someone to experience diarrhea (Sidhi et.al., 2016).

The results showed  $H_0$  was accepted, which means there was not association between wastewater disposal facilities and the incidence of diarrhea in toddler in the working area of Ambal I Health Center in 2022. The result of this study was in line with research conducted by Samiyati et al (2019).

Toddler diarrhea was more common in respondents with unprotected wastewater disposal facilities than toddler diarrhea in respondents with protected wastewater disposal facilities. Unprotected wastewater disposal means can contaminate water sources and the soil surface (Taosu and Azizah, 2013). Contaminated water from wastewater can make water contaminated with diarrheal germs and when consumed by humans can cause diarrhea (Nurnaningsih et.al., 2017). Waste water disposal facilities in the working area of Ambal I Health Center have estuaries far enough from water sources and drinking water cooked first by respondents to boil before consumption so that it can reduce the risk of developing diarrheal diseases.

### **3.7 The association of garbage disposal facilities with the incidence of diarrhea**

This study shows that of the 67 respondents studied, there are respondents who have qualified garbage disposal facilities as many as 3 (4.5%) respondents, while respondents who have unqualified garbage disposal facilities as many as 64 (95.5%) respondents. Qualified garbage disposal facilities are closed, waterproof and regularly cleaned (Langit, 2016). Garbage disposal facilities that do not meet the requirements because the facilities are not closed and not waterproof. Community behavior that supports garbage disposal facilities does not meet the requirements, namely not sorting waste between organic waste and inorganic waste. The majority of respondents did not do waste sorting as many as 46 (68.7%) people, while others as many as 21 (31.3%) respondents did waste sorting.

Garbage thrown at random or does not meet health standards will cause environmental pollution and have a negative impact on human health such as increasing the spread of diarrheal diseases. Garbage disposal facilities that do not meet healthy standards can also interfere with comfort such as causing unpleasant odors and unsightly views. Efforts to reduce the risk of negative impacts of environmental pollution due to waste, waste management must be done properly, including providing a closed and impermeable trash can (Taosu and Azizah, 2013).

The results of this study showed that H0 was received, which means there was not association between garbage disposal facilities and the incidence of diarrhea in toddler in the working area of Ambal I Health Center in 2022. The result of this study was in line with research conducted by Langit (2016) and Oktariza et al (2018).

Many toddlers affected by diarrhea is higher in respondents who have unqualified garbage disposal facilities compared to respondents who are qualified garbage disposal facilities. This does not make the benchmark that garbage disposal facilities and the incidence of diarrhea in infants have a significant association. This condition is suspected because respondents routinely burn household waste generated in the home environment so that respondents do not let the waste left or accumulate long inside or outside their homes. The habit of respondents routinely burning garbage will reduce the potential for pollution due to waste such as pollution of clean water sources because there is no organic waste/wet. This can prevent the carrier vector of diarrheal disease agents from transmitting diarrheal disease.

### 3.8 The association of type of house floor with the incidence of diarrhea

This study shows that of the 67 respondents studied, there are respondents who have waterproof house floors, namely as many as 54 (80.6%) respondents, while respondents who have non-waterproof house floors, namely as many as 13 (19.4%) respondents. The type of waterproof floor of respondents' houses in the form of smooth/regular plaster was 22 (32.8%), tiles were 1 (1.5%) and ceramics were 31 (46.3%). Respondents who have the floor of the house is not waterproof as much as 3 (4.5%) respondents with the floor of the house in the form of land and 10 (14.9%) respondents with the floor of the house in the form of rough plaster/irregular.

A watertight house floor is a good type of house floor, while a non-watertight house floor is a bad type of house floor. A good type of home floor is a type of floor that is not wet during the rainy season and not dusty during the dry season (Saputri and Astuti, 2019) The condition of the

floor of the house is not waterproof as it is still in the form of rough plaster, soil and sand can trigger a person affected by diarrhea because the floor can be a place to live germs and dust (Samiyati et.al., 2019)

The results showed that H0 was accepted, which means there was not association between the type of house floor and the incidence of diarrhea in toddler in the working area of Ambal I Health Center, in 2022. The result of this study was in line with research conducted by Samiyati et al (2019).

The number of diarrhea toddlers in this study was common in toddlers with the type of waterproof floor than toddlers with the type of floor was not waterproof. This shows that the type of waterproof house floor can also affect toddlers affected by diarrhea because diarrhea is caused by various factors not only environmental factors but there are influences from behavioral factors, health services, nutrition, socio-economic and others (Maidartati and Angraeni, 2017). Floors of the house is a place that closely related to toddlers. Toddler activities that play on the floor of the house cause contact between the toddler's body with the house floor (Saputri and Astuti, 2019). Therefore, it is important to keep the floor of the house clean so that the risk of transmitting diarrheal diseases is reduced. The behavior of respondents to maintain the cleanliness of the floor of the house by cleaning it every day (67 or 100% of respondents clean the floor of the house every day) can prevent the transmission of diseases, such as diarrheal diseases (Taosu and Azizah, 2013).

## IV. CONCLUSION

Based on the results of this study can be concluded that: the respondents had diarrhea in toddler in the last 3 months as many as 37 (55.2%) toddlers, there were no association between environmental factors and the incidence of diarrhea in toddlers in Ambal I Health Center working area in 2022.

Ambal I Health Center is expected to improve the performance of residential environmental health programs and provide motivation and education related to environmental-based diarrhea disease prevention efforts such as throwing toddler feces into the toilet and making closed SPAL. The community is expected to improve the cleanliness of the home and surrounding environmental sanitation such as in the bathroom, fecal garbage disposal, waste water disposal environment, garbage disposal sites and cleanliness of the floor of the house to prevent transmission of diarrheal diseases. Further researchers are expected to add other variables, not only clean water sources, means of disposal of feces, waste water disposal facilities, garbage disposal facilities and type of house

floor but other variables such as chemical pollution in the water or in the food that are suspected to have an influence and associated with the incidence of diarrhea.

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## Strategic Planning and Territorial Development: A New Methodological Construction from those affected by the Sobradinho-BA Dam

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Received: 16 Jul 2022,

Received in revised form: 05 Aug 2022,

Accepted: 11 Aug 2022,

Available online: 16 Aug 2022

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**Keywords**—*Political Administration,  
Sobradinho, Social Participation.*

**Palavras-chave**— *Administração Política,  
Sobradinho, Participação Social.*

**Mots-clés**— *Administration politique,  
Sobradinho, Participation sociale.*

**Abstract**— *This article aims to highlight the impacts of a social debt of the Sobradinho-BA dam that left 12,000 families disappropriated, around 70,000 people and 8,619,000 were from rural families (IPEA, 2018). This research is based on a bibliographic review, based on the theoretical and interdisciplinary methodology of political administration, strategic planning and territorial development that investigated the consequences in the social, economic, environmental, political and cultural dimensions of the construction of the Sobradinho-BA dam for those affected. As a result, it is perceived that there are only ruins of the 04 submerged cities, these riverside families and their descendants had their roots and ties of territoriality forbade, generating a social problem in the future generations of the population involved, requiring new scientific research of the administrative sciences of the theme.*

**Resumo** - *O presente artigo tem como objetivo evidenciar impactos de uma dívida social da obra da barragem de Sobradinho-BA que deixou 12 mil famílias desapropriadas, em torno de 70 mil pessoas e 8.619 mil eram de famílias rurais (IPEA, 2018). A pesquisa baseia-se em uma revisão bibliográfica, com base teórico-metodológicas interdisciplinar da administração política, do planejamento estratégico e do desenvolvimento territorial que investigou às consequências nas dimensões sociais, econômicas, ambientais, políticas e culturais da construção da barragem de Sobradinho-BA para os atingidos. Como resultado, percebe-se que restaram apenas ruínas das 04 cidades submersas, essas famílias ribeirinhas e seus descendentes tiveram suas raízes e laços de territorialidade inundados à força, gerando uma problemática social nas gerações futuras da população envolvida, necessitando de novas pesquisas científicas das ciências administrativas da temática.*

**Resumen** - *Este artículo tiene como objetivo resaltar los impactos de una deuda social de la represa Sobradinho-BA que dejó 12.000 familias desapropriadas, alrededor de 70.000 personas y 8.619.000 eran de familias rurales (IPEA, 2018). La investigación se basa en una revisión bibliográfica, basada en la administración teórico-metodológica interdisciplinaria de la administración política, la planificación estratégica y el desarrollo territorial que investigó las consecuencias en*

*las dimensiones social, económica, ambiental, política y cultural de la construcción de la represa Sobradinho-BA para los afectados. Como resultado, se percibe que solo hay ruinas de las 04 ciudades sumergidas, estas familias ribereñas y sus descendientes tuvieron sus raíces y lazos de territorialidad inundados por la fuerza, generando un problema social en El generaciones de la población involucrada, que requieren nuevas investigaciones científicas sobre las ciencias administrativas de La.*

**Résumé** - Cet article vise à mettre en évidence les impacts d'une dette sociale du barrage de sobradinho-BA qui a laissé 12 000 familles désappropriées, environ 70 000 personnes et 8 619 000 étaient issues de familles rurales (IPEA, 2018). La recherche est basée sur une revue bibliographique, basée sur l'interdisciplinarité théorique et méthodologique de l'administration politique, de la planification stratégique et du développement territorial qui a étudié les conséquences dans les dimensions sociales, les aspects économiques, environnementaux, politiques et culturels de la construction du barrage de Sobradinho-BA pour les personnes touchées. En conséquence, il est perçu qu'il n'y a que des ruines des 04 villes submergées, ces familles riveraines et leurs descendants ont vu leurs racines et leurs liens de territorialité interdits, générant un problème social dans les générations futures de la population impliquée, nécessitant de nouvelles recherches scientifiques sur les sciences administratives du thème.

## I. INTRODUCTION

This article presents an interpretative qualitative approach of a methodological framework that evidences social impacts on the social, environmental, economic, political and cultural dimensions caused to affected rural families and their descendants for the construction of the Sobradinho-BA dam.

As highlighted in the literary work of Sá and Guarabyra with the release in 1977 of the song "Sobradinho" portrays the drama experienced by the population expelled from the former Bahians cities of Casa Nova, Remanso, Sento-Sé and Pilão Arcado and the submersion of these municipalities that allowed the formation of the Sobradinho lake in the state of Bahia. The suffering of these people and families was justified by the socioeconomic importance of the creation of the Sobradinho dam, which was part of the strategic actions of the national development public policy led by military governments (1964-1979) and which supported the discourse of bringing progress to the less developed regions in Brazil

To aim at the success of this planning, called the National Project, several structural reforms, including the creation of a new public policy for financing public development policies based on foreign debt, the centralization of public management in the central government, the strengthening of nationalist discourse and

preserving political control in negotiations with local elites keeping traditional patrimonialism alive (SANTOS, 2015).

The impact of the construction of the Sobradinho dam affected several rural and urban communities leaving at the bottom of the great Lake a material and intangible heritage for traditional communities of peoples, such as the indigenous peoples who had (in those valleys and forests a refuge in connection with their spiritual life with the territory (MARQUES, 2008), with the construction of the dam, it also suffered interruptions in the lives of peasants who lived there and dedicated themselves to family rural activities, living off the subsistence economy.

In the letter of the Director of CHESF to the president of ELETROBRAS at the time the barraqueiro is treated as a ("...") the rural type, extremely poor and underdeveloped", which was not the owner of the land, occupying only a "simple possession" by "common use" resulting from the fragmentation of old sesmarias (...). There is also recognized or consented possession of ponds, carnaubais, etc. their professional qualification is limited to work in subsistence crops, fishing for their own use and in small extractive activities.

He was a river-conditioned man who gave him everything, isolated and self-sufficient. Illiterate, without enjoying any benefit of mass communications, his human contacts restricted to his own level, with neighbors and fairs, his mentality cannot evolve, preserving himself primitive, without purchasing power, without aspirations,

conformed and dominated by the dread of the unknown and clinging to the river that assures him of survival and the beliefs that comfort him (AMARAL, 2012), merely technical vision, without the popular participation of the social actors who lived in the territory.

Studies by the Institute of Applied Economic Research - IPEA (2018) presented at a public hearing of the Financial Supervision and Control Commission - CFFC of the Chamber of Deputies, state that the construction of the public works of the Sobradinho dam in Bahia left a social debt with this population originated by the way it was planned and executed, disregarding its social impacts. This article presents a framework of several fields that support the theoretical-historical structure of the research of the impacts on the life history of families for the construction of the Sobradinho-BA dam, with the coherence of social knowledge and practices, embodying an interdisciplinary perspective of a literature review that evaluates the impacts on the social, environmental, economic, political and cultural dimensions of these territories that were destroyed by the waters of the San Francisco River, almost half a century after the beginning of this work, by the Hydroelectric Company of San Francisco - CHESF, as a way of promoting sustainable territorial development, respecting the values, culture and beliefs and the sovereignty of the associated peoples of those territories (CANCLINI, 1997). There is a problem interpreted only in the local reality of the time, managers do not always conceive in their planning the idea of knowing the reality that should act in a profound way and in this way: the design that is presented of social policies is based only on knowledge about the reality in which one wishes to intervene and this, does not mean the social reality of the territory affected (SANTOS, 2017).

## **II. THE CONTRIBUTION OF THE POLITICAL ADMINISTRATION TO THE DISCUSSION ON STRATEGIC PLANNING, MANAGEMENT AND SUSTAINABLE DEVELOPMENT**

The historical experiences accumulated by the Brazilian public administration in government planning, which emerges in the country in the period of 1930 and 1970, resulting from the needs of conception and implementation of the Brazilian (industrial) socioeconomic matrix, founded on the conception of national developmentalism is discussion that deserves attention and its contributions presented by several Brazilian thinkers, with Celso Furtado (1974), Maria da Conceição Tavares (2012), Fernando Pedrão (1984), Otavio Ianni (1979),

Lafer (1973), Fernando Rezende (2010), among others, considered classics of Brazilian administrative thinking that will integrate in the same process, Planning and Public Policies.

There is agreement among scholars that the objective of this effort of forecasting and prospecting is to give the actions of the public authorities a perspective of quality and effectiveness to meet social demands, especially those directed to the poorest population – thus, allowing academics and professionals working in the administrative field who can reflect not only on the conception and results of public and governmental actions, but mainly on the process and dynamics that underlies the dimension of how administrative acts and facts are being managed and managed (operationalized), is not effective management in meeting social demands.

By taking the concept of Political Administration as one of the theoretical and methodological bases for the development of this research, it is considered essential to bring a brief discussion about the boundaries between the concepts and methods of research, with the definition and field of action proper to the Public Administration.

Therefore it is believed that due to the short time of existence of the concept of Political Administration In this sense, much more than advancing in the investigation on the clashes and/or conceptual and institutional reciprocities between both concepts – object of future studies – aims here much more to clarify for the reader a certain confusion that has been perpetrated by some interpretations referring to the concept of Political Administration than by introducing the adjective "politics" as an emphasis or quality of administration, lead some readers to question whether this new field of knowledge would be a different approach to public administration.

Thus, from the natural challenge of the scientificity of this new field of knowledge, there is still a natural confusion with the understanding not only about the concept, but also in relation to the respective spaces of action that ends up being confused with the very concept of Public Administration. This confusion is amplified due to the role that the contemporary State has assumed in the socio-political-economic and cultural context, at the international and national level. The changes in the scenario of the international and national economy, since the 1970s, have contributed to bring even greater confusion about these borders, especially due to the hegemony of (neo)liberal thinking which has confused society, in general, in effectively understanding the limits of the complex relationship between State-Society-Market (between public interests and private interests).

In relation to this dynamic, it should be clarified that several forms (hybrid or not) of intervention in the social sphere coexist, characterizing, therefore, different profiles of the Political Administration of different societies. This confusion in understanding the relationship between The State-Society is even more complex, and difficult to understand for ordinary citizens, in the case of Brazil and most Latin American countries, because they are social spaces where the State has taken a prominent place in the conception of socioeconomic modernization patterns in contemporary times.

With this brief introduction to the theme, it is expected to bring some relevant clarifications on the conceptual and action boundaries between Political Administration and Public Administration. In this sense, evaluating the socio-historical pattern of public administration implies, therefore, advancing the understanding of a broader conception of what we call here political administration. While this latter concept houses and substantiates the complex forms and movements between public, private and social organizations, public administration standards reflect the behavior of public authorities (State) in the conception and/or conduct (execution) of this Nation Project.

The concrete historical example is the standards of Brazilian Political Administration and Public Administration, between the 1930s and 1970s of the last centuries, it can be affirmed, therefore, that there was a conception (political and technical) of a new and complex Nation Project – which we call the standard of Political Administration – which emerged and consolidated in that concrete context. This implies concluding that the new mode of Political Administration of Brazil determined how the State should (re)structure itself to account for the challenges imposed to successfully implement the new socioeconomic matrix founded on the values and principles of international capitalism.

Thus, when analyzing the dimension of the management of social relations of production, circulation and distribution of the new mode of national production, there is evidence that the State was responsible for the more general (abstract) conception of the new mode of production of the country; just as the government deliberately assumed the function of designing and implementing the new management standard that would therefore ensure the implementation of the new model of Political Administration.

Further deepening this example as a methodological resource to help define the boundaries between the two fields, one can use as reference the standards of State Reform and the innovations introduced to promote

administrative modernization through the efforts undertaken, in a complementary way, by Vargas – especially with the creation of DASP and Daspinhos – and the novelties brought by the Military Governments – especially with Law No. 4,320/64 and Decree Law 200/67 (SANTOS and RIBEIRO, 2017).

Based on these historical references of the social formation of the Brazilian State, it is possible, therefore, to recognize the recent dynamics that have guided the conceptions of the patterns of Brazilian Political Administration, materialized in the conception and implementation of a new and transformative mode of social production. From the example, it should be assumed that the field of Political Administration by expanding the concept of administrative sciences incorporates three dimensions that mark the complex relationship between Society-State-Market.

In this sense way Santos (2015) warns that for the understanding of the management of the materiality of social relations it is essential to insert this discussion in a three-dimensional context, which is hierarchical in a logical way by the said author: the first dimension is that of society itself that, through institutions/organizations, is able to reveal itself about the need for total well-being in the concept of Arthur Cecil Pigou (1932) that has with a social purpose to be achieved.

In the social context in which capitalist principles and values are preponderably, as a dominant means for the reach of individual and social desiderate (well-being), there is always an opposition to impended this determination, because the justified negative is that only through its own purpose (capitalism) is it possible to reach the socially intended purpose (SANTOS, 2017).

To better delimit the boundaries between the concepts and domains of the two areas of knowledge and action, it is essential to recognize that the scientific object that underlies the concept of Political Administration is management that, as a proper field of knowledge of administrative sciences, manifests itself, explicitly and/or implicitly, in state actions (materializing, thus, the standards that will guide legally, administratively and socially the role and social functions of public administration) together with corporate (private) actions and social entities.

## **2.1. CHALLENGES OF THE SUSTAINABLE DEVELOPMENT AGENDA IN THE TERRITORIES.**

Since the last decade of the 20th century, the world has been marked by changes in economic and political paradigms, which have interfered in the mechanisms of public and private organization of the territory in which it is part (SANTOS, 2006). In this context, the administrative

political decentralization of the State with the distribution of responsibilities between the union, the state and the municipality stands out, resulting in the permanent reproduction and reconstruction of local and regional territories.

In capitalism, the notion of development presented at the time as a central idea, the differences between peoples and between societies, justifying them by the stages of life to which each one had arrived. In socialism, the notion of development was seen as an ideology that justified the state of exploitation of rich countries over the poor. However, the most elaborate reflection on development occurred in the 1940s in Europe, in view of the restructuring of war-torn countries, because until then, the pattern of each country's progress was measured by its economic growth.

Paul Singer (1982), already pointed out in his studies, the distinction between development and growth, where growth is characterized as a process of quantitative expansion, more commonly observed in industrialized countries, while development is seen as a process of qualitative transformations of the prevailing economic systems in underdeveloped countries. On development in underdeveloped countries, Celso Furtado (1974) was radical, stating: economic development is a simple myth, because the idea that poor people can someday enjoy the life forms of the current rich is simply unachievable.

Until the mid-1980s of the last century, the great development plans made by the state prioritized industrial policy, as well as the strengthening of employer agriculture, ignoring regional characteristics and local social organization, which determined poor results from the general point of view, because, according to Pires et. al. (2006), the process of territorial development has the participation of actors, resources and institutions with strong spatial connection, to develop economic activities and provide social and cultural well-being to the community.

With the acceleration of the globalization of capital, new forms of planning were evidenced by referring to local factors in their diversity, where the collective becomes a priority and from this moment on, according to Saquet (2011) the concept of territory offered subsidies to 'think' not only state intervention, especially for the municipality, but also for the action of actors who seek spaces of action and representation for collective and public interests.

It was to the natural sciences that first elaborated the concept of territory, establishing the relationship between the domain of animal or plant species with a certain physical area. Later, the concept was incorporated and

expanded by geography, relating it to space, natural resources, society and power. Currently, several other disciplines have incorporated the debate, including sociology, anthropology, economics, political science and many others, taking care to differentiate between space and territory. As Raffestin (1993) explains, the concept of space is related to the natural heritage existing in a defined region, while the territory is a process of social construction that involves different public actors and civil society.

With this understanding, Tizon (1995) defines territory as "a space of life, action, and thought of a community, associated with processes of identity construction". Similarly, Pecqueur (2000) conceives the territory as "the meeting of social actors in a given geographical space, which seeks to identify and solve common problems". In a closer approach to development sociology (ABRAMOVAY et. al. 2013).

And this sense of solidarity is defined by Scheren-Warren (1998) as "the principle of individual and collective responsibility with the social and the common good, whose practical implications are the search for cooperation and complementarity in collective action and, therefore, for work in partnership" and, for Albagali (2004), it means the feeling of belonging that is a way of acting within a given geographical space, where territoriality is conditioned by social norms and cultural values, and may vary from one society to another.

In Brazil, this idea only began to be outlined from the Federal Constitution of 1988, when the country initiated important structural changes, causing a decentralization of the functions of the union to states and municipalities. In its Art. 30, it is evidenced that the planning for development, previously traditionally dictated by the central government, began to observe competences and attributions bequeathed to municipalities and regions (BRASIL, 2013).

The new constitutional framework not only took away from the federal public sector the monopoly in the conduct of development-related issues (PETERS, 2003), but also recognized the relevance of other actors and the relevance of proposals formulated from the local space and the regional scale, demanding articulations and partnerships for the construction of territories (BENKO; LIPIETZ, 1994; PAIVA, 2004), which came to meet the conceptual prerogatives of territorial governance.

This new scenario and the demands for a more effective organization have induced new forms of development promotion, especially from the perspective of territorial sustainability, where new technological standards are sought to attenuate the negative effects on



the environment, caused by productive actions, without promoting changes in the capitalist logic of accumulation.

However, the challenge of deconstructing exogenous models of growth to finally build arrangements capable of promoting the transformations required by the country, considering the complexity of development from the economic, environmental, sociocultural and political-institutional dimensions have not been easy, because it is not possible to discuss development without the participation of civil society with the various organizations and actors present in the territory and the government at its various municipal, state and federal levels and to build a process of sustainable territorial development, it is necessary to confront conflicts between the different groups of actors that are directly or indirectly affected by local actions, producing a process of solidarity and collective cooperation (GAZELLA et. al. 2009).

It was from this understanding that the main strategies of territorial development began to consider the human potential of the territories, after the realization that this process is not done by decrees, but by the will of people and groups. Thus, territorial development needs to be readapted to national and international requirements in its production system, considering the decentralization imposed by the globalization of the economy and the strategic feature adopted in relation to the expectations of the integrated, participative and sustainable style of development, which demands governance, new regulatory schemes, alliances and articulation of actors for the generation of work, income and social well-being of populations (PIRES, 2015).

In Brazil, territorial development is not a national policy, even though the collegiates seek to bring together people from various governmental and civil society bodies, the actions of the most important ministries that relate to the interior of the country ignore the very existence of these collegiates, contracting projects with public resources through parliamentary amendments, demonstrating that the old clientelist practices overlap with participatory logic (ABRAMOVAY et. al. 2013).

## **2.2. REVISITING THE THEORETICAL AND HISTORICAL BASES THAT SUSTAINED THE CONSTRUCTION OF DAMS IN BRAZIL AND THEIR IMPACTS ON THE POPULATION AFFECTED IN SOBRADINHO - BA**

The advance of hydroelectric plants in Brazil happened with Vargas' centralized developmental agenda and his project to implement the base industry in the country, for Fainzilber (1980) the energy and transport infrastructures would represent an essential function and from 1950, public resources were invested and applied

research was carried out for the development of a national industry of materials and equipment for the sector (PENTEADO JR.; JR. DAYS, 1995).

However, the nationalization of production collided with its inability to self-finance, establishing, even in the 1950s and the signing of international loans with the Banco Mundial that required the import of equipment with part of the resources achieved. But the electrical deficiency persisted and in 1955 worsened by a long drought in the Southeast region with rationing the city of São Paulo - SP was subject to blackouts that lasted between five and seven hours a day (TENDLER, 1968).

Therefore, at the beginning of the military period a rapid expansion of energy generation was accentuated by the construction of large hydroelectric plants, considered essential to the economic project of the regime and thus, sixty-one large hydroelectric dams were built during the period, almost all of which were implemented under the responsibility of the State (BÔA NOVA, 1985).

A plan of goals was carried out with state investment in the construction of infrastructure, providing a central role with the application of investments in energy and transport that defrayed 73% of the planned resources, of which the cost of the electricity sector represented almost 24% of the Plan of Goals to strengthen this movement of hydroelectric power plants in 1960 (OLIVEIRA, 2018).

In this period, the Ministry of Mines and Energy (MME) was created, becoming the governmental agency branch responsible for all issues related to the production of minerals and energy at that time, expanding the works of the Paulo Afonso dam by CHESF and beginning the construction of two large hydroelectric dams by state-owned companies: FURNAS, by the federal company FURNAS; and Três Marias, by the state CEMIG - CHESF carried out the works of Paulo Afonso I and during this period, hydroelectric power plants were built or approved, such as the Sobradinho power plant on the San Francisco River, the Itaipu power plant, on the border with Paraguay, the Tucuruí plant in Pará and the Ilha Solteira plant in Paraná (OLIVEIRA, 2018). According to (MARQUES 2018) in Brazil, more than one million people were driven from their lands due to the construction of hydroelectric power plants and more than two hundred and fifty thousand people were affected and displaced to other areas organized by CHESF.

To better understand the socio-historical context and highlight the damage to those affected by dams, we analyzed a study conducted by researchers who made a diagnosis of the social debt of the Brazilian State with the population affected by the construction of the Sobradinho-BA hydroelectric dam, reporting the social, territorial,

cultural and economic impacts of the CHESF plant, 37 years after its entry into commercial operation.

The study was a partnership between the Ministry of National Integration - MI and the Institute of Applied Economic Research - IPEA, with the participation of professionals from the University of Brasília - UNB and the Movement of Those Affected by Dams - MAB with the objective of supporting the development of actions and public policies aimed at those affected by dams, presented by IPEA, a foundation linked to the Ministry of Economy and the result was the subject of a public hearing of the Financial Supervision and Control Commission – CFFC of the House of Representatives in December 2018.

The research was presented in a solemn public session, after more than 2 years of documentary and field research, by about 40 researchers who exposed the information resulting from the work, first on May 25, 2018 in a public hearing called the Diagnosis of Social, Economic and Cultural Debt of those affected by the Sobradinho/BA Hydroelectric Power Plant, in Juazeiro-Bahia for approximately 200 affected by the Sobradinho dam with the presence of representatives of the 08 affected municipalities, and the municipalities of Sento Sé, Sobradinho, Casa Nova, Remanso, Pilão Arcado, Xique-Xique, Itaguaçu da Bahia and Barra were surveyed, which compute the total of more than 500,000 inhabitants in 2017, according to IBGE cidadesv estimates (MAB, 2018).

When studying the impacts of dams for the Movement of Those Affected by Dams - MAB are several issues that should be evaluated in Brazil on dam construction, one is the planning and management of the electrical system because the beaconing in experiences of other countries does not reflect our needs or the characteristics of Brazil, only, a colonial model of import is reproduced, unsuitable for the reality of our country, corroborating the research of BERMANN (2007) that the evaluation of the construction of a hydroelectric plant should be measured by its energy production capacity, by the time that the energy produced will be available for the consumption of society and by the social and environmental problems that this plant represents, that is, an assessment of the level of change in the quality of life of these communities.

Finally, we present the concept of (Vainer's) affected (2002) as being, the legitimation of the rights of its holders, determined by a social group, family or individual that suffered impact by a certain enterprise; in some cases, it has its legal right to compensation, compensation, rehabilitation or non-pecuniary reparation, in this perspective, the Movement of Those Affected by Dams -

MAB claims the rights of these populations affected by electrical enterprises in Brazil.

### III. METHODOLOGY

For the development of this study, a review of historical literature was conducted that documented the development of research through the systematic method, aiming at the knowledge to date on the theme, what flaws have already been found and what are the main theoretical and/or methodological obstacles of research publications in SciELO, ANPAD and Google Scholar.

After identifying the analysis of the titles and their respective abstracts, following the inclusion and exclusion criteria, the researcher also baled his studies with images from newspapers of the time and several documentaries on the subject. The aim of this literature review is in the future to develop an instrument of Participatory Strategic Planning - PEp with part of these families affected to be delivered to the Movement of Those Affected by Dams - MAB.

In this format the Brazilian academy, 50 years after the beginning of the construction of the Sobradinho-BA dam may be contributing to the improvement of scientific knowledge about the researched context, verifying previous failures and contributing to the emergence of new scientific knowledge.

### IV. RESULTS ACHIEVED

From the reading of the publications, 12 journals of the theme of territories were evaluated, containing the axes related to space, natural resources, society, power, and social participation. From the political administration there were 7 that correlate with administration, strategic planning, management and social relations and 19 of the themes of the construction of dams with the axes of hit, impact of the dams of Sobradinho-BA, military government, identity.

From the various literatures published for those affected by the Sobradinho dam who have experienced the process of deterritorialization and reterritorialization, we will start from the term "Territory" that has a geographical concept, used in various fields of knowledge such as sociology, politics, planning and thus, several conceptions and uses emerge that demonstrate a polysemic meaning.

As in social relations "power" is presented as a central element and has a political dimension. From the definition of norms for coexistence in the territory, as a way of organizing and establishing rules – whether formal or formal – of use and power for control and social

coexistence, since formal social rules are established by the State and must be written and all subjects are obliged to comply, while the formal rules to the contrary, are not written in writing and all subjects are obliged to comply, while the formal rules on the contrary, are not exposed in written ways, but are recognized and, if accepted, are followed by the collective, as ways of living, emphasizing that these rules are values that have meanings and guide and express the way of living in a given territory, affecting their social dimensions of peoples and social behaviors, as well as their cultural dimension.

For Amaral (2012), after the construction of the Sobradinho hydroelectric plant in 1977, there was a forced removal of 72,000 people who were displaced from the municipalities of Pilão Arcado, Casa-Nova, Remanso and Sento-Sé to other places, leaving under the waters their spaces of reference, sociability and their natural habitat, with the advent of progress and their achieved were featured in newspapers announcing the construction of the Dam of Sobradinho and the disappearance of four cities to give way to progress, that is, the social, environmental, economic, political and cultural dimensions were reached, this highlight is also endorsed by Barros (2016) in "What was under the waters in the ethnographic Essay of a relocated population.

"The hydroelectric projects implemented during the military regime had serious consequences and Sobradinho was no exception, mainly due to the great imbalances in both local social systems and ecological systems that affected the population of the affected areas. Families in four flooded riverside towns have suffered these imbalances with the relocation to another space, since the misstep between the planned by the São Francisco Hydroelectric Company (CHESF) and the one experienced by the population was enormous."

There is evidence of the disarticulation between the planned and executed by CHESF and starting from the hit term of Vainer (2002), of the population reached in the construction of the Sobradinho-BA Dam, around 60% were of small producers, peasants and beiradeiros who lived in some of these territories and generating a social debt, that is, the deterritorialization of these families caused a breakdown of bonds, loss or removal of territory, as well as a undoing of territoriality in contact with the collectivity in the sense of group, influence or control over its political, personal, cultural, religious, economic, environmental relations.

Deterritorialization entailed social, environmental and economic impacts of the loss of soils, plant and animal species that were killed flooded by the waters, in addition to the cultural problems of displacement of traditional peoples bringing economic loss to these families who lived from the river evazantes and from there they took their livelihood and their family, besides the organic stuff that was thrown into the river by the flood.

Regarding social participation, according to the residents of the affected territories, CHESF did not constitute channels of dialogue with these social actors who lived in the territory, all decisions housing the enterprise were made unilaterally. That state aimed, initially transfer about 5,000 families to the Serra do Ramalho Special Colonization Project, built in the municipality of Bom Jesus da Lapa far 700 km from the banks of the dam, without any prior consultation with these riverside dwellers who lived in those localities and took their livelihood, affecting the social, economic, political and cultural dimensions.

"In the truck's backs, families clung to their cachines and pets. In the arched faces of pain were tears that blurred the landscape of the road that led them to the new world. They left behind a scene of destruction, a ghost place that would keep at the bottom of the water their life stories, their past, their dead."

Barros (2016).

Several journals brought the psychological traumas of several affected families that go beyond the economic, social and cultural and political aspects of the loss of belonging. In the construction of the Sobradinho dam, affective losses and psychological disorders left many scars, causing silence and mistrust in the affected population. There is a correlation between the changes caused by the displacement and voices in the wind, which is not a simple metaphor originated by the belonging of the elderly, with found in newspaper clippings of the time that report the loneliness of the elderly who left their dead in that place and all their lives under the waters of the dam.

With regard to the process of reterritorialization, that is, of permanence in the territory, there was a fierce struggle for some families to remain in the community (territory), because it was claimed by various social actors: farmers, grabbers and foreign entrepreneurs who fought for the land on the edge of the lake. Despite this, the riparian's had the support of the pastoral agents of the land, the Archdiocese of Juazeiro-BA at the time led by Bishop Dom José Rodrigues and were also backed by pastoral agents (political dimension).

The main changes in the deterritorialization process in Sobradinho-BA succeeded in the aforementioned productive strategies that moved, since for Neto (2019) the waters dragged part of the sheep herds (economy), the fish pond was permanently flooded by the immense reservoir that formed and, the natural movements of floods and river ebbs were extinguished by the bus (environment).

During the late 1970s, families occupied for 4 years the CHESF office's office in the city of Sobradinho-BA, claiming land on the shores of the Sobradinho lake dam for this population, only in 1980 did the government agency transfer an estimated 6,000,000 productive lots on the lake's edges, trying to lessen the impacts caused.

However, studies show that productive lots (economics) which were distributed to some families between the municipality of Sobradinho and Sento Sé had no natural conditions by the water bus, so the affected had difficulty returning to their plantations as it was before (economy), as a consequence, farmers had to try to adapt to the traditional agriculture model offered by the Green Revolution (economy and environment) and contracted loans from the Northeast Bank by line of specific credits to buy from irrigation systems.

With the costs paid to the bank, the price of crops in the market increased and also demanded from the families the rapid adequacy to the model of traditional crops such as onions, causing significant changes in the form of production (time), as well as in the relationship with the environment that was harmed, generating losses for families who needed to pay their debts in stores that sell agrochemicals (environmental and social dimension), this transition from traditional agriculture to an agricultural model anchored in the scientific technical principles of the Green Revolution, happened in a precarious way, without the technical assistance due to these small producers who have passed the use of pesticides.

In the economic, social environmental dimension to produce the families affected did not use the personal protective equipment, as well as made the irregular disposal of the containers in the river or in their production environment, further contaminating the soil and thus, with the rains and consequent resumption of the level of the dam, the residues of the agrochemicals are carried to the populations of the downstream cities.

With regard to the social dimension, there are still conflicts and land regularization, in the municipality of Casa Nova -BA, which has a large extent and presents many of these issues of cricket and in matters of work and education, there are almost 27% who attend school today, most of them are under 25 years old and attend elementary school (MAB, 2018) e and there is a lack of access to

electricity that affects, especially youth, since it hinders studies and access to assistive technologies, such as computer and internet.

But it was in the issue of work and income (economy) that the reality of young people was highlighted, since 40% of those surveyed between 16 and 25 years are unemployed, and another 33% perform unpaid work, that is, work on family property or own with the same care and the attempt to plant, in addition to the scarcity of work and opportunity to generate income (economic dimension) indicate that just under 50% (fifty percent) of those in extreme poverty or poverty are under 25, young people.

By assuming the challenge of building an interdisciplinary path that contributes to the deepening of a debate on the problem of the construction of large dams in Brazil, especially the Sobradinho-BA dam, we need to pass through several thinkers and representatives from various areas of knowledge, and we present, a new school of administrative thought, or other groups of researchers gathered around the commitment to advance and consolidate spaces of critical thinking of the administration.

In this sense, the theory of Political Administration emerges that proposes to rescue the contributions of these pioneering philosophers to legitimize the efforts to provide the administration as its own field of knowledge that by taking the scientific field of administration as a builder of the forms of management or conduct that the State and society have historically undertaken to carry out the social production directed to achieve social well-being.

## V. SOME CONSIDERATIONS

From the point of view of the literature review constructed in this article, the objective of the study was achieved, using an interdisciplinary qualitative approach, it was possible to improve the researched theme, considering that it becomes possible a better study planning, avoiding errors and thus this way contributing to the increase of knowledge on the studied theme.

Of the limitations found in the study, few investigations were found by other areas of the use of the theory of political administration. This would allow a greater familiarity with the theme researched, making it more explicit for the construction of new assumptions regarding the social, economic, environmental, political and cultural dimensions caused by the construction of the Sobradinho-BA dam to families homeless by the lack of strategic planning at the time, generating a social debt not yet repaired by the Brazilian government. As future recommendations, there is a need to situate the

construction of the Sobradinho Dam in the context of Brazilian government planning and recognize that any critical interpretation of the impacts of this policy on territories, individuals and families requires an expanded methodological theoretical approach to participatory management that allows observing the various aspects involved (social, political, economic, administrative, cultural and environmental).

Because, in this national socio-historical event, this recognition will allow evaluating the political aspects of (strategic) management and management (technical-operational) that guided the conception of the theory of political administration and the dynamics that give meaning to the concrete social relations that is part of the development of modern society incorporates three inseparable dimensions that mark the complex relationship between Society-State-Market.

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# Waste of Electrical and Electronic Equipment (WEEE): Analysis of the Knowledge of Direct Users

## Resíduos de Equipamentos Eletroeletrônicos (REEE): Análise do Conhecimento dos Usuários Diretos

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Received: 15 Jul 2022,

Received in revised form: 04 Aug 2022,

Accepted: 10 Aug 2022,

Available online: 16 Aug 2022

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**Keywords—** Management, Solid Waste,  
Electronic Waste, National Solid Waste  
Policy, Attitudes and Level of Knowledge.

**Palavras-Chave –** Gestão, Resíduos Sólidos,  
Resíduos Eletroeletrônicos, Política Nacional  
de Resíduos Sólidos, Atitudes e Nível de  
Conhecimento.

**Abstract—** The objective of this study was to verify the level of knowledge of users regarding the waste of electrical and electronic products generated by them. Therefore, a qualitative research was implemented, with an exploratory-descriptive objective. 150 questionnaires were sent to users residing in four Brazilian capitals, with a response rate of 91.33%. Overall, 30% of users “infrequently” (PF) segregate waste; 6.57% “very often” (MF) have already looked for an appropriate point of disposal of electronic waste. The city of Maceió-AL has 52.78% of users who “never” (N) disposed of their waste at an appropriate collection point against the same percentage for São Paulo-SP who “often” (F) did so; 29.20% “infrequently” (PF) thought of somehow reducing the amount of waste generated; 91.97% of users “never” (N) have heard about or have unsatisfactory knowledge about the existence of the National Solid Waste Policy – NSWP. Regarding this last question, there was no significant difference between the respondent users with high school and higher education levels.

**Resumo –** O objetivo deste estudo foi verificar o nível de conhecimento dos usuários quanto aos resíduos dos produtos eletroeletrônicos por eles gerados. Para tanto, implementou-se uma pesquisa qualitativa, com objetivo exploratório-descritivo. Foram enviados 150 questionários para usuários residentes em quatro capitais do Brasil, com índice de resposta de 91,33%. No geral, 30% dos usuários “pouco frequentemente” (PF) fazem a segregação dos resíduos; 6,57% “muito frequentemente” (MF) já procuraram por um ponto de descarte adequado de resíduo eletroeletrônico. A cidade de Maceió-AL apresenta 52,78% de usuários que “nunca” (N) descartaram seus resíduos em um ponto de coleta adequado contra o mesmo percentual para São Paulo-SP que “frequentemente” (F) o fizeram; 29,20% “pouco frequentemente” (PF) pensaram de alguma forma reduzir a quantidade de resíduos gerados; 91,97% dos usuários “nunca” (N) ouviram falar ou possuem conhecimento insatisfatório sobre a existência da Política Nacional de

*Resíduos Sólidos – PNRs. Quanto a essa última questão, não houve diferença significativa entre os usuários respondentes com grau de escolaridade ensino médio e ensino superior.*

## I. INTRODUÇÃO

Os Resíduos de Equipamentos Eletroeletrônicos – REEEs, popularmente chamados de “lixo eletrônico”, possuem substâncias perigosas em sua composição, além de metais de alto valor que podem ser reaproveitados, entrando novamente no ciclo produtivo (Dwivedy & Mittal, 2012). Bachi (2013) afirma que alguns países da África e Ásia (China, Paquistão e Índia) estão importando em torno de 70% dos REEEs no mundo, reutilizando os equipamentos em programas de inclusão digital ou extraindo os metais de valor econômico. Todavia, convém destacar que o comércio internacional desses produtos (resíduos sólidos perigosos e controlados) deve atender as diretrizes estabelecidas na Convenção de Basileia. No Brasil, a Convenção foi internalizada na íntegra por meio do Decreto nº 875, de 19 de julho de 1993, sendo também regulamentada pela Resolução CONAMA nº 452, 02 de julho de 2012. O aumento exponencial da quantidade de lixo eletroeletrônico (e-Waste) tem chamado a atenção para o assunto em escala global, sobretudo pelo dano ambiental causado pela disposição incorreta (Widmer, Oswald-Krapf, Sinha-Khetriwal & Schnellmann, 2005). A aquisição e consumo de equipamentos eletroeletrônicos possui uma relação direta com a melhoria do padrão de vida das pessoas. Dados do The Global E-Waste Monitor (2021) apontam que, em média, ocorre um aumento de 2,5 milhões de toneladas no consumo desses dispositivos por ano, o que, conseqüentemente, impactará no aumento na quantidade de dispositivos descartados após concluírem seu tempo de vida útil ou mesmo serem substituídos por outros com tecnologias mais modernas. Em 2019, foram gerados 53,6 milhões de toneladas de resíduo eletroeletrônico em todo o mundo, sendo que, desse total, apenas 17,4% tiveram adequada destinação. No Brasil foram geradas 2.143 toneladas de resíduo eletroeletrônico no mesmo ano o que equivale a 10,2 kg per capita (The Global E-Waste Monitor, 2021).

O objetivo desse estudo foi verificar o nível de conhecimento dos usuários quanto aos resíduos dos produtos eletroeletrônicos por eles gerados. Tem-se a expectativa de que esse trabalho possa ampliar a conscientização dos usuários de produtos eletroeletrônicos sobre a geração desses resíduos, além de contribuir para a implementação de ações para o adequado descarte desses dispositivos. Além dessa introdução, na seção seguinte apresenta-se uma revisão de literatura mínima necessária à sustentação da discussão dos dados; na seção 3 está delineada a metodologia da pesquisa. À seção 4 reservou-

se para apresentação dos dados e discussão; por fim, na seção 5 apresenta-se a conclusão do estudo.

## II. FUNDAMENTAÇÃO TEÓRICA

A gestão dos resíduos sólidos constitui-se em um problema emergente da sociedade moderna. As ações antrópicas, qualquer que seja sua ordem, geralmente, produzem algum tipo de resíduo. Agrava esse quadro o fato de que o acúmulo contínuo dos resíduos sólidos no decorrer do tempo aumenta seu volume, além da inadequação da forma de disposição final desses resíduos (Gomes, Oliveira, Bresciani & Pereira, 2014). A falta de gestão desses resíduos, seja por parte dos entes corporativos, seja por omissão do poder público e até mesmo por aspectos culturais intrínsecos à própria sociedade, contribuem para o acirramento da situação. Por conseguinte, a falta desse gerenciamento impactará negativamente a saúde pública, com repercussões diretas na qualidade de vida das pessoas (Schalch, Leite, Fernandes & Castro, 2002). Considerando que o volume de resíduos gerados tem aumentado de maneira constante (Brollo & Silva, 2001), o aprimoramento da gestão desses resíduos por parte de todos os players envolvidos direta ou indiretamente, torna-se crucial que estejam contempladas em políticas governamentais, políticas setoriais (agentes públicos e privados), mormente em uma ampla política ambiental, uma vez que esta é capaz de fornecer um senso global de direcionamento, além de apresentar os princípios de ação (Oliveira, 2018). A Figura 1 apresenta o volume de resíduo sólido produzido por ano, em geração total e geração per capita nas regiões brasileiras.

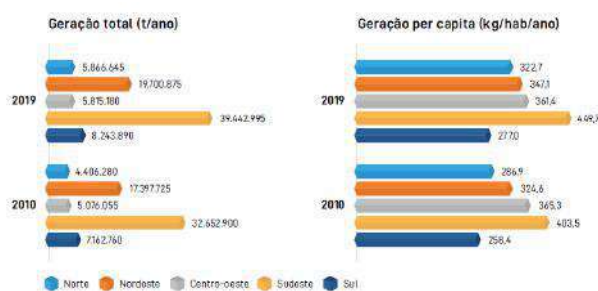


Fig.1. Geração de Resíduo Sólido por Região

Fonte: Abrelpe (2021)

No Brasil, mais frequentemente, os resíduos possuem três destinações: “lixão”, o aterro controlado e o aterro sanitário (Alves, 2019). Segundo o Ministério do Meio



Ambiente (MMA, 2021), dessas três destinações, duas possuem gestão inadequada. O “lixão”, disposição direta dos resíduos a céu aberto, não possui controle ou tratamento, provocando severo impacto ao meio ambiente, além de problemas sociais. O aterro controlado avança muito pouco, uma vez que o que se considera como “controlado” é o fato de os resíduos serem cobertos com camada de terra, permanecendo os mesmos impactos ambientais da modalidade anterior. O aterro sanitário, por sua vez, consiste num sistema de disposição aprimorado, seguindo padrões técnicos de construção, manutenção e operacionalização, capazes de reduzir a níveis aceitáveis os impactos da disposição. A Figura 2 apresenta a disposição final (adequada e inadequada) dos resíduos no período de 10 anos.



Fig.2. Disposição Final Adequada x Inadequada de Resíduo Sólido no Brasil (Tonelada/Ano)

Fonte: Abrelpe (2021)

Embora tenha havido aumento na destinação adequada e redução na destinação inadequada, os valores são inexpressivos. Tem-se algo próximo de 5% de evolução na destinação apropriada em uma década; por outro lado, uma redução aproximada de 6% na forma incorreta de disposição dos resíduos no Brasil. A Tabela 1 apresenta numericamente (toneladas/ano) as diferenças entre destinação adequada e inadequada no decurso de dez anos.

Tabela 1. Disposição final de resíduo sólido por região, por tipo de destinação (ton./ano).

Região	2010			2019		
	AS	AC	L	AS	AC	L
N	1.165.810	1.015.795	1.348.675	1.683.745	1.421.675	1.664.765
NE	4.314.300	4.312.110	4.486.215	5.686.700	5.255.270	5.031.525
CO	1.272.025	2.217.010	1.036.235	2.252.415	1.957.860	1.243.190
SE	22.166.085	5.322.065	3.639.780	28.121.425	6.653.220	3.906.960
S	4.488.040	1.170.555	840.960	5.556.030	1.440.290	873.445
Bra sil	33.406.260	14.037.535	11.351.865	43.300.315	16.727.950	12.720.250

N=Norte; NE=Nordeste; CO=Centro-Oeste; SE=Sudeste; S=Sul; AS=Aterro Sanitário; AC=Aterro Controlado; L=Lixão

Especificamente quanto aos resíduos de eletroeletrônicos – *e-waste* em inglês –, as estatísticas mostram crescimento com tendências de mais crescimento. O contínuo aprimoramento tecnológico, sobretudo em *hardwares* e *softwares*, reduz drasticamente o tempo de uso dos equipamentos eletroeletrônicos, aumentando, por consequência, o índice de obsolescência desses dispositivos – obsolescência programada (Rossini & Napolini, 2017). Por conseguinte, o aumento da demanda por novos produtos eleva substancialmente o uso de matérias-primas (recursos naturais) para sua produção, além do aumento considerável do volume de resíduos e efluentes gerados, gerando fortes impactos ao meio ambiente. Em 2019 o montante de resíduos oriundos desses dispositivos somou 53,6 milhões de toneladas em todo o mundo, com um aumento médio de 2.5 milhões de toneladas a cada ano (The Global E-Waste Monitor 2020, 2021). O aumento da produção puxado pelo aumento na demanda, o reduzido ciclo de vida e poucas possibilidades de reparo são alguns os fatores que contribuem para esse fenômeno.

São considerados produtos eletroeletrônicos todos os equipamentos de informática e processamento de dados de uso doméstico, aparelhos de telefonia (fixo e móvel), tablets, smartphones, além de toda a “linha marrom” (áudio e vídeo). Consoante Acordo Setorial disponibilizado pelo Sistema Nacional de Informações sobre a Gestão dos Resíduos Sólidos, há uma gama bastante diversificada de produtos que se enquadram na categoria de eletroeletrônicos. Na Tabela 2, têm-se a relação resumida dos produtos listados no Acordo Setorial citado no parágrafo anterior, esta seleção foi feita pelo autor deste estudo, para simples demonstração, e para pensarmos como os equipamentos eletroeletrônicos fazem parte do nosso cotidiano e com essa consciência, nos adequarmos para fazermos uma boa utilização e uma destinação correta aos equipamentos que possuímos ou até o que iremos possuir.

Tabela 2. Resumo da lista dos produtos eletroeletrônicos do acordo setorial para a implantação da logística reversa.

Itens	Produtos Eletroeletrônicos - Descrição
	Adaptadores em Geral, Antena Digital, Aparelho de Ar-Condicionado,

	<p>Aparelhos de TV, Cabos e Conectores em Geral, Caixas de Som, Chapa Grill, Circulador de Ar, Desktops, Notebooks, Laptops, Controle Remoto, Fogões (convencional e elétrico), Fritadeiras, Fones de Ouvido em Gera, Furadeiras, Parafusadeiras, Home Theater, Torradeira, Máquina de Lavar Roupas, Monitores em Geral, Mouse, Panela de Arroz Elétrica, Panela de Pressão Elétrica, Pipoqueira, Refrigeradores, Tablets, Celulares, Torneiras Elétricas, Triturador, Umidificador, Ventilador de Teto, Campainha Eletrônica, Vaporizador de Roupas, Sanduicheira, Scanner, Secadora de Cabelo</p>
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Dados do relatório The Global E-Waste Monitor 2020 (2021), informam que do total de resíduos eletroeletrônicos gerados (53,6 milhões de toneladas) em 2019 ao redor do mundo, apenas 17,4% foram descartados de forma adequada. No caso do Brasil, foram geradas 2.143 toneladas de resíduos, sendo que desse volume, 17,94% foram recolhidos em pontos de coleta instalados pela *Green Eletron* – Gestora de Logística Reversa e Associação Brasileira de Reciclagem de Eletroeletrônicos e Eletrodomésticos – ABREE (MMA, 2019). A Política Nacional de Resíduos Sólidos (PNRS) instituída pela Lei nº 12.305/2010, dispõe sobre seus princípios, objetivos e instrumentos, bem como sobre as diretrizes relativas à gestão integrada e ao gerenciamento de resíduos sólidos, incluídos os resíduos perigosos, as responsabilidades dos geradores e do poder público e os instrumentos econômicos aplicáveis. Houve um percurso de 11 anos de tramitação junto ao Congresso Nacional e outros órgãos técnicos envolvidos para a efetiva institucionalização desse marco legal. A Tabela 3 sintetiza os principais processos contidos nesse percurso.

Tabela 3. Etapas do desenvolvimento da Política Nacional de Resíduos Sólidos

Ano	Processos
1999	Projeto de Lei 203 dispõe sobre

	<p>condicionamento, coleta, tratamento, transporte e destinação dos resíduos de serviços de saúde.</p>
2001	<p>Câmara dos Deputados cria e implementa Comissão Especial da Política Nacional de Resíduos.</p> <p>Realizado em Brasília o 1º Congresso Nacional dos Catadores de Materiais Recicláveis.</p>
2003	<p>Realizado em Caxias do Sul (RS) o I Congresso Latino-Americano de Catadores, que propõe formação profissional, erradicação dos lixões, responsabilização dos geradores de resíduos.</p> <p>Realizada a I Conferência de Meio Ambiente.</p>
2004	<p>Elaboração de proposta para a regulamentação dos resíduos sólidos.</p>
2005	<p>Criado grupo interno na Secretaria de Qualidade Ambiental nos Assentamentos Humanos do MMA para consolidar contribuições do Seminário Conama, os anteprojetos de lei existentes no Congresso Nacional e as contribuições dos diversos atores envolvidos na gestão de resíduos sólidos.</p>
2006	<p>Aprovado relatório que trata do PL 203/91 acrescido da liberação da importação de pneus usados no Brasil.</p>
2007	<p>O PL 1991/2007 apresenta forte inter-relação com outros instrumentos legais na esfera federal, tais como a Lei de Saneamento Básico (Lei nº11.445/2007) e a Lei dos Consórcios Públicos (Lei nº11.107/1995), e seu Decreto regulamentador (Decreto nº. 6.017/2007).</p>
2009	<p>Em junho, uma minuta do Relatório Final foi apresentada para receber contribuições adicionais.</p>
2010	<p>Câmara dos Deputados aprova em votação simbólica um substitutivo ao Projeto de Lei 203/91, do Senado, que institui a Política Nacional de Resíduos Sólidos e impõe obrigações aos empresários, aos governos e aos cidadãos no gerenciamento dos resíduos.</p> <p>Publicada no Diário Oficial da União a Lei nº 12.305 que institui a Política Nacional de Resíduos Sólidos e dá outras providências.</p> <p>Publicado o Decreto nº 7.405, que institui o Programa Pró-Catador.</p>
2022	<p>Lançamento do Plano Nacional de Resíduos Sólidos para a execução e aplicabilidade da Lei dos Resíduos Sólidos aplicadas em 2010.</p>

A PNRS se constituiu num importante marco institucional no manejo de resíduos no Brasil; todavia, “o estabelecimento de novos padrões comportamentais e culturais depende de um trabalho de educação e conscientização, e deveria (deve) ser tarefa da atual geração e das próximas, na construção de um novo modelo de mundo” (Ferreira, 2000, p. 19). Dessa forma, espera-se que esse processo de conscientização seja um fator contribuidor na consolidação desse marco legal, a PNRS. Quanto à logística reversa, Alves (2019) a entende como a conjugação de atividades propiciando o reaproveitamento e reuso de materiais, a reciclagem, proporcionando a possibilidade de nova utilização no processo produtivo ou direcionamento ao descarte adequado. A implementação desta prática, surge como uma possível solução para cadeias produtivas com atuações tradicionais que destinam o foco na produção linear, desde a obtenção da matéria prima, confecção do produto, encaminhamento aos pontos de venda, chegando ao acesso do consumidor final que por fim, realiza o descarte. A implementação da logística reversa tem sido vista como uma ótima oportunidade de melhoria na gestão dos resíduos com vistas a obtenção de um ciclo produtivo mais sustentável (Mandarino & De Sinay, 2019).

Vista de uma perspectiva sistêmica, o sucesso na implantação e execução da logística reversa passa, necessariamente, pelo nível de envolvimento e comprometimento dos atores envolvidos em todo o processo. A PNRS propõe em seu Art. 3º, inciso XVII o conceito normativo de responsabilidade compartilhada pelo ciclo de vida dos produtos como um conjunto de atribuições individualizadas e encadeadas dos fabricantes, importadores, distribuidores e comerciantes, dos consumidores e dos titulares dos serviços públicos de limpeza urbana e de manejo dos resíduos sólidos, para minimizar o volume de resíduos sólidos e rejeitos gerados, bem como para reduzir os impactos causados à saúde humana e à qualidade ambiental decorrentes do ciclo de vida dos produtos, nos termos desta Lei. Como se vê, o próprio conceito normativo distribui as responsabilidades para cada um dos players participantes da cadeia. Gadia e Oliveira (2011), entendem que a responsabilidade compartilhada é o marco fundamental proposto como resposta para os problemas que envolvem a destinação final dos resíduos sólidos, como o e-lixo, impondo que todas as partes comprometidas com o ciclo de vida da mercadoria se responsabilizem, segundo a atividade que desenvolvem, no tratamento e direcionamento adequado dos resíduos gerados após o consumo.

### III. MATERIAIS E MÉTODOS

De abordagem qualitativa e, quanto aos seus objetivos, exploratória (Gerhardt, 2009), fez-se uso do questionário (Gil, 2002) para coletar informações que subsidiassem a formulação de uma possível resposta para a questão de pesquisa ora proposta. Por meio do Google Forms – aplicativo de gerenciamento de pesquisas – elaborou-se questionário dividido em duas partes. A primeira parte continha perguntas que levantaram o perfil socioeconômico básico dos usuários de equipamentos eletroeletrônicos; a segunda parte foi composta de questões em uma escala de atitudes do tipo Likert de 5 pontos (Likert, 1932; Malhotra, 2001; Hair Jr., Black, Anderson & Thatham, 2005). Pequenos ajustes nas questões se fizeram necessários após a realização do pré-teste; em seguida, 150 questionários foram enviados a usuários de produtos eletroeletrônicos que fizessem uso regular de pelo menos um equipamento dessa categoria, com índice de retorno de 91,33%. A Tabela 4 apresenta traz essas informações com a distribuição dos respondentes por cidade/estado da federação.

Tabela 4. Número de respondentes separados por capitais brasileiras.

QE	150	Taxa de Retorno (%)	
QR	137		
Capitais		% do Total Q	91,33
Brasília-DF	14	10,22	
Maceió-AL	43	31,39	
São Paulo-SP	60	43,79	
Rio de Janeiro-RJ	20	14,60	
Total	137	100,00	

QE=Questionários enviados; QR=Questionários respondidos

Os dados foram organizados e sistematizados utilizando-se planilha Excel®, possibilitando a confecção de figuras gráficas ilustrativas dos principais resultados obtidos, demonstrados e discutidos a seguir.

### IV. ANÁLISE DOS DADOS E DISCUSSÃO

O maior número de questionários foi aplicado na capital de São Paulo, 60, equivalentes a aproximadamente 44% do total, seguido de Maceió-AL com 43 questionários (31,39%), Rio de Janeiro-RJ (20 – 14,60%) e Brasília-DF com 14 questionários coletados (10,22%). A pergunta 1 do questionário buscou obter uma visão mais generalizada quanto à frequência com o usuário faz a segregação dos resíduos eletroeletrônicos que produz. Os dados mostram

(Figura 3a) que aproximadamente 30% dos usuários pouco frequentemente fazem a separação dos resíduos por eles gerados. Por sua vez, 38 usuários (27,74%) frequentemente fazem a segregação dos resíduos. A Figura 3b destaca a frequência distribuída nas capitais onde a pesquisa foi aplicada. Brasília-DF e Rio de Janeiro-RJ não pontuam em nunca (N) e muito frequentemente (MF), respectivamente. São Paulo pontua muito próximo da média das demais cidades para o nível pouco frequentemente (PF) com 28,34%, e frequentemente (F) com 30%.

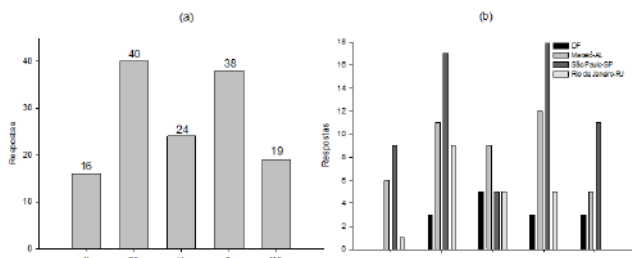


Fig.3. Frequência geral de separação dos resíduos eletroeletrônicos (a); frequência de separação dos resíduos eletroeletrônicos nas capitais pesquisadas (b). N=Nunca; PF=Pouco Frequentemente; M=Moderadamente; F=Frequentemente; MF=Muito Frequentemente.

As respostas à pergunta 2 (“você já procurou por um ponto adequado de descarte de resíduo eletroeletrônico?”) mostra, de forma geral, certa simetria com as respostas da questão anterior (pergunta 1). Contudo, vale ressaltar que para 38 (27,74%) usuários que separam “frequentemente” os resíduos, 41 (29,93%) afirmam que “frequentemente” (F) já procuraram por um ponto de descarte adequado para esses resíduos. Embora com valores próximos, a diferença (2,19%) pode indicar dificuldade de acesso aos pontos de coleta, pouca quantidade ou até mesmo ausência dessa infraestrutura. Uma significativa discrepância pode ser notada no fato de 19 (13,87%) dos respondentes terem afirmado que separam os resíduos “MF” e somente 9 (6,57%) responderem que “MF” já procuraram por um ponto de coleta para esses resíduos. Esse gap pode estar associado a indisponibilidade estrutural do serviço de coleta, dificuldade de acesso (o que acredita-se não ser o caso, tendo em vista o fato de que, via de regra, esses pontos são instalados em locais públicos de fácil acesso), ao desconhecimento pela população da oferta do serviço e até mesmo com o fato de, embora separado, o resíduo seja disponibilizado juntamente com outros tipos de resíduos e, assim seguindo pelos meios convencionais de coleta, sem qualquer diferenciação. A Figura 4 apresenta as informações da frequência geral de procura por ponto de

descarte (a) e a frequência de procura por capitais pesquisadas (b).

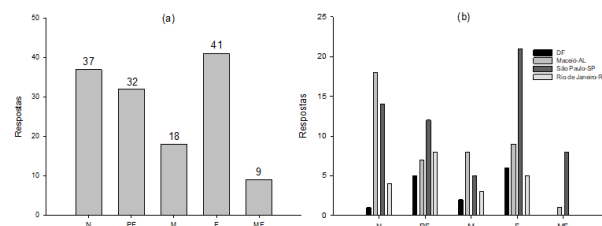


Fig.4. Frequência geral de usuários que já procuraram por um ponto adequado de descarte de resíduo eletrônico (a); frequência dos usuários que já procuraram por um ponto adequado de descarte de resíduo eletrônico por capitais (b). N=Nunca; PF=Pouco Frequentemente; M=Moderadamente; F=Frequentemente; MF=Muito Frequentemente.

Quanto a frequência por capitais (Figura 4b) destaca-se o fato de para o ponto da escala “Muito Frequentemente” (MF) não houve pontuação para as capitais Brasília e Rio de Janeiro. As maiores pontuações vão para São Paulo – nível “F” da escala, com 21 respostas (15,33%), seguida por Maceió – “Nunca”, com 18 respostas, correspondentes a 13,14%, seguido novamente por São Paulo, nesse mesmo ponto da escala (N) com 10,22% de participação (14 respostas). Os usuários foram perguntados se descartavam seus resíduos eletroeletrônicos em ponto de coleta adequado (pergunta 3). A Tabela 5 resume as respostas obtidas no cômputo geral e por capitais pesquisadas.

Tabela 5. Frequência geral e por capitais – usuários que descartam resíduos eletroeletrônicos em ponto de coleta.

Níveis	Geral	Capitais			
		Brasília-DF	Maceió-AL	São Paulo-SP	Rio de Janeiro-RJ
N	36	2	19	12	3
PF	29	4	2	16	7
M	22	4	10	4	4
F	36	4	9	19	4
MF	14	0	3	9	2

N=Nunca; PF=Pouco Frequentemente; M=Moderadamente; F=Frequentemente; MF=Muito Frequentemente

A frequência geral (coluna 2 – Tabela 5) apresenta significativa paridade com a pergunta anterior (2), o que evidencia ausência de dissonância entre a procura por ponto de descarte adequado e a efetiva ação de descartar esses resíduos. Vale destacar que a capital Maceió

apresentou, para o nível “F”, a mesma frequência para as perguntas 2 e 3 mostrando uma total similitude nas respostas; 10% dos usuários da capital Rio de Janeiro descartam “muito frequentemente” (MF) resíduos em pontos de coleta adequado, porém não pontuam na pergunta anterior no mesmo nível (MF). Quanto à pergunta 4 (“Você já pensou em reduzir a quantidade de produtos eletroeletrônicos que compra?”), a Figura 5 traz os resultados que serão discutidos na sequência.

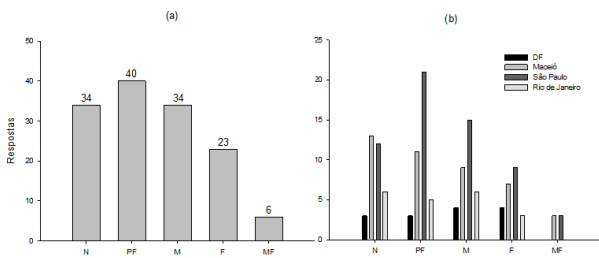


Fig.5. Frequência geral de usuários que pensam em reduzir aquisição de produtos eletroeletrônicos (a); frequência dos usuários que pensam em reduzir a aquisição de produtos eletroeletrônicos por capitais (b). N=Nunca; PF=Pouco Frequentemente; M=Moderadamente; F=Frequentemente; MF=Muito Frequentemente.

Observa-se na Figura 5a que os usuários que fazem a separação dos resíduos (pergunta 1) e os usuários que pensam reduzir a compra de produtos eletroeletrônicos (pergunta 4) apresentaram a mesma frequência nas respostas para o nível “PF”; em outras palavras, aproximadamente 30% dos respondentes possuem equivalência na prática e na intencionalidade. Para 11,68% dos usuários que nunca (N) fizeram separação dos resíduos, mais que o dobro deles (24,82%) intencionam, de alguma forma, reduzir a aquisição desse tipo de produto. Por outro lado, dos 13,87% dos usuários que muito frequentemente (MF) realizam a separação dos resíduos eletroeletrônicos, apenas 4,38% cogitam reduzir a aquisição desses produtos. A Figura 5b mostra que a capital Maceió-AL apresenta igualdade entre os usuários que separam os resíduos e aqueles que de algum modo planejam comprar menos produtos eletroeletrônicos, especificamente para os níveis “Pouco Frequentemente” (PF) e “Moderadamente” (M), ao passo que apenas 50% (9) dos usuários da capital São Paulo-SP que separam os resíduos eletroeletrônicos intentam adquirir menos produtos dessa categoria. Um olhar mais geral, pressupõe certa correlação inversamente entre aqueles que promovem a segregação dos resíduos e ao mesmo tempo planejam adquirir menos desses produtos.

Por fim, a questão de nº 5 buscou aferir o nível de conhecimento dos usuários sobre a Política Nacional de

Resíduos Sólidos (PNRS), instituída pela Lei nº 12.305/2010 (Figura 6). No ano em que este estudo está sendo elaborado, a PNRS completa 12 anos de existência, mesmo assim, o desconhecimento a respeito dessa política pública é bastante expressivo. Deve-se enfatizar que a pergunta não versava sobre o nível do conhecimento do usuário a respeito da PNRS, mas sim, limitou-se a indagá-lo sobre se ele já tinha ouvido falar a respeito dessa política pública.

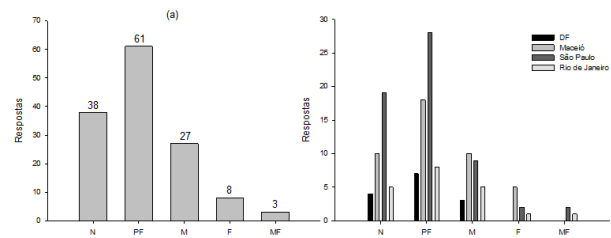


Fig.6. Frequência geral de usuários que já ouviram falar sobre a Política Nacional de Resíduos Sólidos – PNRS (a); frequência dos usuários que já ouviram falar sobre a Política Nacional de Resíduos Sólidos – PNRS por capitais (b). N=Nunca; PF=Pouco Frequentemente; M=Moderadamente; F=Frequentemente; MF=Muito Frequentemente.

Do total geral de usuários pesquisados (137), 27,74% “Nunca” (N) ouviram sequer falar da referida política. 44,52% deles “Pouco Frequentemente” (PF) ouviram falar, e 19,71% ouviram falar “Moderadamente” (M). Se se considerar os três primeiros níveis (N + PF + M) como insatisfatórios, tem-se que 91,97% apresentam alguma deficiência no sentido de saber da existência dessa lei. Em proporcionalidade, a capital São Paulo-SP lidera o ranking das capitais com maiores níveis de desconhecimento a respeito da existência da PNRS, obtendo resultados 19 respostas para o nível N, equivalente a 50% do total de todas as capitais; 28 respostas no nível PF (45,90% do geral), e 9 respostas para o nível M, com equivalência de 33,33% de todas as capitais, respondendo nos três níveis considerados insatisfatórios (N + PF + M) a 44,09% do total geral.

O perfil socioeconômico dos usuários – dados coletados na primeira parte do questionário – mostrou que, do total de respondentes (137), 83,21% (114) possuíam nível superior de escolaridade, contra 23 (16,79%) com grau de escolaridade de nível médio. Não obstante, quando realizado o comparativo das perguntas (p1, p2, p3, p4 e p5), os dados levantados sugerem um cenário bastante peculiar. No geral, não há muitas diferenças significativas entre os dois níveis de escolaridade dos usuários respondentes, o que já soa surpreendente. Um olhar mais específico mostra pelo menos dois pontos que merecem destaque. O primeiro refere-se ao fato de que do total

(100% = 16) de usuários respondentes que nunca (N) separaram o resíduo eletroeletrônico que produzem, 93,75% possuem nível superior de escolaridade contra apenas 6,25% dos que possuem apenas ensino médio. O segundo ponto refere-se à pergunta 5 (“Você já ouviu falar

sobre a Política Nacional de Resíduos Sólidos – PNRS?”). A proporção para os que nunca (N) ouviram falar a respeito dessa política pública, tanto para os respondentes com ensino médio quanto para os de nível superior, respectivamente 26,09% e 28,07%.

Tabela 6. Frequências relativas dos usuários para níveis de escolaridade

Níveis	P1		P2		P3		P4		P5	
	EM	ES	EM	ES	EM	ES	EM	ES	EM	ES
N	4,35	13,16	21,74	28,07	17,39	28,07	21,74	25,44	26,09	28,07
PF	26,08	29,82	43,48	19,30	30,43	19,30	30,43	28,95	39,13	45,61
M	39,13	13,16	13,04	13,16	21,74	14,91	30,43	23,68	30,43	17,54
F	26,09	28,07	21,74	31,58	21,74	27,20	17,39	16,67	0,00	7,02
MF	4,35	15,79	0,00	7,89	8,69	10,53	0,00	5,26	4,35	1,75

N=Nunca; PF=Pouco Frequentemente; M=Moderadamente; F=Freqüentemente; MF=Muito Frequentemente; P1=Pergunta 1; P2=Pergunta 2; P3=Pergunta 3; P4=Pergunta 4; P5=Pergunta 5; EM=Ensino Médio; ES=Ensino Superior.

Para o nível “Pouco Frequentemente” (PF), em frequência absoluta, do total de respondentes (61), 52 possuem nível superior contra 9 com ensino médio. Todavia, a frequência relativa mostra que a diferença é pequena; do total de usuários que assinalaram nível PF, 45,61% possuem nível superior e 39,13% nível médio, uma diferença de 6.48 pontos percentuais. A Figura 7 apresenta as frequências absolutas para as cinco perguntas separadas por nível de escolaridade.

muito frequentemente (MF) a PNRS contra 4,35% dos usuários com apenas ensino médio. Para esse estudo em particular, os dados mostram que o nível de escolaridade não apresenta relação direta com o conhecimento do usuário de produtos eletroeletrônicos, mormente quanto ao descarte dos resíduos oriundos desses equipamentos. Da mesma forma, em caráter preliminar, o estudo evidencia que o nível de escolaridade do usuário respondente não afeta diretamente no seu conhecimento da política pública PNRS, promulgada a mais de uma década.

## V. CONCLUSÃO

Embora tenha havido esforços de várias frentes – poder público, associações civis, organizações não governamentais, entre outras – no sentido de contribuir com a ampliação da consciência ambiental, materializada num comportamento socio responsável, constituída de ações de cidadania e outros aspectos de visão coletiva, a sociedade ainda se encontra aquém do mínimo necessário para a consolidação dessa temática. De atitudes mais basilares como separar o próprio resíduo eletroeletrônico que produz ao conhecimento de uma política pública como a Política Nacional de Resíduos Sólidos (PNRS), o usuário de equipamentos eletroeletrônicos não tem dado evidências de que possui uma consciência ambiental minimamente desenvolvida. Agrava esse quadro o fato de que, no geral, não houve diferença significativa entre os níveis de escolaridade (ensino médio e ensino superior), o que se contrapõe aos fundamentos da educação pública e privada preconizados pelo Ministério da Educação por meio da LDB – Lei de Diretrizes e Bases da Educação Nacional (Lei nº 9.394, de 20 de dezembro de 1996).

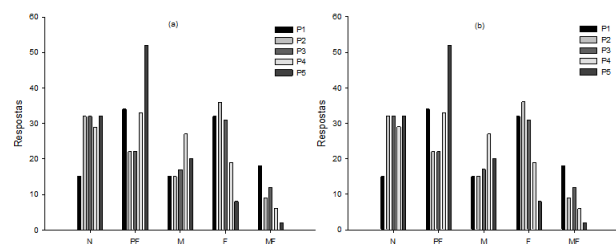


Fig.7. Frequência geral absoluta das perguntas P1, P2, P3, P4 e P5 de usuários com grau de escolaridade nível Médio (a); frequência geral absoluta das perguntas P1, P2, P3, P4 e P5 de usuários com grau de escolaridade nível superior (b). N=Nunca; PF=Pouco Frequentemente; M=Moderadamente; F=Freqüentemente; MF=Muito Frequentemente.

Para o nível MF obteve-se apenas 3 respostas, sendo 1 de usuários com apenas ensino médio e 2 de usuários de nível superior. Em frequência relativa, entretanto, os números mostram que apenas 1,75% dos usuários respondentes de nível superior, afirmam conhecerem

Nesse sentido, sugere-se a execução de um diagnóstico estrutural que permita investigar e questionar se as ações que estão sendo realizadas estão, de fato, alcançando os resultados esperados – princípio da política pública. Notadamente que, se os resultados não estiverem satisfatórios, as correções devem ser feitas urgentemente, sob pena de aumentar custosamente os reparos ou mesmo torná-los impossíveis de serem efetivados. Nutre-se a expectativa de que este estudo, de caráter preliminar exploratório, possa contribuir com novas e mais amplificadas agendas de pesquisa nesse campo, dada a urgência da temática em voga.

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# Hybrid Artificial Neural Networks for Electricity Consumption Prediction

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Received: 26 Jun 2022,

Received in revised form: 14 Jul 2022,

Accepted: 22 July 2022,

Available online: 19 Aug 2022

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**Keywords**— *Artificial Neural Network,  
Artificial Intelligence, electricity  
consumption predictions, time series.*

**Abstract**— *We present a comparative study of electricity consumption predictions using the SARIMAX method (Seasonal Auto Regressive Moving Average eXogenous variables), the HyFis2 model (Hybrid Neural Fuzzy Inference System) and the LSTNetA model (Long and Short Time series Network Adapted), a hybrid neural network containing GRU (Gated Recurrent Unit), CNN (Convolutional Neural Network) and dense layers, specially adapted for this case study. The comparative experimental study developed showed a superior result for the LSTNetA model with consumption predictions much closer to the real consumption. The LSTNetA model in the case study had a rmse (root mean squared error) of 198.44, the HyFis2 model 602.71 and the SARIMAX method 604.58.*

## I. INTRODUCTION

In recent decades, the world population is increasing rapidly and, due to this increase, the global energy demanded and consumed is also growing more and more [6]. Concerning , residential or commercial buildings, are identified as major energy consumers worldwide, accounting for about 30% of the global electricity demand related to energy consumption in the residential sector [7]. Buildings are responsible for a significant share of energy waste as well. Energy waste and climate change represent a challenge for sustainability, and it is crucial to make buildings more efficient [11]. Therefore, the development and use of clean products and renewable energy in buildings have gained wide interest [6]. In the residential and commercial sectors, photovoltaic (PV) systems are the most common distributed generation, minimizing demand dependence on traditional power plants and maximizing household self-sufficiency [8].

Due to PV's dependence on weather conditions, the intermittent nature of the power generated brings some uncertainty [24]. Similarly, the electricity consumption of these buildings also has inherent uncertainties due to

seasonality. The easiest way to manage the risk of solar power and harness this power is to forecast the amount of power to be generated [15] as well as the consumption. A reliable forecast is key for various smart grid applications such as dispatch, active demand response, grid regulation and smart energy management [12].

The energy consumption of a building and the PV generation can be represented by a time series with trends and seasonality [14]. There are numerous prediction studies on time series, from classical linear regressions to more recent works using machine learning algorithms, which are powerful tools in predicting electricity consumption and PV generation [21]. Recently, many PV power forecasting techniques have been developed, but there is still no complete unit versal forecasting model and methodology to ensure the accuracy of predictions. Concerning this, Artificial Neural Networks (ANNs) are very popular machine learning algorithms for object prediction and classification and are based on the classical *feed-forward* neural network approach [23]. ANNs are computing systems inspired by the biological neural

networks of the brain, how neurons work, pass and store information [13; 24].

Due to the accelerated development of computing technology, ANN has provided a powerful framework for supervised learning [5]. Deep learning allows models composed of multiple layers to learn data representations [11]. Deep Neural Networks (DNN<sup>1</sup>) are inspired by the structure of mammalian visual systems and they are also an important machine learning tool that has been widely used in many fields [25]. DNN employs an architecture of multiple layers of neurons in an ANN and can represent functions with higher complexity [5].

This work aimed at predicting the electricity consumption of a commercial building using ANN in its various architectures. Several ANN architectures were used and tested and a hybrid architecture (Dense, Convolutional and Recurrent), originally described by Lai, G. et al. [4] and adapted for this case study, was selected.

## II. FOUNDATION

### 2.1 Time Series

Time series are sets of observations ordered in time [14]. A temporal series can be defined as a class of phenomena whose observational process and consequent numerical quantification generate a sequence of observations distributed over time.

Electricity consumption histories over time are univalued time series [20] with trends, cycles, seasonality and randomness. Trends are long-term characteristics related to a time interval. Cycles are long-term oscillations,

more or less regular, around a trend line or curve. Seasonalities are regular patterns observed from time to time. Finally, randomness is effects that occur randomly and that cannot be captured by cycles, trends and seasonalities.

Thus, the time series prediction models most used in the literature are those of linear and polynomial regressions. Among the regression models, we can mention the SARIMAX method [19]. This statistical model is a variant of the autoregressive moving average model (ARMA), adding derivations to make the model stationary (I), adding seasonality (S) and finally adding the effect of eXogenous (X) or random variables over time. In this work, the SARIMAX model was used as a baseline to compare its results, its application to the test case and the results obtained from other prediction models.

### 2.2 Convolutional Artificial Neural Networks

Convective Artificial Neural Networks (CNN<sup>2</sup>) are a type of DNN that is commonly applied to analyse images. One of the main attributes of CNN is to drive different processing layers that generate an effective representation of the features of image edges. The architecture of CNN allows multiple layers of these processing units to be stacked, this deep learning model can emphasize the relevance of features at different scales [24].

Fig. 1 demonstrates a typical architecture of a CNN, composed of at least, a convolution layer, a pooling layer, a flattening layer and dense layers.

2 CNN - Convolutional Neural Network

1 DNN - Deep Neural Network

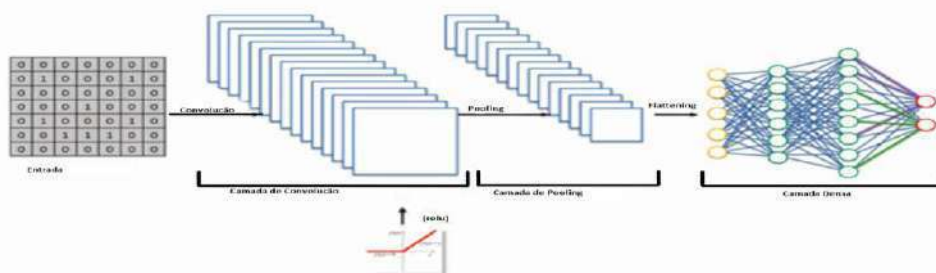


Fig. 1. Basic CNN.

Source: The author

In the convolution layer, a filter (*kernel*, which is also a matrix) is applied to the input matrix aiming at its reduction while maintaining its most important characteristics. Fig. 2 represents, step by step, the application of the convolution function where  $g(x,y)$  represents the element of the convolution matrix, that is

the matrix product of the matrix colored in Fig. 2 by the *kernel*, at each step it shifts one position to the right until the last column of the input matrix after it shifts one line down and continues the process until it runs through the whole input matrix. In the example of Fig. 2, a 7X7 input matrix was reduced to a 5X5 convolution matrix. The

whole process represented in Fig. 2 is repeated for each of the kernels used, generating several convolution matrices.

$$g(x, y) = \omega \diamond f(x, y) = \sum_{dx=-\blacklozenge}^a \sum_{dy=-\blacklozenge}^b \omega(dx, dy) f(x+dx, y+dy)$$

For the *pooling* layer, it is usual to apply the activation function  $relu f(x) = \max(0, x)$  for example, generating a new reduced matrix as shown in Fig. 3.

Finally, the *flattening* layer is nothing more than transforming the matrices of the *pooling* layers into vectors, which will be the inputs of the dense layer.

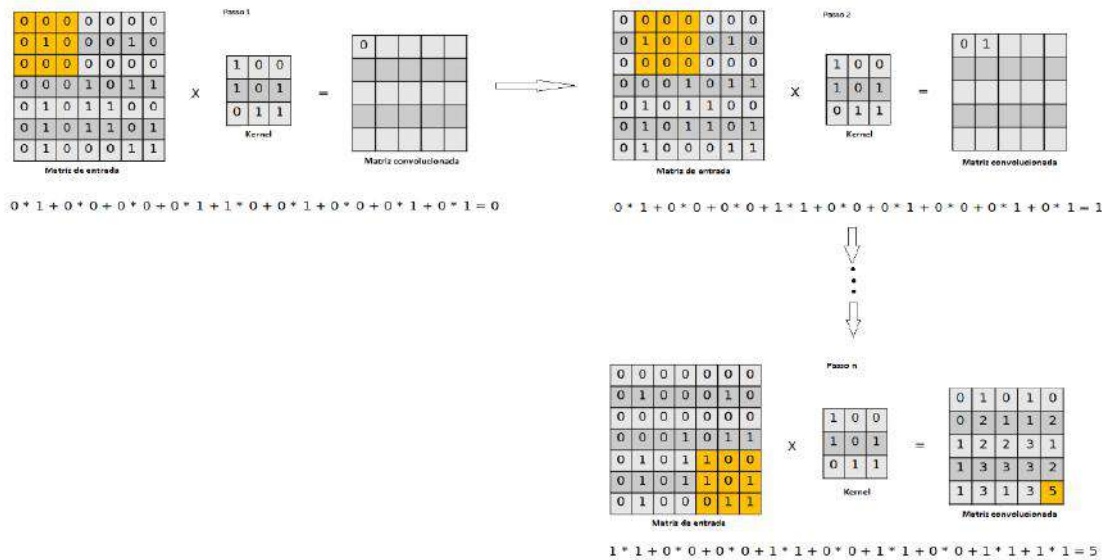


Fig. 2: Convolution process

Source: The author.

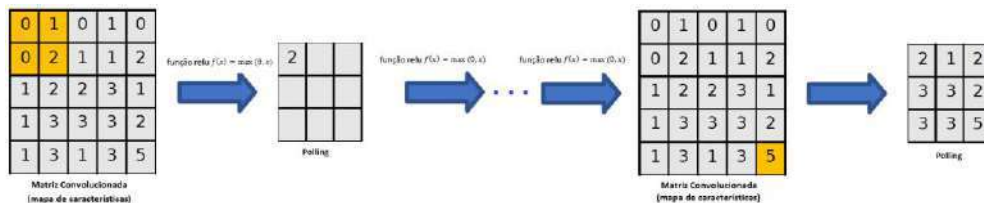


Fig. 3. Pooling Process.

Source the Author.

### 2.3 Recurrent Artificial Neural Networks

In traditional ANNs, the inputs (and outputs) are independent of each other, making it difficult to use them, for example, in natural language processing where a word in a sentence depends on previous words in the same sentence, or in time series where we need to know the values over time for better projections.

In contrast, recurrent artificial neural networks (RNN<sup>3</sup>) [8] store their previous state and also use it as input to the current state for calculations of new outputs. Another way of thinking about RNNs is that they have a "memory" that captures information about what has been

calculated so far. In theory, RNNs can make use of information in arbitrarily long sequences, but in practice, they are limited to looking back only a few steps. Fig. 4 is a typical representation of an RNN.

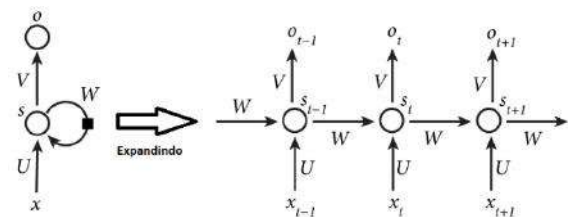


Fig. 4: Basic RNN.

Source: The Author.

Fig. 4 shows an RNN being expanded into a complete network. Where  $X_t$  is the input in time step  $t$ . For example,  $x_t$  could be a *one-hot* vector corresponding to the second word of a sentence,  $s_t$  is the hidden state in the time step  $t$ . It is the "memory" of the network.  $s_t$  is calculated based on the previous hidden state and the input in the current time step:  $s_t = f(Ux_t + Ws_{t-1})$ . The function  $f$  is usually a nonlinearity, such as  $\tanh$  or  $\text{relu}$ .  $s_{-1}$ , which is needed to compute the first hidden state, is usually initialized with zeros.  $O_t$  is the output in step  $t$ . For example, if we wanted to predict the next word in a sentence, it would be a probability vector in our vocabulary.  $O_t = \text{softmax}(Vs_t)$ . By expanding, we simply mean that we write the network for the complete sequence. For example, if the sequence we are interested in is a 5-word sentence, the network would be unfolded into a 5-layer neural network, one layer for each word.

### III. MATERIAL and METHODS

This work was carried out at the *Research Group on Intelligent Engineering and Computing for Advanced Innovation and Development (GECAD<sup>4</sup>)*, a research centre located at the Instituto Superior de Engenharia do Porto of the Instituto Politécnico do Porto ISEP/IPP, Porto, Portugal. Similarly to the HyFIS2 model (Josi et al.; 2016), the posited model uses the actual electrical consumption

4 <http://www.gecad.isep.ipp.pt/GECAD/Pages/Pubs/PublicationsPES.aspx>

data of sectors of Building N of ISEP/IPP where GECAD is located. The building has five energy meters that store the electrical energy consumption data of specific sectors of the building, with a time interval of 10 seconds. This information, as well as meteorological data, are stored in a SQL server automatically, through agents developed in Java.

To validate the model described below, tests were performed using the same consumption data applied to the SARIMAX model and HyFIS2. The N Building laboratories sector was not computed as it has a large variation in consumption due to the experiments conducted there, which generate many *outliers* in the consumption history. For the experiment tests, it was performed an hourly average of the consumption stored every ten seconds, due to the need of predicting the next hour of consumption.

#### 3.1 The Long and Short Time series Network Adapted (LSTNetA) Model

The model developed for energy consumption prediction was based on the model proposed by Lai [4], represented in Fig. 4, which consists of a hybrid ANN with three distinct layers, initially has a convolutional layer for the extraction of short-term patterns of the time series, has as input the time series, the output of this layer is the input of the recurrent layer that memorizes historical information of the time series, which in turn its output is the input of the highly connected dense layer. Finally, the output of the highly connected layer is combined with the output of the autoregressive linear regression (ARMA) [26] ensuring that the output will have the same scale as the input, thus composing the prediction.

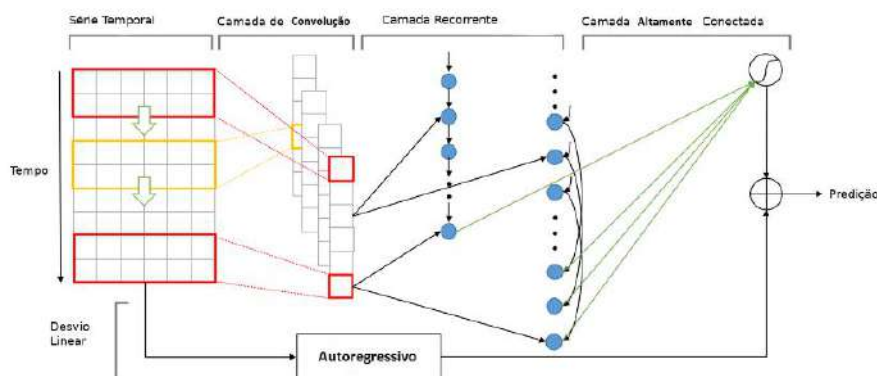


Fig. 5. Architecture of the LSTNetA model.

Source: adapted from Lai [4].

Fig. 6 summarizes the implementation of the LSTNetA network. The convolution layer is represented by the **Conv2D** class, the recurrent layer is represented by the **GRU** classes, the dense layer is represented by the

**Dense** classes, the auto-regression is represented in the **PostARTrans** class.

It is important to note that the recurrent layer uses one of the RNN variants the GRU (*Gated Recurrent Unit*)

[1], this ANN model as well as the LSTM (*Long Short-Term Memory*) aims to solve the problem of short-term memory of RNNs that, in long series, have difficulty transporting the results of previous steps to the later ones.

This may be caused by multiline strings or comments not indented at the same level as the code. Model: "model"

Layer (type)	Output Shape	Param #	Connected to
input_1 (InputLayer)	[(None, 24, 24)]	0	
reshape (Reshape)	(None, 24, 24, 1)	0	input_1[0][0]
conv2d (Conv2D)	(None, 19, 1, 100)	14500	reshape[0][0]
dropout (Dropout)	(None, 19, 1, 100)	0	conv2d[0][0]
reshape_1 (Reshape)	(None, 19, 100)	0	dropout[0][0]
pre_skip_trans (PreSkipTrans)	(None, 1, 100)	0	reshape_1[0][0]
gru (GRU)	[(None, 100), (None, 60600)]	0	reshape_1[0][0]
gru_1 (GRU)	[(None, 5), (None, 5 1605)]	0	pre_skip_trans[0][0]
dropout_1 (Dropout)	(None, 100)	0	gru[0][1]
post_skip_trans (PostSkipTrans)	(None, 95)	0	gru_1[0][1]
pre_ar_trans (PreARTrans)	(None, 24)	0	input_1[0][0]
concatenate (Concatenate)	(None, 195)	0	dropout_1[0][0] post_skip_trans[0][0]
flatten_1 (Flatten)	(None, 24)	0	pre_ar_trans[0][0]
flatten (Flatten)	(None, 195)	0	concatenate[0][0]
dense_1 (Dense)	(None, 1)	25	flatten_1[0][0]
dense (Dense)	(None, 24)	4704	flatten[0][0]
post_ar_trans (PostARTrans)	(None, 24)	0	dense_1[0][0] input_1[0][0]
add (Add)	(None, 24)	0	dense[0][0] post_ar_trans[0][0]

Total params: 81,434  
Trainable params: 81,434  
Non-trainable params: 0

Fig. 6: Summary of the LSTM implementation.

Source: The Author.

In the *backpropagation* stage, the learning process of ANNs, the RNNs suffer from the problem of gradient dissipation (*The Vanishing Gradient Problem*). Gradients are values used to update the weights of neural networks. The vanishing gradient problem is when the weights propagated during network training are multiplied by values smaller than 1 for each network layer passed through, arriving at the initial network layers with tiny values. This causes the adjustment of weights, calculated at each iteration of net training, to be too small, and makes net training more expensive.

Thus, in RNNs the layers that receive a small gradient update stop learning, with this the RNNs can forget what was seen in longer sequences, thus having a short-term memory.

Fig. 7 shows a typical architecture of a GRU. Basically what makes it different from a standard RNN are the *reset gate* and *update gate*, which by applying the *Sigmoid* and *tanh* activation functions, it is defined whether the previous output  $h_{t-1}$  will be considered or discarded for the calculation of the new output.

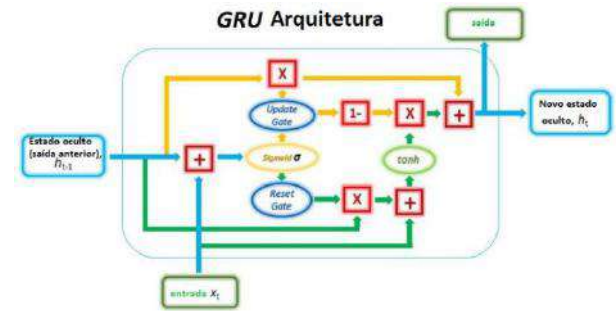


Fig. 7. Typical architecture of a GRU.

Source: The Author

The LSTMNetA model was developed in the Python programming language version 3.7 [17] using the machine learning library, developed by Google, TensorFlow version 2.0 [22].

#### IV. RELATED WORKS

Fig. 8, represents the power consumption time series used by the SARIMAX model to train and test the LSTMNetA model and HyFIS2. The top graph represents the historical series of consumption in *watts*, which starts at zero hours on 08/04/2019 to eight hours on 20/12/2019. The middle graph shows the calculated trend of the series and the bottom graph its seasonality.

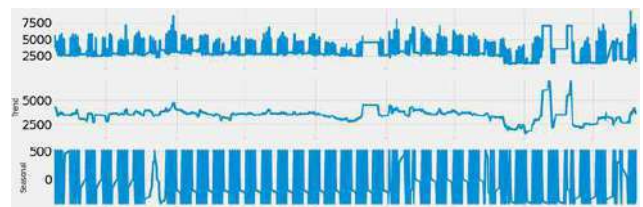


Fig. 8. Historical series of consumption.

Source: The Author.

##### 4.1 SARIMAX

As seen previously, the SARIMAX method is a statistical method of time series analysis, enabling the prediction through linear regressions. Thus, it cannot be characterized as a machine learning algorithm. In the scope of this work, it was applied to obtain prediction data of a widely used model, obtaining results for comparison with the proposed model and with the HyFIS2 model.

To verify the accuracy of all models covered in this work, the last 120 records corresponding to five days of consumption were used for comparison between real and predicted consumption, shown in Fig. 9. To calculate the error used to verify the results of this work, in all models, the *root mean square error* (RMSE - described in

chapter 01) was used, shown in Fig. 10. The application of this model resulted in an average RMSE of 604.72 that was considered as accuracy of this model, in this work.

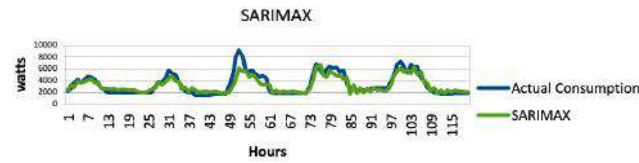


Fig. 9. Comparison Real Consumption X Sarimax.

Source: The Author.

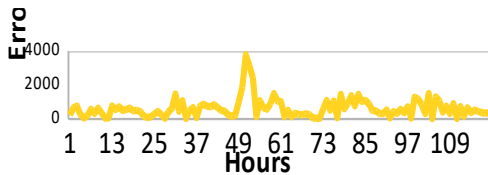


Fig. 10. Verified errors of the SARIMAX method.

Source: The author.

#### 4.2 Model HyFIS2

The HyFIS2 (*Hybrid neural Fuzzy Inference System*) model uses a hybrid approach with the combination of dense ANN and *fuzzy* logic. The system includes five layers, as shown in Fig. 11. In the first layer, the nodes are the inputs that transmit signals to the next layer. In the second and fourth layers, the nodes act as membership functions to express the input-output fuzzy linguistic variables. In these layers, the *fuzzy* sets defined for the input-output variables are represented as: large (L), medium (M) and small (S). However, for some applications, these can be more specific and represented as, for example, large positive (LP), small positive (SP), zero (ZE), small negative (SN) and large negative (LN). In the third layer, each node is a rule node and represents a fuzzy rule. The connection weights between the third and the fourth layer represent certainty factors of the associated rules, i.e., each rule is activated and controlled by the weight values. Finally, the fifth layer contains the node that represents the output of the system.

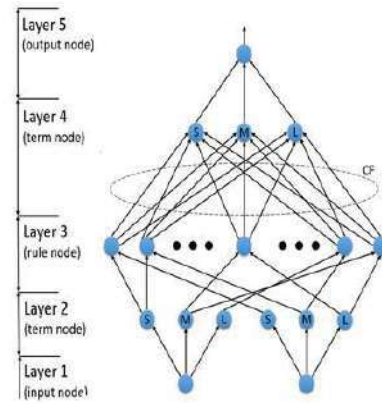


Fig. 11. Neuro-Fuzzy structure of the HyFIS2 model.

Source: Jozi [9]

For prediction of electricity consumption, as in all models tested, the last 120 historical records were used, corresponding to five days of consumption. The comparison between real and predicted consumption is shown in Fig. 12. Fig. 13 shows the RMSE errors calculated. The application of this model resulted in an average RMSE of 602.71 which was considered the accuracy of this model, in this work.

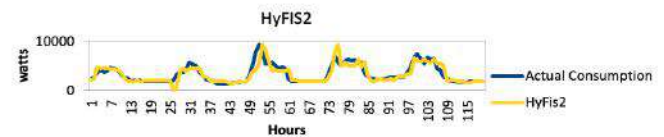


Fig. 12. Real Consumption Comparison X HyFis2.

Source: The Author.

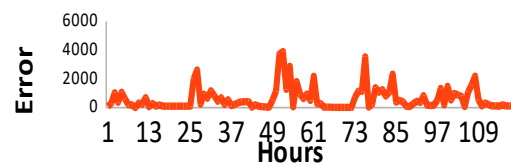


Fig. 13. Verified errors of the HyFIS2 model.

Source: The Author.

#### V. APPLICATION OF THE LSTNETA MODEL

The training of the LSTNetA ANN was performed as previously described, using the data of the real electricity consumption of the N building of the ISEP/IPP where GECAD is located, except for the laboratory sector. The historical series analyzed was from zero hours on 08/04/2019 to eight hours on 20/12/2019, with measurements every ten seconds, totaled every hour, resulting in 4186 records, containing time and consumption. The training was performed with a learning

rate of 0.0003, using the Adam [10] stochastic method of gradient descent optimization for updating the weights in the *backpropagation* process. For the initial weights of the ANN, the algorithm *VarianceScaling* [3] was used, which generates initial weights with values on the same scale as the inputs. The convolution kernel used was a 6x6 identity matrix and a training loop with 1000 epochs was performed. All these parameters were obtained experimentally and the ones with the best results were selected.

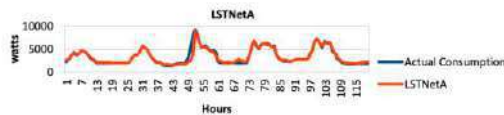


Fig. 14. Comparison Real Consumption X LSTNetA.

Source: The Author.

For the prediction of electricity consumption, as in all models tested, the last 120 historical records were used, corresponding to five days of consumption. The comparison between real and predicted consumption is shown in Fig. 14. Fig. 15 shows the RMSE errors calculated. The application of this model resulted in an average RMSE of 198.44 which was considered the accuracy of this model, in this work.



Fig. 15. Verified errors of the LSTNetA model.

Source: The Author.

## VI. RESULTS AND CONCLUSION

Table 1 shows a fragment of the results of the three models, the *Date and Time* column, the *Actual* column showing the actual electricity consumption in *watts* at that date and time, the *LSTNetA* column the prediction of this model at that date and time, the *Error - LSTNetA* column the absolute error of this model in the prediction, the column *HyFIS2* the prediction of this model at date and time, the column *Error - HyFIS2* the absolute error of this model in the prediction, finally the columns *SARIMAX* and *Error - SARIMAX*, representing the prediction and absolute error, respectively, in the SARIMAX model.

Comparing the results of the SARIMAX, HyFIS2 and LSTNetA models, it can be observed, as shown in Fig. 16, that the LSTNetA method, with the data used for testing, was the one that presented the closest predictions

of the real consumption of electricity, where the red line, which represents the predictions of the LSTNetA model, in most of the period overlapped the blue line that represents the real consumption. This demonstrates a prediction very close to the real consumption value, with low errors.

Table 1. Fragment of Predictions and Errors of the 3 models

Date and Time	Actual Consumption	LSTNetA	Error - LSTNetA	HyFis2	Error - HyFis2	SARI MAX	Error - SARIMAX
19/12/201 9 09:00	4759,38	4824,27	64,8900	3427,13	1332,2500	4721,76	37,6190
19/12/201 9 10:00	6781,51	6685,28	96,2346	6583,38	198,1300	5516,26	1265,2476
19/12/201 9 11:00	7279,1	7194,26	84,8373	5798,56	1480,5400	6124,20	1154,8976
19/12/201 9 12:00	6332,88	6247,08	85,8038	5798,38	534,5000	5497,10	835,7849
19/12/201 9 13:00	5350,34	5569,95	219,6063	6322,98	972,6400	5653,27	302,9276
19/12/201 9 14:00	6677,56	6499,50	178,0639	5798,37	879,1900	5197,56	1479,9983

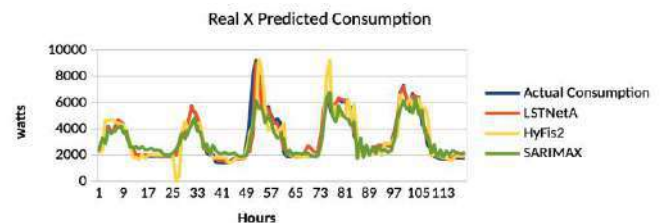


Fig. 16. Comparison of Real Consumption X Prediction Models.

Source: The Author.

Fig. 17 represents the errors (RSME) of the three models, allowing a comparison of the assertiveness of the predictions of each method and also concluding that the LSTNetA method presented a better efficiency in its predictions in comparison to the SARIMAX and HyFIS2 methods. This statement can be corroborated with the data presented in Table 2, where the total average error of the LSTNetA model is significantly lower than the other models.

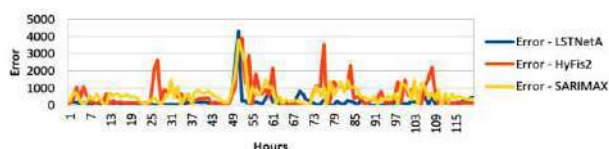


Fig. 17. Comparisons of errors verified in all models.  
Source: The Author.

Table 2. RSME of the 3 Models Tested

	Error - LSTNetA	Error - HyFis2	Error - SARIMAX
RSME	198,4496	602,7109	604,5810

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# A Finite Difference Scheme for the Modeling of a Direct Methanol Fuel Cell

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Received: 16 Jul 2022,

Received in revised form: 05 Aug 2022,

Accepted: 10 Aug 2022,

Available online: 19 Aug 2022

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**Keywords—** Numerical modeling, direct methanol fuel cell, finite difference scheme, methanol cross over.

**Abstract—** A one dimensional (1-D), isothermal model for a direct methanol fuel cell (DMFC) is introduced and solved numerically by a simple finite difference scheme. By using numerical calculation, the model model can be extended to more complicated situation which can not be solved analytically. The model considers the kinetics of the multi-step methanol oxidation reaction at the anode. Diffusion and crossover of methanol are taken into account and the reduced potential of the cell due to the crossover is then estimated. The calculated results are compared to the experimental data from literature. This finite difference scheme can be rapidly solved with high accuracy and it is suitable for the extension of the model to more detail or to higher dimension.

## I. INTRODUCTION

Direct Methanol Fuel Cells (DMFCs) are recently being attracted as an alternative power source to batteries for portable applications since they potentially provide better energy densities. However, there are two key constraints limiting the effectiveness of DMFC systems: crossover of methanol from anode to cathode and the sluggish kinetics of the electrochemical oxidation of methanol at the anode.

The crossover of methanol lessen the system efficiency and decreases cell potential due to corrosion at the cathode. The electrochemistry and transport processes in DMFCs are shown in Fig.1. Methanol is oxidized electrochemically at both the anode and cathode, however the corrosion current at the cathode does not create any useful work. A number of experimental and computational investigations have reported methanol crossover in DMFCs [1-4].

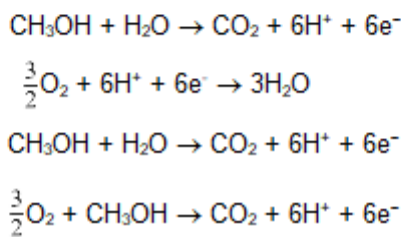
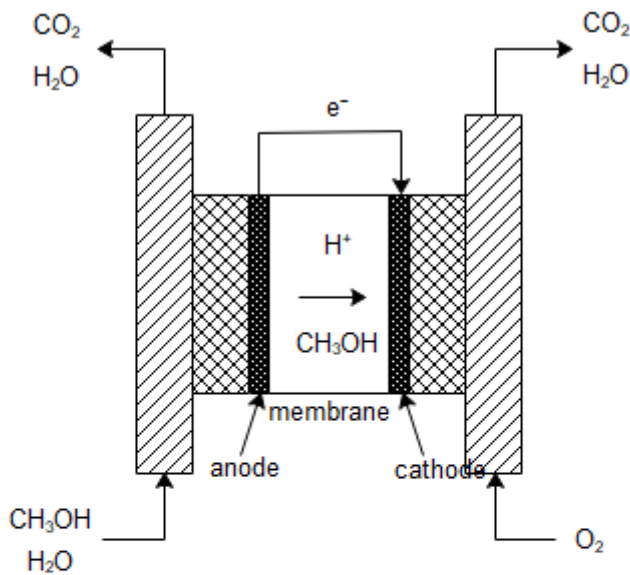


Fig.1 Schematic illustration of a DMFC.

There are several models have developed to predict the behaviour of direct methanol fuel cells, which is important in the design, operation and control. Among them, 1D model show the advantage of simple and fast calculation, which is suitable for real time simulation. García et al. [5] presented a one dimensional, isothermal model of a DMFC to rapidly predict the polarization curve and goes insight into mass transfer happening inside the cell. The model was solved analytically. However, analytical methods have some drawbacks such as the limitation to some specific cases and difficulty to extend to more complicated situation. Therefore, in this current study, instead of using analytical method, the model is solved numerically using a simple finite difference scheme.

**One-dimension mathematical modeling of direct**

**methanol fuel cell**

The model which was developed in [5] is used in this study. The details are briefly discussed as follows.

**Assumptions.** The model considers the 1D variation of methanol concentration across the fuel cell which includes anode backing layer (ABL), anode catalyst layer (ACL), and membrane. The schematic diagram of the layers considered in the model and several assumption illustration were presented in . The assumptions are detailed as follows

- 1) Steady-state and isothermal operation.
- 2) Variables are lumped along the flow direction
- 3) Convection of methanol is neglected.
- 4) Isothermal conditions.
- 5) All physical properties, anodic and cathodic overpotentials are considered constant.
- 6) Local equilibrium at interfaces between layers can be described by a partition function.
- 7) All the reaction are considered as homogeneous reactions.

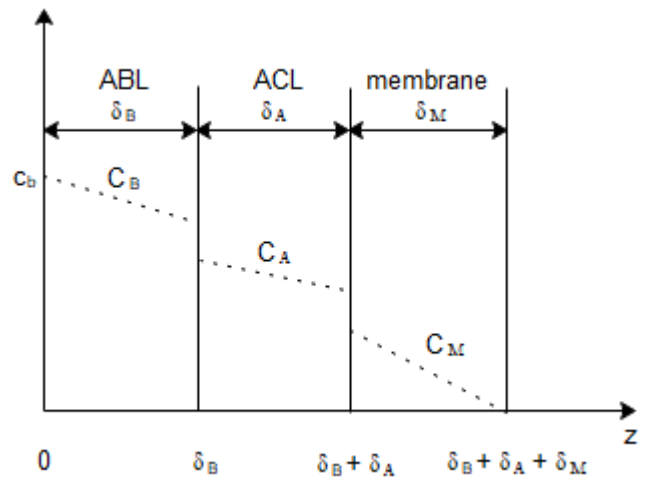


Fig.2 Schematic diagram and concentration distribution of the DMFC layers

The voltage of the cell is calculated as

$$V_{cell} = U^{O_2} - U^{MeOH} - \eta_C - \eta_A - \frac{\delta_M I_{Cell}}{\kappa} \tag{1}$$

in which,

$U_{O_2}$  and  $U_{MeOH}$  are the thermodynamic equilibrium potential of oxygen reduction and methanol oxidation respectively

$\eta_C$  and  $\eta_A$  are the cathode and anode overpotentials, respectively

$\frac{\delta_M I_{Cell}}{\kappa}$  represents the ohmic drop across the membrane.

**Anode backing layer - ABL (domain B)**

In this domain, the differential mass balance for methanol at steady state is

$$\frac{dN_{MeOH,z}^B}{dz} = 0 \tag{2}$$

The methanol flux is the Fickian diffusion with an effective diffusivity  $D_B$

$$N_{MeOH,z}^B = -D_B \frac{dc_{MeOH,z}^B}{dz} \tag{3}$$

Combining Eq. (2) and Eq. (3), the distribution equation for methanol in ABL is

$$\frac{d^2 c_{MeOH,z}^B}{dz^2} = 0 \tag{4}$$

**Anode Catalyst Layer - ACL (domain A)**

In this domain, there is a methanol oxidation reaction. Therefore, the differential mass balance for methanol at steady state is

$$\frac{dN_{MeOH,z}^A}{dz} = \frac{r_{MeOH}}{M_{MeOH}}$$

In which the molar rate of methanol consumption

$\frac{r_{MeOH}}{M_{MeOH}}$  is calculated from the volumetric current density

$j$  as:

$$\frac{r_{MeOH}}{M_{MeOH}} = \frac{-j}{6F} \tag{6}$$

The current density is related to the concentration of methanol as ([6])

$$j = a I_{0,ref}^{MeOH} \frac{kc_{MeOH}^A}{c_{MeOH}^A + \lambda e^{\alpha_a \eta_a F/RT}} e^{\alpha_a \eta_a F/RT} \tag{7}$$

In which  $a$  is the specific surface area of the anode,  $I_{0,ref}^{MeOH}$

is the exchange current density, and  $k$  and  $\lambda$  are constants

The methanol flux is the Fickian diffusion with an effective diffusivity  $D_A$

$$N_{MeOH,z}^A = -D_A \frac{dc_{MeOH,z}^A}{dz} \tag{8}$$

Combining Eq. (5), Eq. (6) and Eq. (8), the distribution equation for methanol in ACL is

$$D_A \frac{d^2 c_{MeOH,z}^A}{dz^2} = \frac{j}{6F} \tag{9}$$

**Membrane (domain M)**

The differential mass balance for methanol at steady state in the membrane is

$$\frac{dN_{MeOH,z}^M}{dz} = 0$$

(10)

The methanol flux in the membrane includes the diffusion and electro-osmotic drag as follows:

$$N_{MeOH,z}^M = -D_M \frac{dc_{MeOH,z}^M}{dz} + \xi_{MeOH} \frac{I_{Cell}}{F}$$

(11)

In which  $D_M$  and  $\xi_{MeOH}$  are the effective diffusion in membrane and the electro-osmotic drag coefficients of methanol, respectively.

Combining Eq. (10) and Eq. (11), the distribution equation for methanol in membrane is

$$D_M \frac{d^2 c_{MeOH,z}^M}{dz^2} = 0$$

(12)

**Boundary condition:**

At  $z=0$  (the interface between the flow-channel and anode backing layer), there is no mass resistance. Therefore, the concentration is given by the bulk concentration of the flow as:

$$c_{MeOH,z=0}^B = c_{bulk}$$

(13)

At  $z= \delta_B$  (the interface between ABL and ACL), there are two conditions. First, the local equilibrium of the concentrations between two domains is given by a partition coefficient  $K_I$  as

$$c_{MeOH,z=\delta_B}^A = K_I c_{MeOH,z=\delta_B}^B$$

(14)

Second condition is the equality of fluxes between two domains (ABL and ACL)

$$N_{MeOH,z=\delta_B}^B = N_{MeOH,z=\delta_B}^A$$

(15)

At  $z= \delta_B + \delta_A$  (the interface between ACL and membrane), there are two conditions. First, the local equilibrium of the

concentrations between two domains is given by a partition coefficient  $K_{II}$  as

$$c_{MeOH,z=\delta_B+\delta_A}^M = K_{II} c_{MeOH,z=\delta_B+\delta_A}^A$$

(16)

Second condition is the equality of fluxes between two domains (ACL and membrane) as

$$N_{MeOH,z=\delta_B+\delta_A}^A = N_{MeOH,z=\delta_B+\delta_A}^M$$

(17)

At  $z= \delta_B+ \delta_A+ \delta_M$ : All the methanol crossing the membrane is assumed to consume immediately at the cathode, result in a zero concentration at the membrane/ cathode-layer interface. Thus,

$$c_{MeOH,z=\delta_B+\delta_A+\delta_M}^M = 0$$

(18)

**Finite difference scheme and overpotential calculation**

The spatial independent variable  $z$  in the three segments (0,  $\delta_B$ ), ( $\delta_B, \delta_B + \delta_A$ ), ( $\delta_B+ \delta_A, \delta_B+ \delta_A + \delta_M$ ) can be discretized into  $n_B, n_A, n_M$  subdivisions, respectively, as

$$0 = z_1^B < z_2^B < .. < z_{n_B}^B = \delta_B$$

(19)

$$\delta_B = z_1^A < z_2^A < .. < z_{n_A}^A = \delta_B + \delta_A$$

(20)

$$\delta_B + \delta_A = z_1^M < z_2^M < .. < z_{n_M}^M = \delta_B + \delta_A + \delta_M$$

(21)

In each segment, note that the length of subsegment is equal to  $\Delta z_B, \Delta z_A, \Delta z_M$ , respectively.

**Governing equations**

Inside the domains (ABL, ACL and membrane), the second derivatives in the governing equations are discretized using central difference formulae. The details are as follows

In ABL region, equation (4) is discretized as:

$$D_B \frac{c_{MeOH,z+\Delta z}^B - 2c_{MeOH,z}^B + c_{MeOH,z-\Delta z}^B}{(\Delta z_B)^2} = 0 \tag{22}$$

Or

$$c_{MeOH,i+1}^B - 2c_{MeOH,i}^B + c_{MeOH,i-1}^B = 0 \tag{23}$$

In ACL region, equation (4) is discretized as:

$$D_A \frac{c_{MeOH,z+\Delta z}^A - c_{MeOH,z}^A + c_{MeOH,z+\Delta z}^A}{(\Delta z_A)^2} = \frac{aI_{0,ref}^{MeOH} \frac{kc_{MeOH,z}^A}{c_{MeOH,z}^A + \lambda e^{\alpha_A \eta_A F/RT}} e^{\alpha_A \eta_A F/RT}}{6F} \tag{24}$$

Or

$$D_A \frac{c_{MeOH,i+1}^A - c_{MeOH,i}^A + c_{MeOH,i+1}^A}{(\Delta z_A)^2} = \frac{aI_{0,ref}^{MeOH} \frac{kc_{MeOH,i}^A}{c_{MeOH,i}^A + \lambda e^{\alpha_A \eta_A F/RT}} e^{\alpha_A \eta_A F/RT}}{6F} \tag{25}$$

In membrane region, equation (12) is discretized as :

$$D_M \frac{c_{MeOH,z+\Delta z}^M - 2c_{MeOH,z}^M + c_{MeOH,z-\Delta z}^M}{(\Delta z_M)^2} = 0 \tag{26}$$

Or

$$c_{MeOH,i+1}^M - 2c_{MeOH,i}^M + c_{MeOH,i-1}^M = 0 \tag{27}$$

**Boundary conditions**

The first derivatives in boundary conditions are approximated using forward difference formulae as follows:

At the left interface, using the forward scheme:

$$\frac{dc_{MeOH,z}}{dz} = \frac{c_{MeOH,z+\Delta z} - c_{MeOH,z}}{\Delta z} \tag{28}$$

At the right interface, using the backward scheme:

$$\frac{dc_{MeOH,z}}{dz} = \frac{c_{MeOH,z} - c_{MeOH,z-\Delta z}}{\Delta z} \tag{29}$$

**Concentration profile**

After discretization, a system of equations for the concentration of methanol is obtained. The system is solved using simple iteration method to find the concentration profile of methanol.

**Anode overpotential**

From the concentration profile, the cell current can be estimated as:

$$I_{cell} = \int_{\delta_B}^{\delta_B + \delta_A} aI_{0,ref}^{MeOH} \frac{kc_{MeOH}^A}{c_{MeOH}^A + \lambda e^{\alpha_A \eta_A F/RT}} e^{\alpha_A \eta_A F/RT} \tag{30}$$

In which  $\eta_A$  is assumed to be constant. The integration is numerically calculated using trapezoidal rule. Because  $\eta_A$  is also included in calculation of concentration profile, an iteration is required to find appropriate  $\eta_A$  for a given value of  $I_{Cell}$ .

**Cathode overpotential**

Tafel kinetics with first-order oxygen concentration dependence is used to estimate the oxygen reduction at the cathode.

$$I_{cell} + I_{leak} = I_{0,ref}^{O_2} \frac{c_{O_2}}{c_{O_2,ref}} e^{\alpha_C \eta_C F/RT} \tag{31}$$

In which  $I_{leak}$  is the leakage current density due to the oxidation of methanol crossing the membrane. The leakage current density can be estimated as

$$I_{leak} = 6FN_{MeOH,z}^M \tag{32}$$

In which  $N_{MeOH,z}^M$  is estimated from Eq. (11). Then, Eq.

(32) is used to obtain  $\eta_C$  for a given value of  $I_{Cell}$ .

Table 1.

After the anode and cathode overpotentials are known, the

$V_{Cell}$  for a given value of  $I_{Cell}$  is calculated using Eq. (1).

The parameters used in the model are summarized in

Table 1 Model parameters

Parameter	Value
a	1000 cm <sup>-1</sup>
D <sub>A</sub>	$2.8 \times 10^{-5} \exp(2436(1/353-1/T))$ cm <sup>2</sup> /s
D <sub>B</sub>	$8.7 \times 10^{-6}$ cm <sup>2</sup> /s
D <sub>M</sub>	$4.9 \times 10^{-6} \exp(2436(1/333-1/T))$ cm <sup>2</sup> /s
$I_{0,ref}^{MeOH}$	$9.425 \times 10^{-3} \exp(33570/R(1/333-1/T))$ A/cm <sup>2</sup>
$I_{0,ref}^{O_2}$	$4.222 \times 10^{-3} \exp(73200/R(1/333-1/T))$ A/cm <sup>2</sup>
$K_I$	0.8
$K_{II}$	0.8
k	$7.5 \times 10^{-4}$
T	343.15 K
$U_{MeOH}$	0.03 V
$U_{O_2}$	1.24 V
$\alpha_a$	0.52
$\alpha_c$	1.55
$\delta_A$	0.0023 cm
$\delta_B$	0.015 cm
$\delta_M$	0.018 cm
$\kappa$	0.036 s/cm
$\lambda$	$2.8 \times 10^{-9}$ mol/cm <sup>3</sup>
$\zeta_{MeOH}$	$2.5x_{MeOH}$

## II. RESULTS AND DISCUSSIONS

The simulation results of the polarization curve for DMFC at different concentrations of the bulk flow are shown in Fig.3. The calculation results well agree with the experimental data report in [5]. However, the difference at

the end of the curve is quite high. The disagreement could be due to the assumption that the methanol electro-osmotic drag coefficient is a constant value. It is better to calculate the electro-osmotic drag coefficient at each point, especially at the end of the curve.

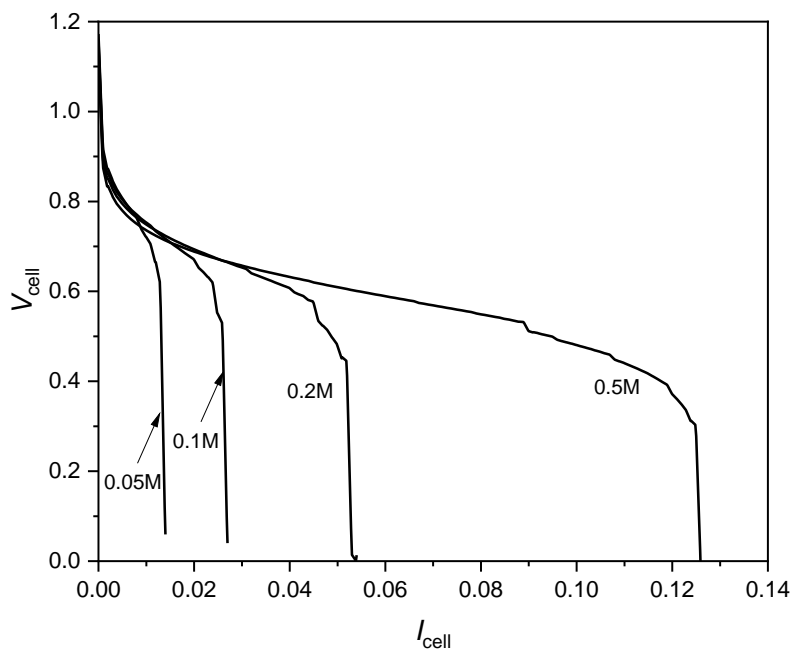


Fig.3 Model predictions for different methanol concentrations

Fig.4 shows concentration profiles across the anode and membrane obtained by the model for the four concentrations at 15 mA/cm<sup>2</sup>.

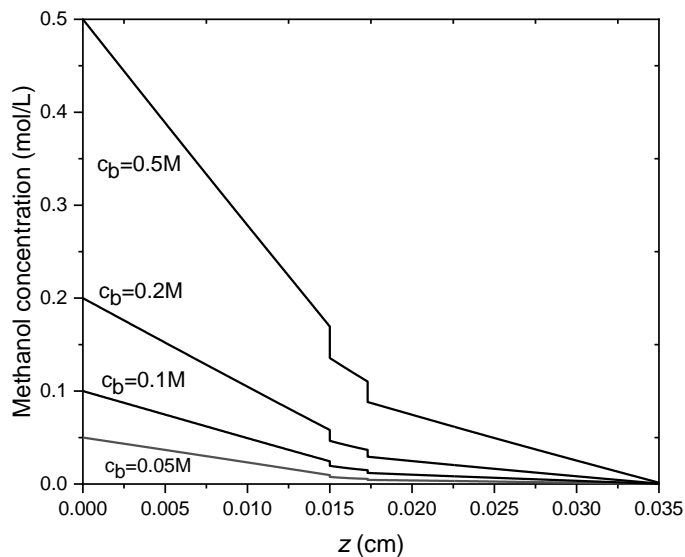


Fig.4 Concentrations profiles for different methanol bulk concentrations

### III. CONCLUSIONS

In this study, a finite difference scheme were successfully applied to solve the one-dimensional, isothermal model of a DMFC. Using reasonable transport and kinetic

parameters from literature, the calculation results well agree with experimental polarization curve. The scheme also is applicable in the estimation of concentration profiles in the anode and membrane as well as predicting

the methanol crossover. The computation time is fast enough for real time application.

### ACKNOWLEDGMENTS

This research is supported by Vietnam National Foundation for Science and Technology Development (NAFOSTED) undergrant number 104.03-2018.367.

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## Analysis of Pharmacotherapy in Patients Assisted by a Long Stay Institution Located in the city of Montes Claros – MG

## Análise da Farmacoterapia de Pacientes Assistidos por Uma Instituição de Longa Permanência Localizada na Cidade de Montes Claros – MG

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Received: 19 Jul 2022,

Received in revised form: 07 Aug 2022,

Accepted: 12 Aug 2022,

Available online: 19 Aug 2022

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**Keywords—** Elderly, Pharmaceutical attention, Problems related to medication use, PRM/MRP

**Palavras-chaves—** Idosos, Atenção Farmacêutica, Problemas relacionados ao uso de medicamentos, PRM.

**Abstract—** Introduction: The longevity of the population observed in the last decades, associated with the growth of chronic-degenerative diseases has increased the need for polytherapy in the elderly population. Studies show that each elderly person uses an average of four to six medications, which increases with age, characterizing a complex therapy that needs pharmacotherapeutic follow-up to avoid the occurrence of problems related to the use of medications (PRM). Objective: To analyze the pharmacotherapy of patients assisted by a long - term institution located in the city of Montes Claros - MG. Methodology: The study presents a transversal and descriptive character. The data were obtained from a clinical interview with the application of a Standardized Form by the Federal Council of Pharmacy for Pharmaceutical Consultation, analysis of medical records and patient records, after proper approval by the Ethics and Research Committee. Results and Discussion: During the study the pharmacotherapy of 40 elderly patients was analyzed, A total of 145 drug - related problems (DRPs) were identified and classified into 14 categories, with the most frequent being drug - drug interaction, inadequate frequency or times of administration, drug - food interaction and inappropriate or contraindicated drug prescription ( 10%). Conclusions: It was concluded that a great number of problems related to the use of drugs were detected, putting at risk the health of the elderly.

**Resumo—** Introdução: A longevidade da população observada nas

últimas décadas, associada ao crescimento das doenças crônico-degenerativas tem aumentado a necessidade de politerapia na população idosa. Estudos demonstram que cada idoso faz uso em média de quatro a seis medicamentos, esse número cresce com o avanço da idade, caracterizando uma terapia complexa que precisa de seguimento farmacoterapêutico para evitar a ocorrência dos problemas relacionados ao uso de medicamentos (PRM). Objetivo: Analisar a farmacoterapia dos pacientes assistidos por uma instituição de longa permanência localizada na cidade de Montes Claros – MG. Metodologia: O estudo apresenta caráter transversal e descritivo. Os dados foram obtidos a partir de uma entrevista clínica com a aplicação de um Formulário Padronizado pelo Conselho Federal de Farmácia para Realização de Consulta Farmacêutica, análise dos prontuários e ficha farmacêutica dos pacientes, após devida aprovação pelo Comitê de Ética e Pesquisa. Resultados e Discussão: Durante a pesquisa foi analisada a farmacoterapia de 40 idosos, constatando um total de 123 patologias e a utilização de 239 medicamentos. As doenças mais prevalentes foram hipertensão arterial sistêmica, diabetes e depressão, sendo as principais classes de medicamentos prescritas indicadas para essas patologias. Foram detectados e classificados 145 problemas relacionados ao uso de medicamentos (PRMs), divididos em 14 categorias, sendo os mais frequentes, interação medicamento – medicamento, frequência ou horários de administração prescritos inadequados, interação medicamento- alimento e prescrição de medicamento inapropriado ou contraindicado (10%). Conclusões: Conclui-se que foi detectado um grande número de problemas relacionados ao uso de medicamentos, colocando em risco a saúde dos idosos.

## I. INTRODUÇÃO

A longevidade da população humana observada nas últimas décadas, associada ao aumento da prevalência das doenças crônico-degenerativas tem aumentado cada vez mais a necessidade de politerapia na população idosa (OLIVEIRA, *et. al.*, 2016, CAVALARI, *et. al.*, 2016). Doenças cardiovasculares, locomotoras, psiquiátricas, dislipidemias e diabetes são as mais recorrentes nessa população e exigem o uso contínuo de medicamentos. (OLIVEIRA, NOVAES, 2013, DAMIANCE, 2015).

As pesquisas apontam que cada idoso faz uso em média de quatro a seis medicamentos e esse número se torna ainda maior com o avanço da idade, caracterizando uma politerapia complexa que precisa de seguimento farmacoterapêutico para evitar a ocorrência dos problemas relacionados ao uso de medicamentos (PRM). Os medicamentos mais utilizados são os agentes cardiovasculares e os psicofármacos, seguidos de anti-inflamatórios, analgésicos e agentes gastrintestinais (OLIVEIRA, NOVAES, 2012; DAMIANCE, 2015).

No decorrer da Conferência Europeia sobre Atenção Farmacêutica da “Pharmaceutical Care Network Europe” (PCNE) em 1999, o Problema Relacionado ao

Medicamento (PRM) foi estabelecido como: “a ocorrência de problemas na terapia medicamentosa de um paciente que causa, ou pode ocasionar, interferência nos resultados terapêuticos”. Assim, um PRM acontece se houver ocorrência ou mesmo a possibilidade de uma ocorrência na terapêutica medicamentosa (CINFARMA, 2015). Por outro lado, segundo o II Consenso de Granada (2002) “PRMs são problemas de saúde vistos como resultados clínicos negativos, provenientes da farmacoterapia que, produzidos por diversas causas, interferem no resultado terapêutico ou levam a efeitos indesejados”. Dentro dos PRM’s se enquadra o Erro de Medicação (EM), que é determinado como “qualquer erro que ocorra durante o processo de prescrição e utilização do medicamento”. Estes erros podem ser relacionados com os procedimentos e sistemas da prática profissional que incluem: a prescrição, comunicação de pedido, rotulagem, dispensa, distribuição, administração e adesão do paciente. (CINFARMA, 2015).

Considerando esse contexto de politerapia, faz-se necessário cada vez mais passar as orientações de forma clara aos pacientes sobre a utilização adequada dos medicamentos, posologia, forma farmacêutica a ser administrada, e fornecer aos idosos e aos seus cuidadores

todas as informações serem seguidas para que se tenha a melhor resposta dos tratamentos farmacológicos, melhorando a qualidade de vida dos pacientes durante o tratamento. Diante desse cenário, a Atenção Farmacêutica vem se tornando cada vez mais aplicável no acompanhamento de pacientes que fazem uso de politerapia (OLIVEIRA, *et.al.*, 2016, CAVALARI, *et.al.*, 2016).

Diante do exposto, esse trabalho teve como objetivo analisar a farmacoterapia de pacientes assistidos por uma instituição de longa permanência localizada na cidade de Montes Claros – MG.

## II. MATERIAIS E MÉTODOS

Este estudo tem caráter transversal e descritivo. O estudo foi realizado em uma instituição de longa permanência localizada na cidade de Montes Claros – MG,

*Tabela 01: Distribuição da idade, do número de doenças, dos medicamentos e dos Problemas relacionados ao uso de medicamentos (PRM's) por paciente.*

Pacientes	Idade	Nº de doenças	Nº de medicamentos	Nº de PRMs
1	75	4	4	2
2	70	1	5	3
3	70	3	7	8
4	70	2	7	2
5	71	5	11	7
6	84	3	5	2
7	81	2	3	1
8	70	3	9	5
9	75	1	4	1
10	82	3	6	2
11	80	2	3	1
12	89	3	6	1
13	76	5	7	3
14	81	4	8	4
15	91	3	9	3
16	86	3	4	1
17	90	3	7	3
18	81	4	9	9
19	87	3	7	2
20	70	3	8	5
21	77	5	10	5
22	76	4	10	6
23	73	3	8	4

depois de devida aprovação pelo Comitê de Ética e Pesquisa (CEP) obedecendo a Resolução nº 466/12, de 12 de dezembro de 2012. Os dados foram coletados a partir de uma entrevista clínica com a aplicação de um Formulário Padronizado pelo Conselho Federal de Farmácia para Realização de Consulta Farmacêutica, análise dos prontuários e ficha farmacêutica dos pacientes. Os dados obtidos foram expressos pelo programa Microsoft Office Excel 2007.

## III. RESULTADOS E DISCUSSÃO

De acordo com a **Tabela 01**, durante o período de estudo foram entrevistados 40 idosos moradores da instituição de longa permanência, com idade entre 71 e 91 anos. Por meio da avaliação dos prontuários constatou-se a ocorrência de 123 patologias, 239 medicamentos utilizados pelos pacientes e 145 PRMs detectados.

24	84	5	6	0
25	71	2	5	0
26	81	2	7	3
27	83	4	5	3
28	83	4	8	7
29	70	2	7	9
30	73	3	11	9
31	85	2	4	2
32	87	3	3	1
33	84	5	7	5
34	75	3	7	4
35	70	3	2	1
36	90	5	4	7
37	89	1	2	4
38	85	2	1	1
39	78	1	1	4
40	90	4	2	5
Total		123	239	145

**Fonte:** Formulário Padronizado para Realização de Consulta Farmacêutica aplicado durante entrevista clínica.

A **Figura 01** descreve a distribuição das patologias identificadas na população estudada. Constatou-se que as doenças crônicas comuns a esta faixa etária é

realmente prevalente na população estudada, sendo a hipertensão arterial sistêmica a patologia mais abrangente, pois é comum a quase todos os pacientes.

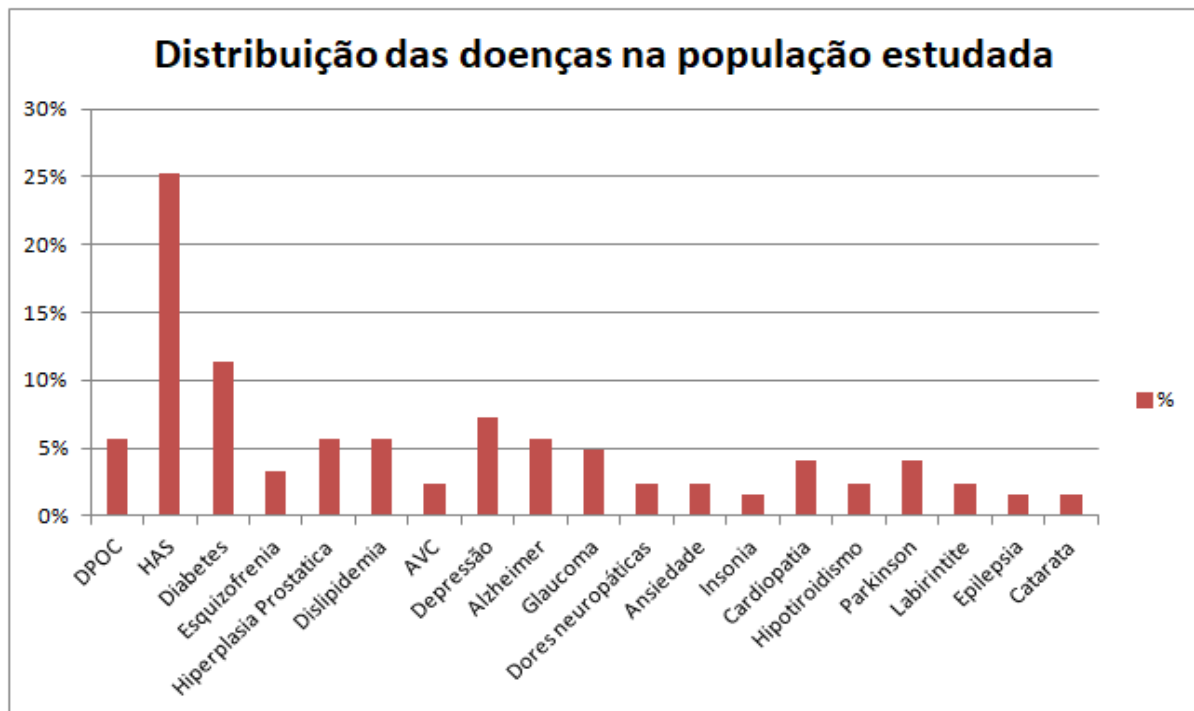


Fig.1: Distribuição das doenças na população.

**Fonte:** Prontuário dos pacientes

Sabe-se que com o aumento da idade o sistema cardiovascular passa por uma série de alterações, tais como arteriosclerose, diminuição da distensibilidade da aorta e das grandes artérias, causando comprometimento da condução cardíaca e redução na função barorreceptora (GROUP F.H.S., 1994). Segundo pesquisa da Sociedade Brasileira de Hipertensão (2017) 25% da população brasileira faz uso de anti-hipertensivo, que corrobora com a pesquisa realizada pelo Sistema de Vigilância de Fatores de Risco e Proteção para Doenças Crônicas por Inquérito Telefônico (VIGITEL) de 2017, demonstrou que um entre quatro brasileiros fazem uso de medicamento para pressão. Há também um grande índice de moradores portadores de diabetes, sendo a diabetes *mellitus* tipo 2 a mais presente. Conforme a SOCIEDADE BRASILEIRA DE DIABETES (SBD, 2017) a maior incidência de diabetes *mellitus* tipo 2 (DM2) nos idosos ocorre devido ao desenvolvimento e perpetuação da hiperglicemia, que se desenvolve concomitantemente com hiper glucagonemia, resistência dos tecidos periféricos à ação da insulina, aumento da produção hepática de glicose, disfunção incretínica, aumento de lipólise e consequente aumento de ácidos graxos livres circulantes, aumento da reabsorção renal de glicose e graus variados de deficiência na síntese e na secreção de insulina pela célula  $\beta$  pancreática. Isto ocorre devido as mudanças fisiológicas que ficam em baixa devido ao processo de envelhecimento, associadas aos fatores de risco comportamentais como tabagismo, alimentação inadequada com ingestão elevada de alimentos calóricos, sal e açúcar; sobrepeso e obesidade, sedentarismo e inatividade física (GOULART, 2011).

Em seguida destaca-se a depressão, visto que determinados fatores neurobiológicos contribuem significativamente para desenvolvimento do quadro depressivo dos idosos, tais como alterações neuroendócrinas (redução da resposta ao hormônio estimulador da tireoide), alterações de neurotransmissores (atividades serotoninérgicas e noradrenérgicas), alterações vasculares e processos de degeneração de circuitos corticais e subcorticais responsáveis pelo processamento e elaboração da vida afetiva e emocional (SIQUEIRA *et al.*, 2009). Observa-se que os motivos que desencadeiam a depressão no idoso configuram-se dentro de um vasto conjunto de motivos. Casos como a perda da saúde, do companheiro, dos papéis sociais, bem como o abandono, o isolamento social, a institucionalização, a incapacidade de reengajamento na atividade produtiva, são reconhecidamente fatores de risco para a depressão (STELLA F. *et al.*, 2002).

Nota-se que logo em seguida, aparecem a dislipidemia e a hiperplasia prostática na distribuição das patologias. A dislipidemia ocorre com processo de envelhecimento, porque a composição corporal se altera, levando há uma redução percentual de massa muscular concomitante a elevação da quantidade e do volume de tecido adiposo, principalmente na cavidade abdominal, que favorece ao aumento da obesidade gerando a dislipidemia e a hiperplasia prostática se caracteriza, por se tratar de pacientes com faixa etária superior a 50 anos, faixa que compreende a maior pré-disposição de desenvolver o crescimento nodular nos homens (KAMIMURA, *et al.*, 2005).

Conforme a **Figura 02** foram identificadas 28 classes farmacológicas de medicamentos prescritas para os idosos, sendo que cada paciente faz uso de pelo menos um medicamento.

Os resultados obtidos durante análise dos prontuários se assemelham a um estudo realizado em ILPIs (Instituto de Longa Permanência para Idosos) no Rio Grande do Sul, onde identificou que os fármacos mais utilizados pelos idosos foram referentes ao sistema cardiovascular, seguidos pelos fármacos de ação no sistema nervoso central (GAUTÉRIO D.P. *et al.*, 2012). Embora epidemiologicamente na distribuição das doenças a diabetes tenha aparecido em segundo lugar, observou-se que na distribuição das classes farmacológicas os antidepressivos ocuparam a segunda posição, indicando que a doença está sendo tratada sem diagnóstico. Também são evidentes o uso acentuado de hipoglicemiantes, antipsicóticos, suplementos minerais, anti-hipertensivo ocular, anti-inflamatórios não esteroidais (AINE) e estatinas. Esses dados correlacionam com as doenças mais comuns em idosos, uma vez que esses apresentam maior incidência de doenças crônicas, pior capacidade funcional e menor autonomia (SILVA *et al.*, 2012)

A **Figura 03** mostra a distribuição dos 145 PRM's identificados de acordo com as treze classificações definidas pelo Formulário Padronizado para Realização de Consulta Farmacêutica aplicado durante a entrevista clínica. Ressalta-se que 98% das prescrições dos idosos apresentaram algum tipo de PRM, pois a combinação de medicamentos é uma estratégia utilizada na clínica médica, a fim de que se alcance o objetivo terapêutico. Porém, essas combinações podem resultar em eventos adversos (GAUTÉRIO D.P. *et al.*, 2012).

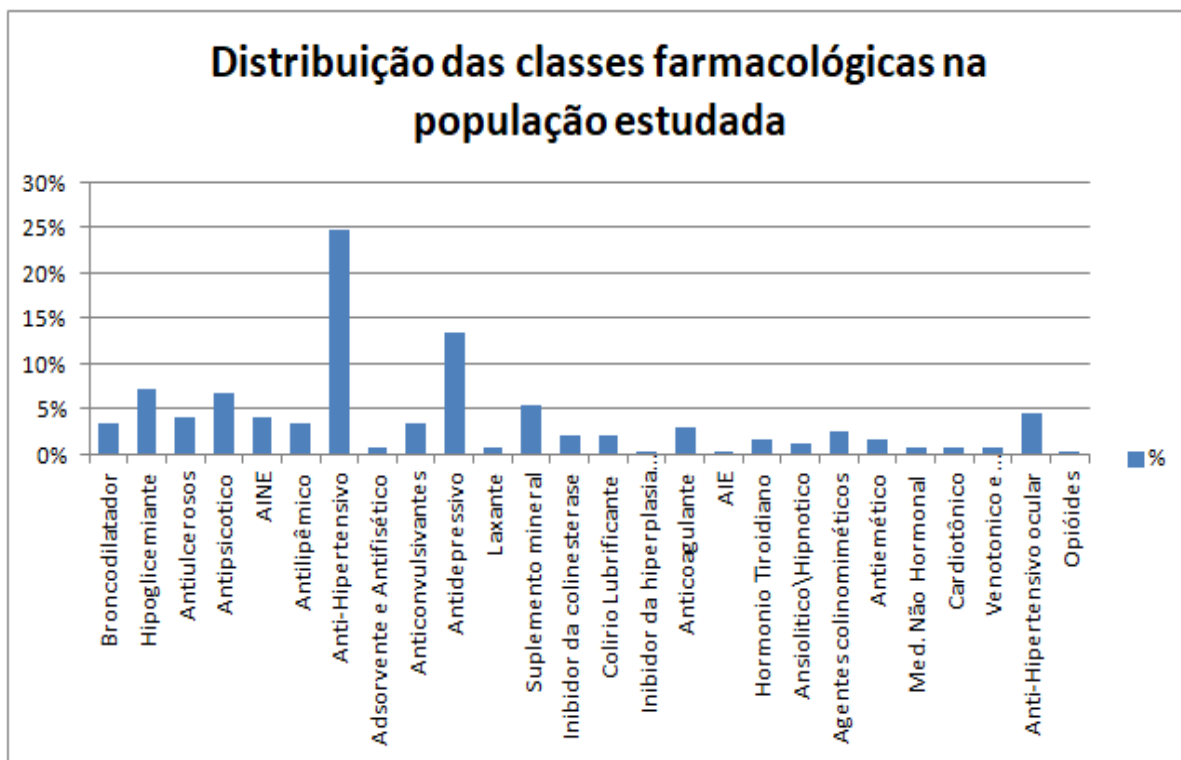


Fig.2: Distribuição das classes farmacológicas na população estudada.

Fonte: Formulário Padronizado para Realização de Consulta Farmacêutica aplicado durante entrevista clínica.

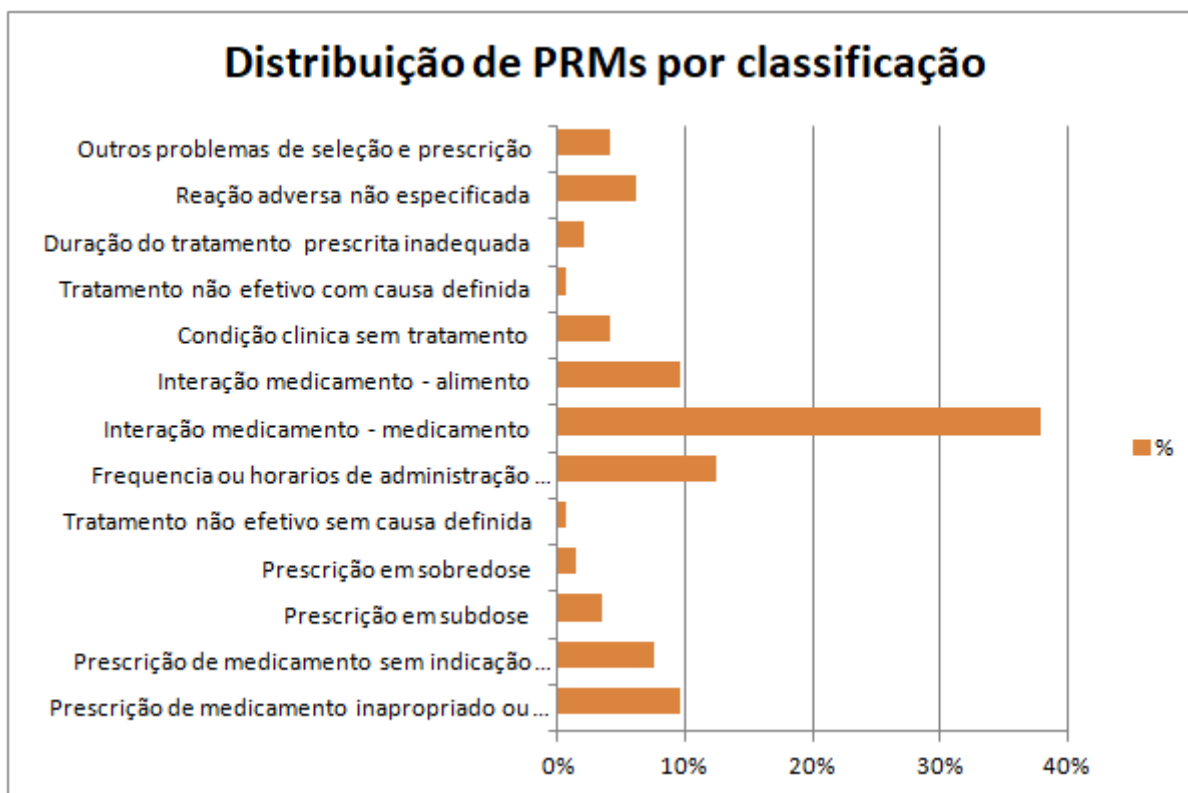


Fig.3: Distribuição dos PRM's por classificação na população estudada.

Fonte: Formulário Padronizado para Realização de Consulta Farmacêutica aplicado durante entrevista clínica.

O PRM mais encontrado foi interação medicamento – medicamento. Esse fato pode ser explicado pela polimedicação utilizada pelos assistidos. Entretanto, é bem descrito que para idosos acometidos por diversas comorbidades, em muitos casos faz-se necessária a utilização da politerapia, onde se deve avaliar sempre a relação risco-benefício (LINJAKUMPU T., 2002).

O segundo PRM mais prevalente foi frequência ou horários de administração dos fármacos prescritos. Observou-se que esse ponto não era atendido em mais de 10% das prescrições. Provavelmente, isto acontece devido o sistema de dispensação que ocorre de forma coletiva em horários fixados pela instituição, que fogem a posologia indicada pelos fabricantes. Posologia esta que é extremamente importante, porque ela determina a forma de utilizar os medicamentos, ou seja, o número de vezes e a quantidade de medicamento a ser utilizada a cada dia – que varia em função do paciente, da doença que está sendo tratada e do tipo de medicamento utilizado (APPENDIX A. STATE OPERATIONS MANUAL, 2007) A posologia está relacionada com o tempo de ação e a dose terapêutica do medicamento em questão. Um esquema posológico racional baseia-se na pressuposição de que existe uma concentração-alvo que irá produzir o efeito terapêutico desejado. Cada medicamento passou por vários estudos, que determinou a janela terapêutica, que compreende a concentração plasmática mínima da droga necessária para fazer o efeito e a concentração máxima acima da qual o fármaco irá apresentar efeitos tóxicos (APPENDIX A. STATE OPERATIONS MANUAL, 2007).

Em seguida, destaca-se a interação medicamento – alimento, pois se não temos a posologia seguida conforme o fabricante, somado ao fato do sistema de dispensação seguir um padrão fixo de horários, ocorre que alguns medicamentos não tem seu intervalo de tempo suficiente ou são administrados sem aguardar o tempo indicado antes ou pós-refeições comprometendo a farmacocinética e, conseqüentemente, a biodisponibilidade dos fármacos (LOMBARDO M., ESERIAN J.K., 2014; CAVALHEIRO A.H., COMARELLA L., 2016).

A prescrição de medicamentos inapropriados ou contraindicados apresentou índices elevados. Provavelmente, este indicador é resultado da prescrição de esquemas terapêuticos inadequados. Resultado semelhante foi encontrado em população de idosos estuda na cidade do Rio de Janeiro-RJ. Verificaram que 10% dos medicamentos utilizados por esses indivíduos eram potencialmente inadequados, sendo que a maior parte destes possuía grau de severidade elevado (ROZENFELD S., FONSECA M.J.M., ACURCIO F.A., 2008).

Os demais PRMs identificados apresentaram menor incidência, o que não significa ter menor importância, pois estes resultados demonstram que a polifarmacoterapia precisa ser devidamente supervisionada, uma vez que os resultados demonstram esquema terapêutico inapropriado para os idosos, comprometendo a eficácia do tratamento e a segurança do paciente.

#### IV. CONCLUSÃO

Conclui-se que as doenças identificadas são de características crônico-degenerativas e que os pacientes, em sua grande maioria, fazem uso de mais de um medicamento, o que propiciou a identificação de um grande número de problemas relacionados ao uso de medicamentos.

Diante do exposto, verifica-se a necessidade da realização de acompanhamento farmacoterapêutico dos idosos residentes na instituição, pois são indivíduos que apresentam histórico de diversas patologias concomitantes, fazem uso de diversos medicamentos que geram um número significativo de PRMs. Este acompanhamento tem como objetivo monitorar constantemente e reavaliar a farmacoterapia dos idosos visando realizar a intervenção farmacêutica, quando necessária e notificar os PRMs para a equipe multidisciplinar para realização de possíveis intervenções visando melhorar a farmacoterapia dos pacientes e conseqüentemente melhorar a qualidade de vida dos idosos.

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# Development of Power Back-Up System using Motor Control for Large Equipment

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Received: 19 Jul 2022,

Received in revised form: 08 Aug 2022,

Accepted: 13 Aug 2022,

Available online: 19 Aug 2022

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**Keywords**— *back-up system, engineering, energy, storage devices, uninterruptible power supply.*

**Abstract**— *Uninterruptible power supply became a vital technology in the modern era. Through the advancement of technology, the development of this kind of technology seems to be more advanced in terms of size, efficiency, and the delivery of purpose and functionality. However, the compatibility of the device to a certain load remains to be the problem. With this, the researchers developed a power back-up system that can deliver the same purpose for any load including large and critical equipment. This technology was able to vary the storage system capacity, which also integrated the use of other energy sources such as new and renewable. The technology used motor control devices for the same purpose. To validate the effectiveness of the technology, the researchers used factorial design and comparative study to match with the performance of a commercially available uninterruptible power supply. In terms of performance with the commercially available uninterruptible power supply, the comparative study showed that there is no significant difference and thus the power back-up system is as efficient and equally reliable as the commercially available devices. Therefore, the power back-up system is highly adaptable, can substitute commercially available uninterruptible power supply, and can be an effective back-up system for large and critical equipment.*

## I. INTRODUCTION

In a developing country like the Philippines, electricity has been a substantial factor in determining economic growth. According to the Asian Development Bank (1), the Philippines has been subjectively experiencing power outage that is approximately 40% and transmission and distribution losses amount to nearly 10% as of 2015, ranking highest amongst Southeast Asian Nations.

An advisable device to compensate for this threat is to consider installing a power back-up system. However, commercially available uninterruptible power supply (UPS) has low back-up power suitable for critical equipment and extortionate (2), has a short lifespan, and is unsustainable. As a solution, the researchers propose a back-up system that is not traditionally made using

electronics but instead uses motor control devices. Motor control devices, such as contactors, relays, and time-delay relays, are usually common in an industrial machine. These devices can improve the lifespan of the back-up system device since it is easy to repair, and the device can tailor for any load requirements (3). The power back-up system also can adapt to any power source including renewable energy compared to the commercially available uninterruptible power supply (UPS).

The utmost advantage of the system is the use of a magnetic contactor which eliminates the dependence of the system on electronic components devices (4). Because of this, only the defective components will be replaced and not the whole system. Also, the magnetic contactor acts as a switch and a circuit breaker, therefore, fuse and another delimiting device can be omitted. For the large capacity of

equipment, it is advisable to have a heavy-duty system back-up that can withstand the availability of power.

$$i = I_{max} \sin 377t \quad (1)$$

$$v = V_{max} \sin 377t \quad (2)$$

Critical loads have been identified as loads to which power has to be maintained under any circumstances (5). The power supply must not be interrupted as much as possible. Critical loads vary depending on the type of establishment and needs of the company- for instance, an IT infrastructure is the critical load of an IT services company that needs to provide uninterrupted access to its website and online store. For a manufacturing company, a critical load can be equipment whose function is to deliver and process products for the entire day. The power back-up system is a reliable source of continuous power for these critical loads. It is usually integrated into any loads including computers to prevent extemporaneous outage of power. Commercially available uninterruptible power supply (UPS) can be also considered to address the need for continuous power (6). However, limitations of using the UPS system include the short lifespan of the device, impractical operation relative to the time of consumption of power, difficult or impossible repair of malfunctioning parts, and the negative environmental impact of the life cycle of the device. Meanwhile, the power back-up system is proven to be a reliable source of power and is not limited to a specific device. The adaptability of the power back-up system to any equipment will be determined by (1) system performance (2) runtime (3) reliability (4) maintenance and (5) total cost of ownership. The power back-up system can adjust to the requirement of the equipment— capacity and the time it needs to be supplied with pure sine wave power. Composed with motor-control devices, the system can allow replacement of the damaged part without affecting the other components or the whole system, thus, this eliminates the possibility of complete replacement of the equipment and can adapt to any electrical set-up including standby mode. Continuous Power back-up system has been established to be an alternative for commercially available UPS with the advantage as a power back-up system using on-grid supply and renewable energy supply. With the continuous improvement in energy storage technologies, the future of this system is also expected to advance and will be more appreciated in industries.

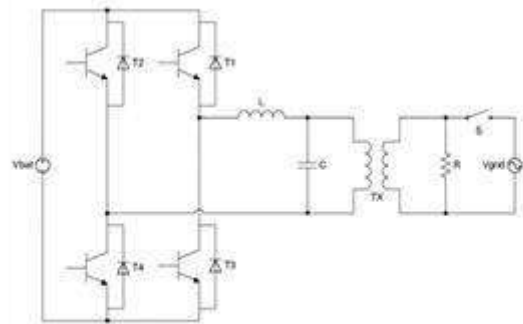


Fig 1. Generic schematic diagram for UPS

The goal of the study is to analyze the developed power back-up system electrical parameters based on the resulting sinusoidal equation requirement of the load (see eq. 1 and 2). The developed power back-up system which uses independent parts integrated to improve maintenance, design, and applicability to large equipment was tested for functionality and reliability using on-grid supply and renewable supply.

## II. REVIEW OF RELATED LITERATURE

Electricity storage can be deployed throughout an electric power system. A UPS is an example of an electricity storage application. Commercially available UPS has been a vital part of the power system of the commercial establishment for the prevention of sudden shut-off (7). The disadvantages of using UPS include difficulty in repairing electronic parts that are embedded in the printed circuit board. (See schematic diagram above) (8).

For the development of the Back-up System, electronic components are being omitted and replaced by fewer maintenance devices such as contactors and relays. The power back-up system is also adjustable to the power sources including renewable energy.

Motor control devices are used to regulate the operation of an electrical motor in prescribed settings. Motor controls are also known as motor controllers. Some of the functions include automatic start and stop of the operation of the electric motor, forwarding or reversing the course of rotation, regulation of rotor speed, and adjusting the torque setting (9). These devices protect the electrical motor from overloads and faults. Moreover, these devices can be applied to other applications including non-motor loads for purposes indicated as advantages of motor control devices (10).

There are different types of motor control devices (11). These include motor control starters, motor circuit breakers, contactors, mini contactors, thermal overload relays, and time-delay relay. Each of these is different in

function and can be used to functionality control the performance of a motor. In the setup indicated in the project, the researcher will only use a motor circuit breaker, time delay relay, and contactor.

Magnetic control permits the installation of power contact close to the load (12). It also provides safety features, which limit the use of fuse and other delimiting devices. The magnetic control device also has switching controls, which make the system independent in terms of per unit assembly. Each device will make the system safe and take replacement of devices easily. Also, since it is a power back-up system, the magnetic contactor acts as a balancer that homogenizes changes in electrical frequency. Once abnormalities are detected in the electrical supply, the contactor will switch the electrical supply source.

### III. METHODOLOGY

The researchers will follow the simple protocol for prototype designing. A prototype is an early sample, model, or release of a product built to test a concept or process. It is a term used in a variety of contexts, including semantics, design, electronics, and software programming. First, the researchers constructed a material architecture based on the concept of using motor control devices such as contactors, timer relay, and power relay. The researcher also uses simulation software to further develop the schematic diagram.

The researchers developed the prototype, designed accordingly to the analysis result of the simulation. The system was further evaluated with several testing before proceeding with commissioning.

The researcher analyzed the combinational effect of the factors using a factorial design. Instead of conducting a series of independent studies, the researchers were effectively able to combine these studies.

The study included comparative research, to analyze the research problem. Using the parameters of power in watts, samples are treated using a match paired t-test. Comparative research seeks to decipher the relationship between two or more parameters by obtaining observed similarities and differences between two or more subjects or groups (13).

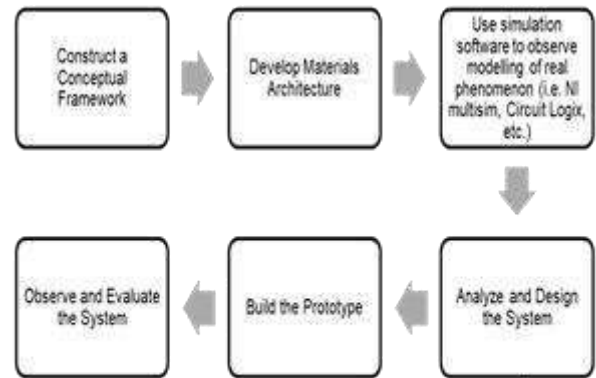


Fig 2. Prototype Model Methodology

### IV. RESULTS AND DISCUSSION

The researcher conducted a statistical analysis in terms of the line voltage supply to the load by the utility mode and the back-up mode.

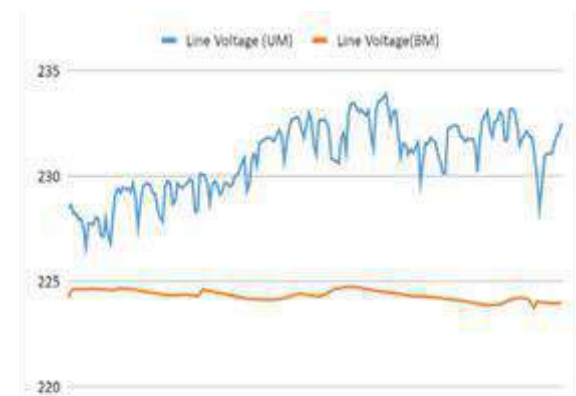


Fig 3. Comparative graph of the line voltage of the System in Utility Model and in Back-up Mode using the datalogger

Figure 3 shows the line voltage input from the system using the utility mode and the back-up mode. As shown, the line voltage of the Back-up system is more stable than the line voltage in Utility mode. But both voltages are within the voltage variation level of +/-10% of the rated voltage (standard based on the Phil Distribution Code and U.S. National Electric Manufacturers Association or NEMA).

From the result using match paired t-test, the data shows that the t-critical two-tailed is lesser than the statistical t-result (1.972<50.77). This shows that there is no significant difference in the data of line voltage for utility mode and back-up mode thus accepting the null hypothesis. In terms of correlation, the data shows that there is a mid-level significance with movement of the utility-mode line voltage versus the back-up mode line voltage (Refer to Table 1).

Table 1. t-Test: Paired Two Sample for Means for Line Voltage

	Utility Mode	Back-up Mode
Mean	230.8411	224.3502
Variance	2.932314362	0.056652221
Observations	200	200
Pearson Correlation	-0.343586871	
Hypothesized Mean Difference	0	
df	199	
t Stat	50.77026603	
P(T<=t) one-tail	3.7404E-116	
t Critical one-tail	1.652546746	
P(T<=t) two-tail	7.4808E-116	
t Critical two-tail	1.971956544	

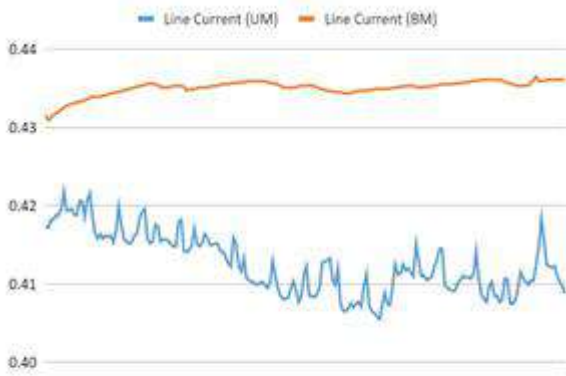


Fig 4. Comparative graph of the line current of the System in Utility Model and in Back-up Mode using the datalogger

The researcher conducted a statistical analysis in terms of the line current supply to the load by the utility mode and the back-up mode. Figure 4 shows the line current of the system using the utility mode and the back-up mode. As shown, the line current supply of the Back-up system is stable, while the line current in Utility mode is fluctuating.

From the result using match paired t-test, the data shows that the tcritical two-tailed is lesser than the statistical t-result (1.972<72.21). This shows that there is no significant difference in the data of line current for utility mode and back-up mode, thus accepting the null hypothesis. In terms of correlation, the data shows that there is a mid-level significance with movement of the utility-mode line current versus the back-up mode line current (Refer to Table 2).

Table 2. t-Test: Paired Two Sample for Means for Line Current

	Utility Mode	Back-up Mode
Mean	0.4125895	0.435033
Variance	1.47231E-05	9.25539E-07
Observations	200	200
Pearson Correlation	-0.497103236	
Hypothesized Mean Difference	0s	
df	199	
t Stat	-72.21329874	
P(T<=t) one-tail	5.1489E-145	
t Critical one-tail	1.652546746	
P(T<=t) two-tail	1.0298E-144	
t Critical two-tail	1.971956544	



Fig 5. Comparative graph of the true power of the System in Utility Model and in Back-up Mode using the datalogger

The researcher conducted a statistical analysis in terms of power in watts between utility mode and the back-up mode to determine the reliability of supply from different modes. Figure 5 shows the true power of the system using the utility mode and the back-up mode. As shown, the true power output of the Back-up system is higher than in Utility mode. This shows that there is higher actual power generated by the equipment to do useful work.

From the result using match paired t-test, the data shows that the tcritical two-tailed is lesser than the statistical t-result (1.972<58.02). This shows that there is no significant difference in the data of power in watts for utility mode and back-up mode thus accepting the null hypothesis. In terms of correlation, the data shows that there is a mid-level significance with movement of the

utility-mode power versus the back-up power. (Refer to Table 3)

*Table 3. t-Test: Paired Two Sample for Means for True Power*

	Utility Mode	Back-up Mode
Mean	47.664	48.362
Variance	0.010355779	0.009001005
Observations	200	200
Pearson Correlation	-0.496336575	
Hypothesized Mean Difference	0	
df	199	
t Stat	-58.02509743	
P(T<=t) one-tail	5.7304E-127	
t Critical one-tail	1.652546746	
P(T<=t) two-tail	1.1461E-126	
t Critical two-tail	1.971956544	



Fig 6. Comparative graph of the power factor of the System in Utility Model and in Back-up Mode using the datalogger

The researcher conducted a statistical analysis in terms of the power factor between utility mode and the back-up mode.

Figure 6 shows the true power of the system using the utility mode and the back-up mode. As shown, the power factor of the system for both back-up and utility mode is almost 0. This shows that the energy flow is entirely reactive and the stored energy in the load returns to the source on each cycle.

From the result using match paired t-test, the data shows that the tcritical two-tailed is lesser than the statistical t-result (1.972<98.36). This shows that there is no significant difference in the data of power factor for

utility mode and back-up mode thus accepting the null hypothesis. In terms of correlation, the data shows that there is a low-level significance with movement of the utility-mode power factor versus the back-up power factor. (Refer to Table 4)

*Table 4. t-Test: Paired Two Sample for Means for Power Factor*

	Utility Mode	Back-up Mode
Mean	-0.004751	-0.0037415
Variance	1.17578E-08	7.16357E-09
Observations	200	200
Pearson Correlation	-0.116791237	
Hypothesized Mean Difference	0	
df	199	
t Stat	-98.36482245	
P(T<=t) one-tail	5.4492E-171	
t Critical one-tail	1.652546746	
P(T<=t) two-tail	1.0898E-170	
t Critical two-tail	1.971956544	

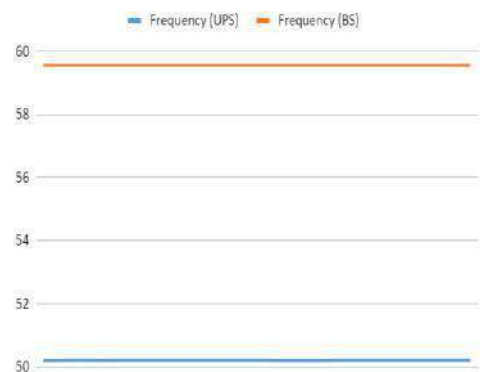


Fig 7. Comparative graph of the frequency output of the back-up system vs the commercially- available Uninterruptible Power Supply (UPS)

The researcher conducted a comparative study of electrical performance between the developed power back-up system technology versus the commercially available UPS in terms of frequency. Figure 7 shows the comparative study of the frequency output of the back-up system vs the commercially- available Uninterruptible Power Supply (UPS). The frequency operating in the Philippines shall be 60 Hz, with the allowable variation of 59.7 to 60.3 Hz. The graph shows that the back-up system

is within the allowable variation whereas the commercially available UPS is only at about 50Hz.

From the result using match paired t-test, the data shows that the tcritical two-tailed is lesser than the statistical t-result ( $2.05 < 19346.81$ ). This shows that there is no significant difference in the data thus accepting the null hypothesis. This shows that the performance of the developed power back-up system is comparable with the commercially available UPS in terms of frequency. (Refer to Table 5)

Table 5. t-Test: Paired Two Sample for Means for Frequency

	Uninterrupted Power Supply	Back-up System
Mean	50.19286667	59.549
Variance	7.01609E-06	2.08912E-28
Observations	30	30
Pearson Correlation	0	
Hypothesized Mean Difference	0	
df	29	
t Stat	-19346.81119	
P(T<=t) one-tail	5.742E-105	
t Critical one-tail	1.699127027	
P(T<=t) two-tail	1.1484E-104	
t Critical two-tail	2.045229642	

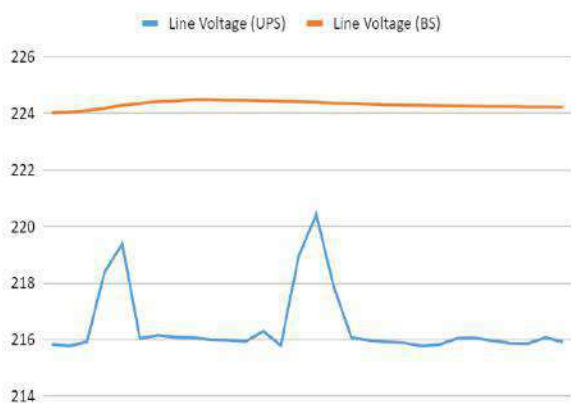


Fig 8. Comparative graphs of the line voltage of the back-up system vs the commercially- available Uninterruptible Power Supply (UPS)

The researcher conducted a comparative study of electrical performance between the developed power back-

up system technology versus the commercially available UPS in terms of line voltage. Figure 8 shows the comparative study of the line voltage output of the back-up system vs the commercially- available Uninterruptible Power Supply (UPS). As shown, the line voltage of the developed back-up system is more stable than the line voltage of the UPS. But both voltages are within the voltage variation level of +/-10% of the rated voltage (standard based on the Phil Distribution Code and U.S. National Electric Manufacturers Association or NEMA).

From the result using match paired t-test, the data shows that the tcritical two-tailed is lesser than the statistical t-result ( $2.05 < 35.63$ ). This shows that there is no significant difference in the data thus accepting the null hypothesis. This shows that the performance of the developed power back-up system is comparable with the commercially available UPS in terms of line voltage. (Refer to Table 6)

Table 6. t-Test: Paired Two Sample for Means For Line Voltage

	Uninterrupted Power Supply	Back-up System
Mean	216.475	224.3096667
Variance	1.471743103	0.01561023
Observations	30	30
Pearson Correlation	0.12183761	
Hypothesized Mean Difference	0	
df	29	
t Stat	-35.6315269	
P(T<=t) one-tail	8.50947E-26	
t Critical one-tail	1.699127027	
P(T<=t) two-tail	1.70189E-25	
t Critical two-tail	2.045229642	

Table 7. t-Test: Paired Two Sample for Means For Line Current

	Uninterrupted Power Supply	Back-up System
Mean	0.53424	0.435076667
Variance	5.75459E-05	1.34954E-07
Observations	30	30
Pearson Correlation	0.076321367	

Hypothesized Mean Difference	0
df	29
t Stat	71.77994425
P(T<=t) one-tail	1.63096E-34
t Critical one-tail	1.699127027
P(T<=t) two-tail	3.26192E-34
t Critical two-tail	2.045229642

Observations	30	30
Pearson Correlation	-0.062163256	
Hypothesized Mean Difference	0	
df	29	
t Stat	105.639555	
P(T<=t) one-tail	2.31181E-39	
t Critical one-tail	1.699127027	
P(T<=t) two-tail	4.62363E-39	
t Critical two-tail	2.045229642	

The researcher conducted a comparative study of electrical performance between the developed power back-up system technology versus the commercially available UPS in terms of line current. Figure 9 shows the comparative study of the line current output of the back-up system vs the commercially- available Uninterruptible Power Supply (UPS). As shown, the line current of the developed back-up system is more stable than the line current of the UPS.

From the result using match paired t-test, the data shows that the tcritical two-tailed is lesser than the statistical t-result (2.05<71.77). This shows that there is no significant difference in the data thus accepting the null hypothesis. This shows that the performance of the developed power back-up system is comparable with the commercially available UPS in terms of line current. (Refer to Table 7)

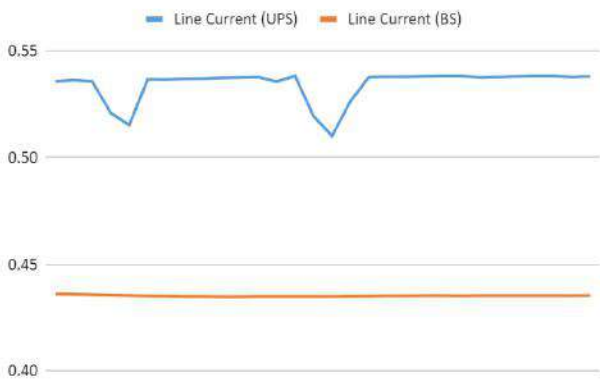


Fig 9. Comparative graphs of the line current of the back-up system vs the commercially- available Uninterruptible Power Supply (UPS)

Table 8. t-Test: Paired Two Sample for Means for True Power

	Uninterrupted Power Supply	Back-up System
Mean	59.72666667	48.28
Variance	0.335126437	0.009931034

Figure 10 shows the comparative study of the true power of the back-up system vs the commercially- available Uninterruptible Power Supply (UPS). As shown, the true power output of the developed back-up system is lower than the UPS. To verify the significance of the difference. A paired two-sample t-test was conducted by the researchers. The researcher conducted a comparative study of electrical performance between the developed power back-up system technology versus the commercially available UPS in terms of line true power.

From the result using match paired t-test, the data shows that the tcritical two-tailed is lesser than the statistical t-result (2.05<105.64). This shows that there is no significant difference in the data thus accepting the null hypothesis. This shows that the performance of the developed power back-up system is comparable with the commercially available UPS in terms of power (watts). (Refer to Table 8)

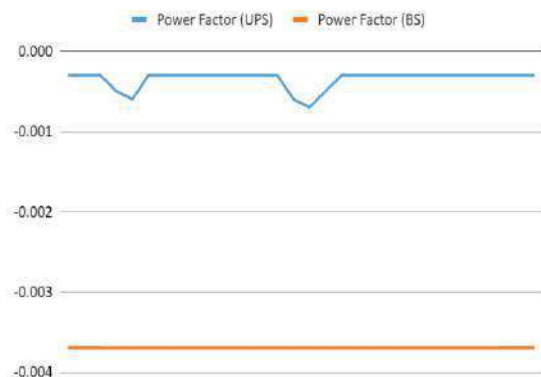


Fig 11. Comparative graph of the power factor of the back-up system vs. the commercially- available Uninterruptible Power Supply (UPS)

The researcher conducted a comparative study of electrical performance between the developed power back-up system technology versus the commercially available UPS in terms of line power factor. Figure 11 shows the

Table 9. t-Test: Paired Two Sample for Means for Power Factor

	Uninterrupted Power Supply	Back-up System
Mean	-0.000346667	-0.0037
Variance	1.22299E-08	1.75108E-36
Observations	30	30
Pearson Correlation	2.21589E-16	
Hypothesized Mean Difference	0	
df	29	
t Stat	166.0833766	
P(T<=t) one-tail	4.73017E-45	
t Critical one-tail	1.699127027	
P(T<=t) two-tail	9.46033E-45	
t Critical two-tail	2.045229642	

comparative study of the power factor of the back-up system vs the commercially- available Uninterruptible Power Supply (UPS). As shown, the power factor of the developed back-up system is lower than the UPS. To verify the significance of the difference. A paired two-sample t-test was conducted by the researchers.

From the result using match paired t-test, the data shows that the tcritical two-tailed is lesser than the statistical t-result (2.05<166.08). This shows that there is no significant difference in the data thus accepting the null hypothesis. This shows that the performance of the developed power back-up system is comparable with the commercially available UPS in terms of power factor. (Refer to Table 9)

### V. CONCLUSION

The power back-up system replaces commercially available UPS to address issues that are for the advantage of the developed backed-up system. Inclusions that are part of the objectives are: simplicity yet sturdy design, easy operation, and maintenance, use of locally-available materials for fabrication.

Solution for the need of a continuous source of energy without interruption for large equipment. For comparative study in terms of scalability, input voltage, output voltage, input current, and output current tend to have no significant difference between utility mode and back-up mode. This shows that the performance of the delivered electrical parameter using two different supplies has no variations when using the power back-up system. There is

also evidence that the parameters indicated in the experimental design are highly significant and tend to affect the performance of the power back-up system. The researchers also indicated the importance of the performance of the parameters for both utility mode and back-up mode for the technology. The effect of the voltage, current, power, and power factor are compared using a comparative study. The data portray evidence that there is no significant difference in the performance in terms of the electrical parameters supply in the load for the power back-up system. Therefore, it is concluded that the power back-up system is highly adaptable and can be a substitute technology for commercially available uninterruptible power supply and can be a technology that will provide a back-up system for large equipment.

### ACKNOWLEDGEMENTS

The authors gratefully acknowledge the financial support received from the General Appropriation Act, Govt. of Philippines, in the form of R&D project grants

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# The integrated administrative development region of polo Petrolina/PE - Juazeiro/BA and its creative cities

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Received: 11 Jul 2022,

Received in revised form: 06 Aug 2022,

Accepted: 12 Aug 2022,

Available online: 19 Aug 2022

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**Keywords**— Ride, Creative Economy,  
Development..

**Abstract** — The creative city is one of the ways found by UNESCO to highlight new ways for cities to carry out their economic processes, related or applied in the routines of the regions. The objective of this study was to identify the characteristics that make the Integrated Region of Economic Development (RIDE) of the Petrolina Pole (PE) - Juazeiro (BA) a potential candidate for a vacancy in the select group of the Creative Cities Network - RCC of the United Nations Educational, Scientific and Cultural Organization (UNESCO). In addition, it was intended to point out the benefits of the insertion of the region in this network, which, among other objectives, seeks cooperation between cities, cultural, tourist, creative, economic development, and the reduction of social inequalities, through the Creative Economy. Thus, it is a qualitative, exploratory, descriptive, and bibliographical research, where for its development was used the systematic literature review (RSL) in order to meet relevant criteria. The main findings indicate that the RIDE region of Petrolina has characteristics and elements such as transport infrastructure and socio-environmental and cultural potential that can make it a hub of creative economic development.

## I. INTRODUCTION

The world is going through major transformations caused by the advancement of technologies, where social inequalities grow, and jobs are reduced with the frequent replacement of man by machines. These changes have increased the need for reinvention of societies and ways to promote a sustainable world.

Brazil, despite being considered by many experts the first place in the world ranking of countries with greater natural beauty, is placed in a median position regarding the amount of foreign tourists, according to the World Economic Forum, position (RESENDE, 2019).

In this regard, registration is open annually for the Creative Cities Network (RCC) of the United Nations

Educational, Scientific and Cultural Organization (UNESCO). "The promotion of cooperative actions at the international level is one of the objectives of the CCR", in order to establish joint policies in which "The cities involved can interact in favor of creative investments aimed at urban development and sustainability, social inclusion and cultural dissemination" (MIRSHAWAKA, 2017, p.94).

Among the main benefits of the participation of cities in the program, we can mention the promotion of tourism, the strengthening of cultural activities, the protection of public goods, urban equipment, historical heritage, and the stimulus to the Creative Economy, conceptualized by Howkins (2013) as one of the measurements regarding the use of intellectual activities within the economic

environment. Also, according to Soete (2018), this economic methodology promotes a new observation of the market regarding the process of using resources in addition to those measured by products.

The Creative Economy in Brazil is not defined or measured consistently. The increased strategic awareness of the Creative Economy resulted in a plethora of approaches, notably in 2011, with the creation of the Creative Economy Secretariat (SEC), subordinate to the Ministry of Culture, that led to the development of the Creative Economy Secretary's Plan for the period 2011-2014. Within the federal government, the document was classified as an inter-ministerial plan, articulating various institutional partners, development agencies, bilateral and multilateral agencies (HOWKINS, 2013).

The RIDE of the Petrolina - Juazeiro polo is composed, in addition to the two cities, by Casa Nova, Curaçá and Sobradinho, in the state of Bahia; Lagoa Grande, Orocó and Santa Maria da Boa Vista, in the state of Pernambuco. It was established by Complementary Law 113/2001 and regulated by Decree 4,366/2002, with the aim of articulating and harmonizing the Union's administrative actions, States and municipalities to promote projects aimed at economic dynamization and provision of infrastructure necessary for development, on a regional scale (BRAZIL, 2015).

With a strategic location, RIDE serves as a link between different regions of the country and has a total area of 33,442 km<sup>2</sup> (BRAZIL, 2015). It is important to note that by law, only these cities are part of the RIDE, but in practice, about 50 cities, within a radius of 300 kilometers of the conurbated area of Petrolina-PE and Juazeiro (BA), depend on the region and vice versa.

Regarding the Integrated and Sustainable Action Plan of RIDE Petrolina - Juazeiro, prepared by the Ministry of National Integration, in 2010, the law of creation "privileges investment in resources for projects with emphasis on irrigation, water resources, tourism, agrarian reform, the environment, transportation systems, the rest related to basic infrastructure and job creation" (BRASIL, 2010, p. 27).

In order to enable economic development from the diversification of the systematic structure of organizations participate and share such objectives, RIDE promotes actions aimed at such scopes as a way to, together with the Federal Government, and the São Francisco and Parnaíba Valleys Development Company - CODEVASF, promote an internal performance capable of stimulating creative cities and coastal capitals. In this sense, "such advances represent a nature that promotes the development of these cities, based on the assumption that they must act to

strengthen these municipalities" (BRAZIL, 2010, p.40).

Regulated by Complementary Law 113/2001, in addition to Decree 4,366/2002, the Petrolina Polo RIDE includes eight municipalities that, through these laws, have their administrative activities maintained in articulation between the federative entities. In this context, there is a joint action between the municipal, state, and federal spheres, so that it can promote the development of infrastructure and economic-cultural diversification directed to the evolution of the respective regional projects (BRAZIL, 2015).

According to the Brazilian Institute of Geography and Statistics (IBGE), the population of RIDE, in 2010, was 686,410 inhabitants, spread across its eight municipalities (BRAZIL, 2010), this population, which has increased, being estimated at 779,351 inhabitants in 2017 (BRAZIL, 2018).

Considered a prosperous and innovative region, RIDE still finds it difficult to solve the problems that involve the common interests of the federative entities that make up, among them, the public transport system, public security, conservation of public goods, the protection of historical and cultural heritage and the promotion of the Creative Economy.

Thus, being the area object of this study, there is a great natural and cultural potential, which is little used by managers and the population of cities belonging to RIDE. Thus, we seek to problematize what the region has of attractions able to put it in a position to participate in the Creative Cities Network of UNESCO and what benefits can be enjoyed by the populations of cities in case of insertion.

Given this contextualization, this work aimed to demonstrate to managers and society in general of the cities belonging to the Integrated Administrative Region of Development (RIDE) of the Petrolina (PE) - Juazeiro (BA) the relevance of the application, as an Integrated Development Region, to the UNESCO Creative Cities Network. The objectives of the work are directly linked to the promotion of economic, social, and environmental sustainability and aligned with the Sustainable Development Goals (SDGs) of the United Nations.

Thus, it was intended with the study to list the natural, historical, and cultural characteristics of RIDE Petrolina - Juazeiro, able to present the benefits that the insertion of the region in the Creative Cities Network of UNESCO can bring to the population of cities belonging to RIDE.

Therefore, the results found in the research point out that one of the main ways to reduce social inequalities in

Brazil, reduce unemployment and promote sustainable development, is directly linked to the use of what the country has best, its people and its natural beauty, through tourism. Thus, the insertion of RIDE Petrolina - Juazeiro in the UNESCO Creative Cities Network represents a major advance in the constant search for regional development.

## II. THEORETICAL FRAMEWORK

One of the main aspects that underpinned the study consists of a presentation of the main characteristics of the

economy in creative cities, promoting an evaluation of how economic directly, in the process of understanding a city as creative. The creative city is one of the ways found by UNESCO to highlight new ways for cities to carry out their economic processes, related or applied in the routines of the regions. Understanding that in locations where economic activities are promoted without the productive or industrial nature, through the intellectual actions of individuals are understood as a different form of economy. In Table 1, we describe some general information of the municipalities in the region of our object of study for the contextualization of this area as a possible creative region:

Table 1: General information of the municipalities belonging to RIDE Petrolina - Juazeiro

TOWNSHIP	KM² AREA (2016)	POPULATION (2010)	ESTIMATED POPULATION (2017)	GDP R\$ (2015) GDP X 1000	GDP PER CAPTA R\$ (2015)
Casa Nova (BA, Brazil)	9.647	64.940	73.382	541.675	7.505
Curaçá (BA)	5.935	32.168	35.524	258.510	7.342
Juazeiro (BA)	6.721	197.965	221.773	3.131.076	14.241
Lagoa Grande (PE)	1.850	22.760	25.294	254.805	10.292
Orocó (PE)	554	13.180	14.794	154.974	10.728
Petrolina (PE)	4.561	293.962	343.219	5.533.900	16.670
Santa Maria da Boa Vista (PE)	3.000	39.435	41.652	471.365	11.415
Sobradinho (BA) Language	1.154	22.000	23.713	362.188	15.358
<b>TOTAL</b>	<b>33.442</b>	<b>686.410</b>	<b>779.351</b>	<b>10.708.493</b>	<b>11.693*</b>

Source: Brazil (2010, 2015, 2018, online). \*Average.

A city can be understood as a set of social relations. Different societies and diverse groups within them tend to have very different social networks, so understanding that diversity is important. In many so-called favela removal projects, it is often assumed that better quality physical conditions in new public buildings or apartments would lead to improvements in social conditions, while the importance of social networks has been ignored (MEHEDFF, 2012). Thus, preserving social networks later became much more important for some residents than physically improved housing in less accessible places with less space for social relationships.

One of the theoretical contributions used as a basis for this research will be the book by Mirshawaka (2017), entitled Creative Cities. In it the author presents the results of a series of studies focused on creative cities in the world context, bringing, from a literature review on concepts,

applicability and elements of cities considered creative, to studies focused on the transformations that hundreds of world cities had to win their titles of Creative Cities.

In addition to the work of Mirshawaka (2017), scientific articles from the systematic literature review were used in the research, secondary data such as news published in the regional media, consultation of sites specialized in tourism, documents made available on the Internet, data, photographs, and documents collected during field data collection activities.

According to Lerner (2011), the creative city must know how to detect its problems in any order, study them, evaluate them and carry out the corresponding actions, and these, in turn, must be creative. All creativity presupposes a change that will respond to a project, and this is inscribed in a context. There is another way in which cities are defined and known as creative: to exploit their existing

resources or put their potential at stake. A city must not fail to value its history, its traditions, but must activate them in degrees of perfection and historical memory and, at the same time, through innovation, update its meaning, anticipate the future making memory of it.

In the view of Reis and Kageyama (2011), the so-called creative city is one that takes advantage of all aspects of society (culture, economy, innovation, opportunity) to promote profitable activities or a return to the point of social equilibrium. The author considers that it is one of the current ways to observe new opportunities within the business field, being an improvement in the process of products or services according to the intellectual aspect.

Among the main Creative Cities in the world, which are part of the RCC of UNESCO, one can mention: Fortaleza, Belém, Salvador, João Pessoa, Florianópolis, Curitiba, Brasília, Paraty, Santos and Belo Horizonte. All are Brazilian cities that due to the economy or business routine applied have become fundamental for the managerial or organizational forms of these cities are considered creative.

Creative cities benefit from their historical importance as a focal point, geographical and economic. According to the author, a creative city should be focused on establishing a process that ensures demographic integration and the stimulation of people and companies that care about issues such as cultural values, community, attention, justice, innovation, gender, racial and religious equity, thus generating a value-based economy (REIS, 2011).

In the conception of Florida (2012) the idea of the Creative City is the politics of the day, on everyone's menu, and launches some questions: What is there not to like? Who would like to be a 'creative city'? What if we can be the most outstanding creative city among so many others? In a world where many cities have suffered from deindustrialization or mass immigration, there has been a disbelief in the traditional economic bases to deliver on the promised; the desire of the majority is to attract the dwindling stock of mobile foreign direct investment and thus generate new jobs.

Creative cities in the modern world are typically organized around production systems marked by shifting interfirm networks and flexible labor markets of the types described above. These structures provide a foundation, essential for high levels of information generation and exchange and for frequent experimentation by individual companies in relation to industrial processes and products (REIS, 2017). The very fluidity of the economies of cities like these means that the companies

and workers that make them up are constantly in touch with each other in ways that help unleash diverse innovative energies.

One of the aspects most observed in the development process of a creative city consists in the cultural process, since these impact on the economic process of the region. For Silva (2012b), culture is one of the main contributors of creative economies, as promoting events within the cultural scope, a city can obtain financial stability or even evolve economically.

One of the main ways to evaluate culture as an economic instrument can be exemplified by the carnival of Rio de Janeiro, where much of the economic progress occurs along with the development of programs or carnival programs. Matos (2017), points out that the creative economy in the case of regions where cultural traits are expressive has been growing, promoting an opportunity for financial stability in many places.

Still addressing the creative economic aspects, it can be seen that gastronomy also enters as a way to promote a turnover of consumption linked to local culture, giving the cities an economic base considered stable (SANTOS; PINTO; THE WARRIOR, 2016). Gastronomy is an important cultural manifestation, in which cuisine is a symbol of culture, memory and the identity of a people, both that has been recognized as cultural heritage, which directly contributes to the process of valuing cultural tourism, as it offers unique experiences to tourists and collaborates in the permanence of regional cuisines (PIRES; QUEIROZ; RODRIGUES, 2013).

Reis (2008) also understands that gastronomy is beyond the kitchen, defined by him as an improvement in food, which went through the stage of cooking and reached a level of specialization never seen before. Food, an action of culture on food, would gain distance from nature as this transformation acquires greater complexity. The gastronomic practice expresses everyday life: labor, health, political moment, ideological conflicts, inflation, penury, bonanza, cultural heritage, and customs. Many people start to self-define themselves as vegetarians, carnivores, macrobiotics, among others.

Given the information presented can be verified that in the gastronomic market some processes are fundamental and must be properly observed by managers, as is the case of the menu and the particularities of the places where the enterprises will be established (RICHARDS, 2010).

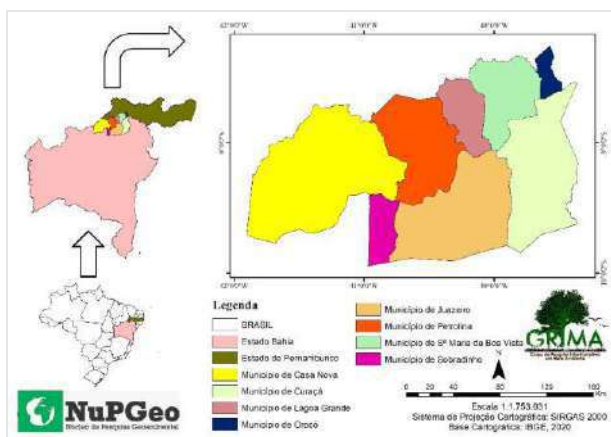
Thus, like the other activities performed, cooking requires certain care and certain practices in order to minimize, mainly, the commitment of the food or products used in the preparation of the dishes. There are many cases of people who have contracted diseases after eating

contaminated or poorly maintained food. It is worth mentioning that, according to the points presented by Vieira (2013) the economic conditions and procedures brought by the cities present all conditions or requests to be included in the identification process as creative cities.

### III. METHODOLOGY

#### Geographic Location

The RIDE of the Petrolina - Juazeiro polo is composed, in addition to the two cities, by Casa Nova, Curaçá and Sobradinho, in the state of Bahia; Lagoa Grande, Orocó and Santa Maria da Boa Vista, in the state of Pernambuco. It was established by Complementary Law 113/2001 and regulated by Decree 4,366/2002, with the aim of articulating and harmonizing the Union's administrative actions, States, and municipalities to promote projects aimed at economic dynamization and provision of infrastructure necessary for development, on a regional scale (BRAZIL, 2015).



Map 1: Cities that make up the RIDE

Source: Research Data (2022)

Regarding the objectives, this study can be considered descriptive, in the case of concepts rescued on the theme of Creative Cities and Creative Economy; is also informative, while one of its objectives is to inform managers and the population belonging to the RIDE Petrolina - Juazeiro the possibilities and benefits of the region participate in the Creative Cities Network of UNESCO and can be considered as qualitative.

The first step in the construction of the study was to conduct a bibliographic survey on the UNESCO Creative Cities Network and the characteristics that give cities this status.

After the stage of concepts and norms, other secondary research was carried out on websites and newspapers about participation in the Network and examples of cities that had great transformations in their social context through creativity.

The third step was to conduct a Systematic Literature Review (RSL) on the subject, addressing scientific articles published between 2015 and 2020, focusing on Brazilian Creative Cities, in order to fulfill the proposed objectives for the study.

As for the articles of the Systematic Literature Review (RSL), Van Wee and Nanister (2015) apud Loureiro et al. (2016) highlight that "they are useful for both researchers and readers for providing an overview, updated and structured of a specific area of knowledge". For RSL, SciELO platform and Google Scholar were used.

In the databases we followed the following steps, first, was accessed the research area of the platform, where the keywords "Creative City" were used in the field "with all words", in quotation marks, was marked the field "anywhere in the article" and the fields "include patents" and "include citations" were cleared, totaling a number of 1,640 works.

As exclusion criteria were used publications prior to 2015 and published in a language other than Portuguese, resulting in a new number of 891 works. The next step was the marking of the field "in the title of the article", in order to accurately research the actions directed directly to the theme, resulting in 46 works.

The next step was to read the titles and abstracts of the works selected so far, excluding the different materials of scientific articles, which were not linked to the experiences of Brazilian cities with the UNESCO Creative Cities Network, resulting in 5 articles.

Table 2: Criteria used in the Systematic Literature Review

ORDER	EXCLUSION CRITERIA	NUMBER OF SELECTED PAPERS
1°	The advanced search area of the platform was accessed, where the keywords “Creative City” were used in the field “with all the words”, between quotation marks, the field “anywhere in the article” was marked and the fields “include patents” and “include citations”.	1.640
2°	Excluded publications prior to 2015 and published in languages other than Portuguese (because the research focuses on the applicability of genuinely Brazilian experiences).	891
3°	Marking of the field "in the title of the article", in order to search with accuracy, the actions directed directly to the theme.	46
4°	Reading the titles and abstracts of the works selected so far, excluding the different materials of scientific articles and that were not properly linked to the experiences of Brazilian cities with the UNESCO Creative Cities Network.	5

Source: Research data (2021).

The Systematic Literature Review (RSL) aimed to bring an up-to-date character to the study, including contributions from recent publications (from the last 5 years) and that were in accordance with the objectives of this study. Table 1 shows the list of papers, organized by year, title, authors, type, source and Qualis CAPES:

Chart 1: List of articles used in the Systematic Literature Review

TITLE	AUTHORS	YEAR	SORT	FOUNTAIN	QUALIS
History of the city of Juazeiro da Bahia	COSTA, Rosy	2015	Article	SciELO	i
In the San Francisco Valley, Census Agro collects data of fruits that win the world.	LIMA, Alana	2017	Monograph	SciELO	i
<b>Creative cities:</b> talents, technology, treasures, tolerance. Vol. 1.	MIRSHAWAK, Victor	2017	Book		

Source: Research data (2021)

The data analysis was performed in a qualitative way contextualizing the results found with the objectives of the study, always considering the regional aspects that served to guide researchers on the practical applications of the study in the RIDE of the Petrolina - Juazeiro pole.

According to Closs and Oliveira (2014), regional issues are the main impactors when dealing with economy and creative city, giving an even greater success to the work or enterprise developed in the intellectual field. Therefore, we highlight which instruments or business processes are highlighted, within the vision of UNESCO, as relevant methodologies for creative cities.

**IV. RESULTS AND DISCUSSIONS**

**THE CREATIVE POTENTIAL OF RIDE PETROLINA CITIES - JUAZEIRO**

**Irrigated fruit growing**

The Region is a pole of technological development of irrigated fruit growing, becoming the largest exporter of fruit in the country (BRAZIL, 2015, online). The planting and harvesting of fruits are carried out, for the most part, in the various Irrigation Projects (IP) spread throughout the territory of the municipalities belonging to RIDE, demonstrating a great financial and social importance of rural areas. According to CODEVASF data:

In economic terms, in 2016, the most significant results of the Gross Value of Production were the IP Senador Nilo Coelho

(R\$ 1.39 billion), Curaçá (R\$ 135 million), Maniçoba (R\$ 116 million), Tourão (R\$ 101 million), Bebedouro (R\$ 44 million) and Mandacaru (R\$ 9 million). It is estimated that these irrigation projects currently generate around 81,000 indirect jobs and 54,000 direct jobs, totaling 135,000 jobs in 2016 (LIMA, 2017, s.p. online).

The generation of jobs provided by irrigated fruit farming fixes residents in the region and attracts outsiders in search of job opportunities. It is estimated that, only in the Irrigation Projects of the region, more than 130 thousand direct and indirect jobs are generated. Still according to estimates of the year 2010, more than 20 thousand jobs are generated by fruit growing irrigated outside the PIS (BRAZIL, 2010).

In addition to the generation of jobs and the development caused by irrigated fruit growing, the local population can benefit from the quality of fruits produced and sold at fair prices at fairs and supermarkets in the region, raising the quality of life of the RIDE population.

#### **The wine growing pole**

Recently, RIDE Petrolina - Juazeiro became the second winegrowing pole in Brazil, with annual production of 7 million liters of wine or 15% of national production. Of this percentage, 30% are fine wines, awarded nationally and internationally, produced in the eight wineries installed in the municipalities of Lagoa Grande-PE, Santa Maria da Boa Vista-PE, and Casa Nova-BA (BRAZIL, 2015, online).

It is important to highlight that none of the wineries installed in the region operate in the cities of Petrolina-PE or Juazeiro-BA, reinforcing the idea that all cities belonging to RIDE are of great importance for regional development. It is also added that, in addition to the wines and sparkling wines produced and sold for the domestic and foreign markets, these cities increase the economy of RIDE with trade, tourism and related products.

#### **The transport infrastructure**

RIDE has the infrastructure of the Petrolina International Airport, the São Francisco River Waterway, with Sobradinho Lake (one of the largest artificial lakes in the world) and has a road connection with the main capitals of the Northeast (BRAZIL, 2015). Being cut by the BRs 122, 235 and 407, which also give access to other important highways in the country, the region concentrates great movement of vehicles on the bridge President Eurico Gaspar Dutra, which connects the cities of Petrolina-PE and Juazeiro-BA, reaching a daily traffic of 38 thousand vehicles (BRAZIL, 2010).

The Senador Nilo Coelho Airport was created in 1941 and its works ended in 2004 (BRAZIL, 2010, p. 95). In addition to representing another major axis of development through the rapid displacement of passengers, it passes through it much of the region's fruit production, exported to Africa, Asia, Europe, and North America. According to Neves (2016, online) the airport has the second largest runway in the Northeast region, with 3,250 meters long and capacity to receive large cargo aircraft, such as the Boeing 747-400, which can transport more than 100 tons at once, with autonomy for 13 hours of flight.

#### **The medical-hospital pole**

The health area also deserves special mention in RIDE Petrolina - Juazeiro, as it attracts thousands of patients from various cities in the region daily, in search of public and private health networks. In addition to generating thousands of jobs, it captures investments and contributes to improving the quality of life of the population.

According to the Brazilian Hospital Services Company (EBSERH) (2018, online), the Petrolina University Hospital is the largest hospital unit of RIDE and serves as a reference for an approximate population of 2,068,000 inhabitants spread over 53 municipalities in the states of Pernambuco and Bahia. Together with the HU Polyclinic, they are part of the Unified Health System (SUS) and are fields of study for health courses coming not only from the Federal University of Vale do São Francisco, but also from other higher education institutions and technical health schools in the region.

According to the Integrated Action Plan of RIDE Petrolina Juazeiro (BRAZIL, 2010, 108), in 2007, the region already had 25 hospital units and 1,160 hospital beds, with about 86% of these beds located in the cities of Petrolina-PE and Juazeiro-BA.

#### **The educational pole**

Education is one of the main axes of RIDE development and attracts students from different regions of the country. The region stands out for the amount of vacancies offered in public and private institutions of high school, technical, higher education and the quality of courses attested by the Ministry of Education (MEC). Meeting the demands of public transport for all this student public demands a harmony between the government, operators, and users of the public transport system.

Among the main universities located at RIDE, the following stand out: the Federal University of the São Francisco Valley (UNIVASF), the Faculty of Applied Sciences of Petrolina (FACAPE) and the campus of the University of Pernambuco (UPE) and Bahia State



University (UNEB) based in Petrolina and Juazeiro, respectively. The Federal Institutes of Science and Technology (ifs) are also present in the region offering high school, technical, short-term vocational, undergraduate, and graduate, lato and stricto sensu, as well as numerous private colleges.

The region also has a wide range of technical and vocational courses. The "S" System, defined as "the set of organizations of corporate entities focused on professional training, social assistance, consulting, research and technical assistance, formed by an entity that, in addition to having its name started with the letter S, have common roots and similar organizational characteristics" (BRAZIL, 2018, s.p., online), trains professionals for the labor market. Institutions such as the Brazilian Service of Support to Micro and Small Enterprises (Sebrae), the National Service of Industrial Learning (Senai), the Social Service of Commerce (Sesc), the Social Service of Industry (Sesi), the National Service of Trade Learning (Senac) and the Social Service of Transport (Sest), offer, in addition to vocational courses, health services, education, sport and culture to the community in general.

### **The cultural and heritage wealth**

Throughout the year, there are important cultural events in all cities of RIDE, ranging from religious events to popular festivals, especially the feast of Our Lady of the Grotto and Carnival in Juazeiro-BA; the feast of Saint John in Petrolina-PE; the Grape Festival in Lagoa Grande-PE; the Festival of the Cowboys and the pilgrimage to the Cave of Patamuté, in Curaçá-BA; the Serenade of Saudade in Santa Maria da Boa Vista-PE; the Orocó-PE Cultural Festival; the Forró do Vaqueiro, in Sobradinho-BA; and, the Interior Party, in Casa Nova-BA. Such celebrations, in addition to moving the local economy, help to publicize the cities and maintain a regional identity.

The Juazeiro Carnival was made official in 1914 (COSTA, 2015), with great artistic presentations, street blocks and electric trios, represents part of the Bahian culture in the form of a party. The São João de Petrolina-PE, held every June, also receives attractions at the national level and usually drags crowds to the courtyard of events Ana das Carrancas. The Vaqueiros Festival of Curaçá-BA involves religiosity, party, and regionalism, providing a true immersion in the northeastern culture.

The region is also full of material cultural heritage. Churches, museums, theaters, event centers, sculptures and statues help beautify cities and attract tourists. The Raul Coelho theater, in the city of Curaçá (BA), founded in the nineteenth century, in full activity to the present day, is a symbol of local history (CARVALHO, 2011, online).

### **More vocations to the Creative Economy (EC)**

The Creative Economy has become a great alternative for cities to develop using their natural wealth and human talents. In all RIDE cities, we can identify the exploration potential of the Creative Economy, but unfortunately in many of them, managers and population have not yet specialized to take advantage of its full potential.

Mirshawaka (2017) details the characteristics that can make a city be considered creative, and all of them covered by the Law of creation of RIDE Petrolina - Juazeiro have the potential to give this status to the region. Among them, we can mention: tourism, the potential for generating energy produced from renewable sources, corporate events held in the region, food engineering, among others.

Tours of wineries and grape vineyards, the various river islands along the São Francisco River, the dunes of Casa Nova-BA, the various archaeological and historical sites, the farm hotel located in Curaçá-BA or even the (fruition) the sunset in the 800 meters of the boat crossing between the cities of Petrolina-PE and Juazeiro-BA, make tourists fall in love and spend the region.

Lake Sobradinho is another important vector of regional development. With more than 300 km long by 20 km wide, provides a wide variety of economic activities ranging from passenger transportation to electricity generation (BRAZIL, 2010, online). Thanks to him, the region has become a major producer of energy generated through renewable sources. According to the São Francisco Hydroelectric Company - (CHESF, 2016, online), the Sobradinho Hydroelectric Plant, operating since 1979, has installed power of 1,050,300 kW and is responsible for about 7% of the supply in the Northeast region.

Recently, the lake has received great investment for the installation, in a pioneering way, of the Floating Photovoltaic Plant of the Sobradinho Reservoir. According to CHESF (2018, online), in the first phase of implementation 7,300 solar panel modules were installed, at a cost of 13 million reais, providing an installed capacity of 1 MW peak (MWp).

These characteristics may well include the cities belonging to RIDE in the Network of Creative Cities - RCC of the United Nations Educational, Scientific and Cultural Organization (UNESCO) inclusion that depends on the political will of managers and some adjustments of legislation and structures.

It is worth considering that these are just some of the attractions of the cities of the RIDE Petrolina - Juazeiro pole. The commerce, the nightlife, the relative tranquility of the cities and the hospitality of its people, also usually attract many visitors and new residents to the region.

## THE BENEFITS OF THE INCLUSION OF RIDE IN THE UNESCO RCC NETWORK

Considering all the characteristics of RIDE listed in the previous subsection, there is a great potential for framing the region in the UNESCO Creative City Network.

Among other benefits, inclusion in the Network could: a) promote tourism and consequently increase the number of jobs; b) encourage information sharing and cooperation between cities belonging to RIDE; c) ensure that public managers and the public give more value to public goods and urban facilities; d) encourage the protection of natural assets; e) bring investments to the region; f) to disseminate and enrich regional culture through exchanges with other cities and other countries; g) strengthening regional ties; and, h) increase the capacity of incentives to the Creative Economy.

Therefore, we consider that the development of coordinated actions between the cities belonging to RIDE and the promotion of public policies in the region can be fundamental for the consolidation of the region as a creative area, due to the various characteristics that have already been listed previously.

## V. CONCLUSION

With this study we were able to obtain an initial understanding of our object of study, as well as have a deeper insight into the research problem chosen in this work. We can verify that RIDE has attractions that were listed and contextualized according to the vocations necessary for the insertion of cities in the Creative Cities Network of UNESCO.

The results of the work may serve as a basis for the development of several studies focused on the Creative Economy and sustainable development in the RIDE region, as well as to raise awareness of its role as fiscal and responsible for this transformation, since RIDE presents characteristics of the economy in creative cities.

Among the obstacles to creativity and sustainability, we can mention the political and power disputes between authorities belonging to the various federal entities that make up the RIDE, it is essential to have an educational work with the whole society in order to absorb the philosophy of the Creative Cities.

As an extension of studies and actions, it is intended to deepen the readings on the subject, develop new scientific articles and disseminate among the academic community, public managers, and society, in general, the ability to transform the Creative Economy.

Finally, another lesson learned during the construction of the study was that, as much as a city or region seems to be in full development, there will always be room for innovation and construction of integrated actions capable of fostering creativity and sustainability.

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# Diagnosis of the Sugar-Energy Sector in Paraná State and Assessment of its Potential for Producing Electricity and Biomethane from Biogas

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Received: 16 Jul 2022,

Received in revised form: 06 Aug 2022,

Accepted: 12 Aug 2022,

Available online: 20 Aug 2022

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**Keywords**—renewable energy, revenues,  
vinasse, sustainability.

**Abstract**—The sugar-energy sector is one of the main economic activities in Brazil and has a high availability of residues with the potential for biogas production. In this sense, the present study sought to analyze the characteristics of the sugarcane processing plants and to define a theoretical plant with the average characteristics for the state of Paraná, with the aim of identifying the biogas production potential of this unit and to evaluate the monetization strategy that presents the best results. The analysis performed shows that the state has 23 units in operation that have an installed capacity to process up to 246,530 tons of sugarcane per day; the biogas production potential of the theoretical plant would produce over 21,127 MWh.year<sup>-1</sup> of electric energy or 6,302,463 Nm<sup>3</sup>.year<sup>-1</sup> of biomethane. When analyzing the different monetization methods of biogas, the self-consumption of biomethane associated with the commercialization of the surplus portion presented a better financial performance (R\$16.1 million.year<sup>-1</sup>) when compared to the exclusive sale of biomethane (R\$12.6 million.year<sup>-1</sup>) or electricity (R\$7.3 million.year<sup>-1</sup>).

## I. INTRODUCTION

The sugar-alcohol sector was consolidated in Brazil in the 1970s from incentives offered by the National Alcohol Program (PROALCOOL). This federal government initiative offered reduced financing rates and made possible both the installation of plants dedicated to ethanol production and the construction of distilleries attached to existing sugar mills [1].

Brazil is currently the largest producer and exporter of sugar in the world [2] and the second largest producer of

ethanol, accumulating 29.5% of world production [3]. According to [4] in the 2020/21 harvest, Brazil will produce approximately 41.5 million tons of sugar and 32.5 million m<sup>3</sup> of ethanol.

Brazilian ethanol is mostly produced from sugarcane, however, the number of units using corn as a source of raw material is growing. Currently, there are 8 Flex<sup>1</sup> and 5 Full

<sup>1</sup> Combined processing of corn and sugarcane.

<sup>2</sup> Exclusive corn processing.

<sup>2</sup> plants in operation in the country, plus 2 Flex and 7 Full units under construction [5]. Using other sources of raw material for ethanol production occurs mainly because of the need to complement the supply of ethanol to the market between the months of December and March (off-season), a period in which sugarcane is not available [6].

Currently, 365 plants operate in Brazil, 96% of which use sugarcane to produce sugar and/or ethanol. Of these, 221 are annexed (producing sugar and ethanol), 114 are autonomous (dedicated to ethanol production) and 16 produce only sugar [5].

Despite being one of the main integrants of Brazil's agroindustry [7], the sugar-energy sector still faces some challenges to be solved, such as the management and treatment of its waste. During the sugarcane processing, high volumes of organic waste are generated, in the agricultural phase, the straw is generated, while in the industrial stage bagasse, vinasse and filter cake are obtained [8].

Straw is a substrate that became available after the beginning of the transition to mechanized harvesting, previously sugarcane plantations were set on fire to facilitate manual harvesting. Data regarding the 2019/20 harvest shows that the mechanized method is the most used for sugarcane harvesting in Brazil, representing 91.8% [2]. The main application of straw has been to cover the soil to control erosion, maintain moisture, promote soil biodiversity and control weed growth [9].

Bagasse is a residue got during the extraction phase of the sugarcane juice [10] for each ton of processed sugarcane, 260 kg of bagasse is obtained [8]. This waste is used as fuel for cogeneration plants in the mills themselves, which besides meeting the internal demand for steam and electricity, can often market the surplus electricity [11]. According to [12], the power licensed for the production of electric energy from sugarcane bagasse in Brazil is approximately 11.9 GW, which represents 6.8% of the country's electricity matrix.

Filter cake is a solid waste generated during the cleaning of sugarcane juice. For each ton of processed sugarcane, 35 to 40 kg of this waste is generated [8, 13]. Inorganic particles, residual sugars, bagasse fragments, and water composed this material. The filter cake is widely used as fertilizer in the sugar cane plantation areas [14].

The vinasse is a liquid waste, potentially polluting and generated on a large scale. Each liter of ethanol generated 12 liters of vinasse. The primary use of this waste is also as

fertilizer, it is transported from the industrial units to the planting area where it is applied in natura [8].

It is notable that the only residue of the sugar and alcohol sector that receives energy application is the bagasse, the others are used only as soil conditioning. In this sense, it is highlighted that the energy recovery of organic waste can be performed from the generation of biogas, through anaerobic digestion [15]. The production of energy through biodigestion is helpful because it makes it possible to recover the energy potential of the substrates without compromising their subsequent use as fertilizer.

Biogas comprises a mixture of gases composed mainly of methane (60 to 70%) carbon dioxide (30 to 40%) and other trace-level gases such as nitrogen, hydrogen sulfide, hydrogen, ammonia, and moisture [16].

Because of the high methane content this biofuel can be used for energy generation, the application with less technological complexity is the generation of heat from burning in boilers. In addition to thermal use, biogas has two other routes for energy use: (i) burning for combined heat and power, and (ii) purification to achieve quality levels comparable to natural gas [17]. In Brazil, purified biogas is commonly called biomethane or renewable natural gas.

In the State of Parana, the only biogas plant built to process residues from the sugar-energy sector has electricity as its main energy application. This industrial unit has an installed capacity of 10 MW and was the pioneer in Brazil to produce biogas on a commercial scale with this type of residue [12].

It is noteworthy that the State of Parana makes important contributions to Brazil's sugar-energy sector, being the third largest sugar producer in the country, the fifth in sugarcane processing and the sixth in ethanol production [4]. However, even with its high representation in the national scenario, Paraná has little information prepared specifically for the state, especially regarding sector characterization and projections of biogas production potential, a fact that explains the incipient diffusion of biogas projects in this sector in the state.

Thus, to enrich the technical literature on this subject for the state, the present study seeks to characterize the sugar-energy sector in Paraná and define a theoretical plant with the average characteristics for the state, in order to estimate the potential for biogas production for this unit and identify the energy application that presents the best revenue generation.

## II. METHODOLOGY

### 2.1 CHARACTERIZATION OF THE SUGAR-ENERGY SECTOR IN PARANÁ

To carry out the diagnosis of the sector, the fundamental characteristics of the industrial units of the sugar-energy sector in Paraná were analyzed. The aspects evaluated were the number of mills by type (independent or annexed), their respective location, as well as their sugarcane processing and ethanol production capacities.

The Ministry of Agriculture, Supply and Livestock (MAPA) is the Brazilian agency that provides public information on sugarcane mills through the Sugarcane Production Monitoring System (SAPCANA). Thus, from SAPCANA it was possible to define the number of sugarcane mills in the State of Paraná, as well as to perform the grouping according to their operational configuration (autonomous or annexed) [18].

The respective processing and ethanol production capacities per unit were determined based on public information made available by the National Petroleum, Natural Gas and Biofuels Agency through the public consultation center [19].

After evaluating the characteristics of the state a theoretical plant gathering the average characteristics of the state was estimated. The location of the theoretical unit was defined through an analysis that verified the Mesoregion of the State of Paraná that concentrates the largest number of productive units. To define the type of plant, the units were grouped into annexed and autonomous, and the group with the largest number of units was selected to compose the configuration of the theoretical unit.

Finally, an analysis of the average among the mills allowed the definition of the sugarcane crushing capacity (tons.day<sup>-1</sup>) and ethanol production capacity (m<sup>3</sup>.day<sup>-1</sup>). It should be noted that the specific waste generation coefficients, as well as their respective biogas production potentials, were determined through information available in the literature.

### 2.2 ESTIMATED PRODUCTION OF BIOGAS, ELECTRIC ENERGY AND BIOMETHANE

Among the wastes available in the sugar and energy sector, in the present study vinasse and filter cake will be considered as substrates for biogas production, because of the greater biodegradability of these materials and the absence of competing uses, as suggested [20].

The strategy adopted to estimate the potential for biogas production consists in evaluating the co-digestion of these materials during the sugarcane harvest period (approximately 200 days per year) and maintaining the

operation of the biodigestion system using filter cake during the off-season.

A mass balance was performed to estimate the flow rate, solids content, and biogas production of the unit. The calculation of total solids concentration was performed from (1), adapted from [21]:

$$C_0 = \frac{\sum_{i=1}^n Q_i * C_i}{\sum_{i=1}^n Q_i} \quad (1)$$

whereby

$C_0$  = Total solids concentration of the mixture (%),

$C_i$  = Concentration of the mixture component (%),

$Q_i$  = Flow of the mixture component (m<sup>3</sup>.day<sup>-1</sup>),

$n$  = Number of components in the mixture,

The estimation of methane production was performed using (2), adapted from [22]:

$$Q_{CH_4} = Q_S * C_{COD} * BMP * E_{COD} \quad (2)$$

whereby

$Q_{CH_4}$  = Methane flow (Nm<sup>3</sup>.day<sup>-1</sup>),

$Q_S$  = Substrate flow rate (m<sup>3</sup>.day<sup>-1</sup>),

$C_{COD}$  = COD in the substrate (kg.m<sup>-3</sup>),

$BMP$  = methanogenic potential of the substrate (Nm<sup>3</sup>.kg<sub>COD</sub><sup>-1</sup>),

$E_{COD}$  = Conversion efficiency of COD to biogas (%),

(3) [23], was used to estimate the daily biogas flow rate:

$$Q_{Biogas} = \frac{Q_{CH_4}}{C_{CH_4}} \quad (3)$$

$Q_{Biogas}$  = Biogas flow (Nm<sup>3</sup>.day<sup>-1</sup>),

$Q_{CH_4}$  = Methane flow (Nm<sup>3</sup>.day<sup>-1</sup>),

$C_{CH_4}$  = methane concentration in the biogas (%),

The estimate of electric energy production was performed considering the multiplication between the lower calorific value of the biogas, the flow rate, and the electrical efficiency of the selected generator. The electrical efficiency refers to the efficiency that the generator set has to convert biogas into electricity.

On the other hand, the estimation of biomethane production potential was performed by the multiplication of the biogas flow and a conversion factor from biogas to biomethane, which considers the methane content present in the biofuel and the losses involved in the process.

The electricity revenue estimate was made considering the price of R\$ 347.5 per MWh commercialized, which corresponds to the updated value of the price achieved in

the last energy auction won by a biogas plant in Brazil [24]. For biomethane it was considered as an assumption the commercialization with a price of R\$ 2 per m<sup>3</sup> of renewable molecule.

Furthermore, the avoided cost with diesel that could be replaced by biomethane in the truck fleet that performs the agricultural logistics during the harvest was also evaluated. For this, the price of diesel was considered to be R\$ 6.5 per liter and the specific consumption of diesel was considered to be 1.04 L<sub>diesel</sub>·Ton<sub>cana</sub><sup>-1</sup> [25] to estimate the total demand. It was also considered that 35% of the diesel demand could be replaced by biomethane if the fleet were converted to the combined use of diesel and gas [26].

### III. RESULTS

#### 3.1 CHARACTERIZATION OF THE SUGAR-ENERGY SECTOR IN PARANÁ

Paraná has 24 plants allowed to produce ethanol, however, one of them produces ethanol from soy, and for this reason was disregarded, so 23 units were accounted for in this study. Altogether the state can process 246,530 tons of sugar cane per day [19].

Fig. 1 shows the distribution of the number of mills by daily processing capacity.

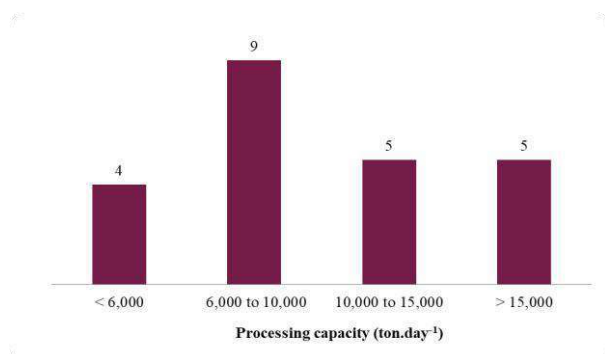


Fig. 1: Number of mills by processing capacity.

From the analysis carried out, it was found that approximately 39% of the mills in the state analyzed have a daily processing capacity of 6,000 to 10,000 tons of sugarcane, and, therefore, this is the range that brings together the largest number of units.

The territorial layout of the ethanol plants in Paraná is illustrated in Fig. 2.

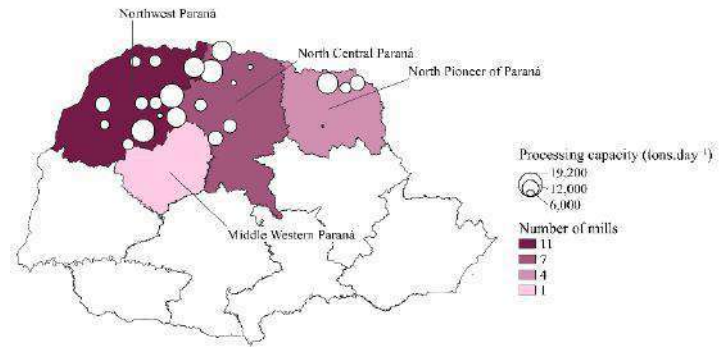


Fig. 2: Territorial arrangement of the sugarcane mills in Paraná.

Source: Own preparation based on data from [19].

The Mesoregion of Northwest Paraná, besides concentrating the largest number of mills, also aggregates the largest processing capacity. Altogether this region can process 126,040 tons of sugarcane daily, equivalent to 51% of the state capacity.

Besides understanding the location of the plants, it is also necessary to analyze their respective production characteristics. Fig. 3 presents the number of mills by type of configuration.

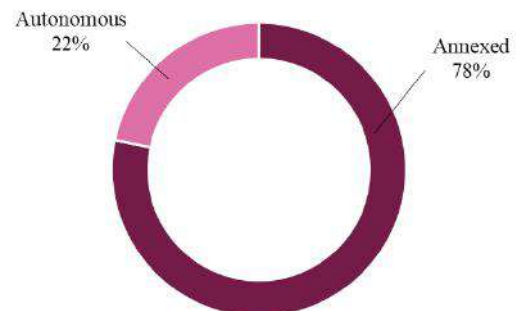


Fig. 3: Number of mills by type.

Source: Own preparation based on data from [18].

The predominance of annexed mills is explained given the vocation of the State of Paraná in the sugar sector. This federative unit is the third largest producer of sugar in Brazil, behind only São Paulo and Minas Gerais. In the 2019/20 harvest, the state produced approximately 2 million tons of this commodity [4], which corresponds to 7% of the national production.

The aforementioned information defined the main characteristics of the state to configure a theoretical plant that represents the average parameters of Paraná.

Therefore, the theoretical mill that best represents the average characteristics for Paraná is located in the Northwest region of Paraná, is annexed and can process

10,719 tons per day, a value that is equivalent to the average sugarcane processing capacity in the state. The estimated total ethanol production capacity is 880 m<sup>3</sup> per day.

### 3.2 WASTE GENERATION ESTIMATE

Among the waste from the sugar and ethanol sector, vinasse and filter cake were the substrates selected for the estimation of the biogas production potential, because of

their high availability and for presenting physical-chemical characteristics that propitiate the energy recovery of this material through anaerobic digestion, as observed by [20].

Table 1 shows the estimated waste generation for the unit under analysis.

Table 1: Estimated waste generation

	Input/Output	Unit	Source
Operational Days	200	days.year <sup>-1</sup>	[27]
Specific generation of vinasse	11.84	m <sup>3</sup> <sub>vinasse</sub> .m <sup>3</sup> <sub>ethanol</sub> <sup>-1</sup>	[8]
Specific generation of filter cake	35	kg <sub>filter cake</sub> .ton <sub>cane</sub> <sup>-1</sup>	[8]
Daily generation of vinasse (volume)	3,248	m <sup>3</sup> <sub>vinasse</sub> .day <sup>-1</sup>	-
Vinasse Density	1.14	ton.m <sup>-3</sup>	[28]
Daily generation of vinasse (mass)	3,713	ton <sub>vinasse</sub> .days <sup>-1</sup>	-
Daily generation of filter cake	264.71	Ton <sub>filter cake</sub> .day <sup>-1</sup>	-
Generation of vinasse by harvest	742,702	ton <sub>vinasse</sub> .harvest <sup>-1</sup>	-
Generation of filter cake by harvest	52,943	ton <sub>filter cake</sub> .harvest <sup>-1</sup>	-

The vinasse production was estimated from its respective specific generation and the total ethanol production capacity, however, the maximum capacity was not considered because it was found that the mills in Paraná use, on average, only 31% of the available capacity. This rate was calculated from the ratio between the volume of ethanol produced in the 2020/21 harvest, 6,305 m<sup>3</sup>.day<sup>-1</sup> [4], and the total capacity of the state, 20,220 m<sup>3</sup>.day<sup>-1</sup> [19].

The amount of filter cake produced was estimated similarly. For this calculation, the specific generation of filter cake and the cane processing capacity were considered, adjusted by the average occupancy rate of the Paraná mills (71%). The occupancy rate corresponds to the ratio between the amount of processed cane 173,950

ton.day<sup>-1</sup> [19] and the state’s processing capacity 246,530 ton.day<sup>-1</sup> [19]. According to [5] the occupancy rate of the sugar-alcohol sector in Brazil in 2020 was 90%, therefore, it is possible to observe that the State of Parana has an utilization rate of its installed capacity lower than the national average.

### 3.3 ESTIMATION OF BIOGAS PRODUCTION

In this sense, using the assumptions presented so far, a mass balance was performed (Table 2) to estimate the amount of cake to be stored (in order to ensure the generation of biogas in the off-season), to estimate the physical-chemical characteristics of the mixture and its potential for biogas production.

Table 2: Mass balance for harvest and off-season.

	Substrate	Flow rate (ton.day <sup>-1</sup> )	TS <sup>a</sup> (% <sub>FM</sub> )	Methanogenic Potential (Nm <sup>3</sup> .ton <sup>-1</sup> ) <sub>a</sub>	Methane (%v/v) <sup>b</sup>	Biogas Production (Nm <sup>3</sup> .day <sup>-1</sup> )
Harvest	Vinasse	3,713	3.44%	8.15	57.67%	52,480
	Filter Cake	150	28.90%	54	57.67%	14,046
	Digestate	1,000	2%	-	-	-
	<b>Mix</b>	<b>4,863</b>	<b>3.93%</b>			<b>66,526</b>
Off-Season	Filter Cake	139	28.90%	54	57.67%	13,021
	Digestate	2,000	2%	-	-	-
	<b>Mix</b>	<b>2,139</b>	<b>3.75%</b>			<b>13,021</b>

Source: <sup>a</sup> [29], <sup>b</sup> [30]; TS – Total Solids, FM - FRESH MATTER



The mass balance performed needed to equalize the amount of stored cake and the volume of vinasse available to estimate the characteristics of the mixture that will be co-digested. In this context, the quantities considered for the composition of the mixture were calculated strategically so that the content of total solids (ST) did not exceed 4%, and for this reason it was necessary to consider the use of digestate (recirculated) as a diluent to increase the moisture of the mixture. The maximum value of 4% was determined, imagining that the biodigestion system would be a covered lagoon reactor.

Co-digestion of substrates is beneficial for biogas production, [31] when analyzing the associated digestion of waste from the sugar-energy sector observed higher potential for methane production compared to mono-digestion of the same materials. [32] they report that co-digestion confers greater stability to the process, favors the balance of nutrients and promotes better adaptation of microorganisms to the substrate. In addition, the authors state that co-digestion favors the solids content of the mixture to suit the parameters of the biodigestion system.

The estimated potential biogas production is 66.5 thousand  $\text{Nm}^3_{\text{biogas}} \cdot \text{day}^{-1}$  for the harvest and approximately 13 thousand  $\text{Nm}^3_{\text{biogas}} \cdot \text{day}^{-1}$  in the off-season. The notable difference is expected because vinasse accumulates 79% of the volume of biogas that can be produced daily during the operational period of the plant, and it is not available for the off-season. The total volume of filter cake to be stored for the off-season is 22,943 tons, a material that allows for the feeding of 139 tons per day when there is no generation of effluents by the sugar and ethanol mill.

It is noteworthy that the proposed biodigestion system has a conversion efficiency of organic matter into biogas equal to 70% [33]. For this reason, the effective volume of biogas produced during the harvest would be  $46,569 \text{ Nm}^3_{\text{biogas}} \cdot \text{day}^{-1}$  and  $9,114 \text{ Nm}^3_{\text{biogas}} \cdot \text{day}^{-1}$  in the off-season.

### 3.4 BIOGAS MONETIZATION

From the volume of biogas estimated for the theoretical plant, the respective potential for production of electricity and biomethane was evaluated. Table 3 gathers the results got during the estimation of the potential for electricity and biomethane production.

Table. 3: Estimated potential for electricity and biomethane production.

	Harvest	Off-season	Unit
<b>Biogas production potential</b>	46,569	9,114	$\text{Nm}^3_{\text{biogas}} \cdot \text{day}^{-1}$
<b>Electricity Assessment</b>			
<b>Lower Heating Value biogas</b>		4.5	$\text{kWh} \cdot \text{Nm}^{-3}$
<b>Electrical Performance</b>		43.4%	-
<b>Electricity Generation</b>	90,948	17,801	$\text{kWh} \cdot \text{day}^{-1}$
<b>Biomethane Assessment</b>			
<b>Conversion Factor</b>		0.58	$\text{Nm}^3_{\text{biomethane}} \cdot \text{Nm}^{-3}_{\text{biogas}}$
<b>Biomethane Production</b>	27,131	5,310	$\text{Nm}^3_{\text{biomethane}} \cdot \text{day}^{-1}$

The value of 43.4% refers to the conversion efficiency of biogas into electric energy of the J620 engine manufactured by INNIO company, while the conversion factor of  $0.58 \text{ Nm}^3_{\text{biomethane}} \cdot \text{Nm}^{-3}_{\text{biogas}}$  was calculated considering that the methane content in biomethane is 97% and that there are losses of 2% of the processed methane [34].

From the estimates made (Table 3) it was found that the potential for electricity generation is  $21,127 \text{ MWh} \cdot \text{year}^{-1}$  while the estimate made for biomethane indicates a potential of  $6,302,463 \text{ Nm}^3_{\text{biomethane}} \cdot \text{year}^{-1}$ . However, to define which alternative is more attractive, it was necessary to evaluate them in terms of the possible financial gains that both can generate.

In this sense, Fig. 4 presents the estimated realized revenues for both energy sources.

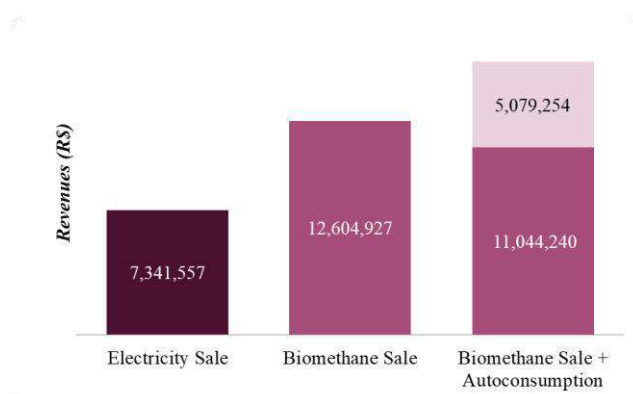


Fig. 4: Estimated revenues for biomethane and electricity.

The sale of biomethane combined with its use as a substitute for diesel is the one with the highest annual revenue generation, R\$ 16,123,494, followed by the exclusive sale of biomethane. [35] when analyzing the different factors that influence the economic viability of biogas projects using vinasse as a substrate source, they concluded biomethane was the energy application with the best economic performance compared to electricity.

Besides the higher revenue generation compared to electricity, another factor motivating the purification of biogas to biomethane is the National Biofuels Policy (RenovaBio), instituted by Law No. 13,576 of 2017. RenovaBio seeks to boost biofuels in Brazil by remunerating producers through Decarbonization Credits (CBIOs), a financial asset that is issued according to the environmental energy efficiency of the producing unit, traded through the stock exchange in the country [36]. On average, a biomethane plant emits 0.028 CBIOs per cubic meter of the renewable molecule, if we consider the average price of CBIO equal to R\$ 94.94 [37]. It is estimated that an additional gain with CBIOs of R\$ 1,697,923 could be generated for the theoretical plant analyzed.

#### IV. CONCLUSION

Biodigestion is an interesting alternative for treating the residues available in the sugar-energy sector and recovering them energetically from biogas. In this sense, it was verified that the State of Parana has 23 sugar-alcohol mills predominantly annexed, and that they are mainly located in the northwest region of the state, it is also highlighted that over 39% of the identified mills can process from 6,000 to 10,000 tons of sugarcane per day.

It was found that a plant with the average characteristics of the state evaluated, has a potential for biogas production equal to  $46,569 \text{ Nm}^3_{\text{biogas}} \cdot \text{day}^{-1}$  in the harvest and  $9,114 \text{ Nm}^3_{\text{biogas}} \cdot \text{day}^{-1}$  in the off-season. This volume suffices to produce up to  $21,127 \text{ MWh} \cdot \text{year}^{-1}$  of electric energy or  $6,302,463 \text{ Nm}^3 \cdot \text{year}^{-1}$  of biomethane.

When analyzing the possible financial gains from each of the energy applications, it was found that the commercialization of biomethane combined with the use of this energy source as a substitute for diesel is the one that presents the best performance, R\$16,123,494 per year.

The financial results got are linked to the current geopolitical situation of Brazil and the world, because the fossil fuels are tied to international indicators that are on the rise because of the moment of global instability created by the pandemic of COVID-19 and which were driven again by the war between Russia and Ukraine. Therefore, biomethane as an energy source analogous to natural gas

and a potential substitute for diesel in logistics, ends up benefiting from the rise of its fossil counterparts and generates more attractive revenues for the projects.

Besides this, the use of biogas to produce biomethane is also positive because this is an alternative energy source that could be included in the product portfolio of the Paraná mills, since electricity is already a widespread product in this sector. As a suggestion for future works, the authors suggest evaluating not only the revenues but also the expenses related to biomethane production to assertively verify the economic feasibility of implementing this type of project.

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# Treatment of Opioid Overdose with Naloxone: A discussion on the implementation of intranasal therapy in Brazil

## Tratamento de Overdose por Opiáceos com Naloxona: Uma discussão pela implementação da terapêutica intranasal no Brasil

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Received: 15 Jul 2022,

Received in revised form: 08 Aug 2022,

Accepted: 13 Aug 2022,

Available online: 20 Aug 2022

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**Keywords—** Overdose; Opioid; Naloxone; Intranasal Treatment; Emergency

**Palavras-chave—** Overdose; Opióide; Naloxona; Tratamento Intranasal; Emergência

**Abstract—** The increasing use and dependence on opioids has resulted in numerous events with serious psychosocial disorders associated with unpredictable behavioral situations, in addition to morbidity and mortality due to overdose. Heroin leads the ranking of overdoses due to its high addiction power. The use of antidotes during the care of overdose patients minimizes mortality and improves survival, thereby reducing the damage caused. The objective of this study is to correlate the observed cases and to glimpse the efficacy in the treatment with injectable naloxone versus intranasal spray, its efficacy, practicality, and punctuality in the prognosis. This is a systematic and explanatory study based on scientific articles that are in line with the descriptors controlled by indexing sites and, from the data systematically collected, according to the method described above, the quality of the therapy that demonstrated a promising way to basic life support, when suggested by the lay population or nonmedical community. Continuity of studies is recommended in order to mediate the implementation of the intranasal spray method in Brazil.

**Resumo—** O crescente uso e dependência de opiáceos tem por consequência inúmeros eventos com graves perturbações psicossociais associadas a situações comportamentais imprevisíveis, além de morbimortalidade por overdose. A heroína lidera o ranking de overdoses pelo seu alto poder de adicção. O uso de antidotos durante o socorro a pacientes vítimas de overdose minimiza as mortalidades e proporciona

*uma melhora na sobrevida, diminuindo por consequência os danos ocasionados. O objetivo deste estudo é correlacionar os casos observados e vislumbrar a eficácia na tratativa com naloxona injetável versus spray intranasal, sua eficácia, praticidade e pontualidade no prognóstico. Trata-se de um estudo sistemático e explicativo fundamentado em artigos científicos que se encontram em consonância com os descritores controlados por sites indexadores e, a partir dos dados sistematicamente coletados, conforme o método descrito acima pode-se verificar a qualidade da terapêutica que demonstrou uma promissora maneira ao suporte básico de vida, quando sugerido o uso pela população leiga ou comunidade não médica. Indica-se a continuidade dos estudos a fim de mediar a implementação do método spray intranasal no Brasil.*

## I. INTRODUÇÃO

Desde a antiguidade o uso de substâncias psicoativas é notoriamente presente na história da sociedade, sendo considerado uma prática milenar e universal, utilizadas por diferentes grupos étnicos com intuito recreativo, religioso, cultural, medicinal, psicológicos, entre outros (BARRETO; BÚCHELE; QUEIROZ, 2015).

Segundo a Organização Mundial da Saúde (OMS) as substâncias psicoativas (SPA) se referem a substâncias que atuam principalmente no sistema nervoso central (SNC) e alteram as sensações, o humor, consciência e funções psicológicas e comportamentais do indivíduo, assim como suas funções cognitivas. Essas substâncias além de modificarem o organismo do indivíduo, quando usadas em associação a outras alteram seus efeitos entre si, potencializando e alterando os efeitos no indivíduo (CERQUEIRA, 2015).

A presença de transtornos mentais, relacionados ao uso de substâncias psicoativas tem sido alvos de estudo, principalmente devido as consequências do uso abusivo, que pode resultar em complicações para o meio social e de saúde do usuário, além de apresentar altos índices de morbimortalidade especialmente quando associado a complicações e emergências psiquiátricas (FERNANDES *et al.*, 2017).

Os problemas relacionados ao uso de SPA têm sido considerados um grave problema de saúde pública no Brasil e no mundo (BÍSCARO, 2016). O atendimento aos usuários com transtornos por uso de substâncias psicoativas é prevalente nos serviços de emergência, nas unidades de pronto atendimentos ou em hospitais, sendo que no Brasil, 6% da população apresenta esses transtornos de forma consideradas graves. Muitas mortes e complicações na emergência estão relacionadas ao uso de mais de duas substâncias simultaneamente, indivíduos tidos como poliusuários (BARRETO; BÚCHELE; QUEIROZ, 2015).

Opioides são todas as drogas, naturais ou sintéticas, derivadas do ópio e com propriedades semelhantes às da morfina, incluso os peptídeos endógenos e se apresentam como agonistas, agonistas parciais, agonistas-antagonistas e antagonistas competitivos (METRI; PORTUGAL, 2011 *apud* SILVA, 2002).

Inicialmente era preconizado a utilização de opioides dentro da clínica médica em razão do seu poderio analgésico, principalmente à pacientes oncológicos, por queimaduras de segundo e terceiro grau e para indivíduos politraumatizados, mas passou a ser utilizado de forma indiscriminada e recreacional (METRI; PORTUGAL, 2011 *apud* CEBRID, 20--).

Em especial, o crescente uso e dependência de opioides tem por consequência a alta taxa de mortalidade por overdose. Em 2016, a estimativa era de cerca de 100 mil mortes anuais em todo o mundo (STRANG *et al.*, 2019 *apud* UNODC, 2016). Apesar do uso do antídoto naloxona em sua forma spray nasal ser aprovado por diversos órgãos de fiscalização em saúde, além das diretrizes da OMS e do endosso das Nações Unidas, a inércia de alguns governos põe em risco a vida de muitos pacientes (STRANG *et al.*, 2019 *apud* OMS, 2013; QUEM, 2016).

## II. MATERIAL E MÉTODOS

Revisões sistemáticas e meta-análises se consagraram como métodos de extrema importância na assistência à saúde, fornecendo um compilado de dados baseados em evidências que servem como um norte para a atuação clínica nas mais diversas áreas. Fazendo uso dessa metodologia, esse trabalho constitui-se de uma revisão sistemática, realizada remotamente, a partir da consulta de estudos publicados em bancos de dados reconhecidos pela qualidade de suas publicações com o objetivo de verificar a eficácia de novos métodos para tratar crises de overdose por opioides.

Baseado na estratégia PICO, a pergunta de pesquisa foi construída da seguinte forma: “Quais os resultados do uso de spray nasal de naloxona 2 mg para tratar pacientes numa crise de intoxicação aguda por opioides, em comparação aos tratamentos convencionais de injetáveis?”

Os critérios de elegibilidade dos estudos foram artigos científicos originais, publicados entre 2011 e 2020 sobre o tema tratamento intranasal de intoxicação aguda por opioides constantes nas bases de dados da Biblioteca Virtual em Saúde (BVS), Google Scholar, Medical Literature Analysis and Retrieval System Online (Medline) e National Library of Medicine (Pubmed). A estratégia de busca bibliográfica, se restringiu a artigos em português e inglês e ocorreu entre os dias 02 de setembro de 2020 e 08 de setembro de 2020. Para a seleção dos estudos foram removidas as pesquisas em duplicidade, em seguida foi feita uma triagem inicial baseada nos títulos, sendo excluídas as pesquisas não relacionadas ao tema tratamento de intoxicações agudas por opioides com naloxona. Após a leitura dos resumos foram excluídas as pesquisas que não atendiam os critérios de elegibilidade.

Para identificação dos descritores mais adequados para uma busca eficaz dos estudos relacionados ao tema tanto em inglês quanto em português, foi feita uma pesquisa nos sites Descritores em Ciências da Saúde (DeCS) e Medical Subject Headings (MeSH) a partir das seguintes palavras: overdose, opioides, naloxona, tratamento intranasal de overdose por opioides, tratamento para opioides, dependentes em opioides, epidemia em opioides e manejo de dependentes em opioides. Obtidos os melhores descritores em português e inglês relacionados ao tema de pesquisa, decidiu-se utilizar em todas as bases os operadores booleanos da seguinte forma: (naloxone and opioid and intranasal treatment or spray) e (naloxona and opioide and tratamento intranasal or spray).

Na BVS foram encontrados inicialmente 162 artigos. Após a aplicação de filtro pelo assunto principal: “Overdose de Drogas” o número de artigos selecionados foi reduzido para 72, sendo a seleção se restringindo a 23 artigos quando foi inserida a limitação de artigos publicados a partir de 2018. Em seguida, os 23 artigos foram ordenados por relevância pela ferramenta disponível na própria plataforma, sendo selecionados os 8 artigos com maior aderência à pergunta de pesquisa deste trabalho.

No Google Scholar a pesquisa apresentou inicialmente 2.270 estudos. Em seguida foi aplicado filtro buscando apenas artigos publicados a partir de 2018, cujo título constasse todas as seguintes palavras: naloxone, overdose e intranasal; restringindo a seleção para 9 artigos, sendo os 6 com maior afinidade ao objetivo desse estudo selecionados para análise.

Na Medline a pesquisa apresentou 60 artigos para a estratégia de busca definida. Esses artigos foram ordenados segundo sua relevância, sendo utilizado ferramenta da própria plataforma para este ranqueamento. Foram escolhidos os 6 artigos de maior consonância com o presente tema de pesquisa.

Aplicando a estratégia de busca definida anteriormente na plataforma PUBMED foram obtidos 41.307 resultados, pois a mecânica de busca do site busca também estudos com as palavras pesquisadas isoladamente. Para filtragem dos artigos foram selecionados estudos publicados a partir de 2019, restringindo este universo para 52 estudos, que por sua vez foram ordenados segundo sua relevância, sendo apenas 3 deles selecionados segundo sua pertinência com o problema desse estudo.

O quadro 1 demonstra o processo desenvolvido para a escolha da amostragem aleatória sistemática. Este tem como escopo dimensionar as opções de inclusão e exclusão supracitados de forma simples e clara.

Quadro 1: Artigos encontrados versus artigos selecionados para análise nas bases de dados

Base de Dados	Nº de artigos encontrados	Nº de artigos selecionados	Idioma
BVS	162	8	Inglês
Google Scholar	2270	6	Inglês
Medline	60	6	Inglês
PUBMED	41.307	3	Inglês

### III. RESULTADOS E DISCUSSÃO

Dentro do grupo dos opiáceos a heroína é a droga agente causadora de maior adicção, potenciadora de profunda dependência e passível escravidão unilateral. É a droga preferida pelos toxicômanos e lidera o ranking de

episódios de overdoses por opioides não prescritos, cerca de 13 mil mortes em 2015 nos Estados Unidos em contrapartida às mortes por opioides prescritos, 20 mil mortes (STRANG *et al.*, 2019 *apud* RUDD *et al.*, 2016; METRI; PORTUGAL, 2011 *apud* SILVA, 2002).

Para garantir um suporte básico a vida ao paciente, seja por atividade de um profissional socorrista ou pela comunidade leiga em geral, é importante ter acesso irrestrito a todos os protocolos disponíveis. As crises de abstinência são caracterizadas por uma demanda de sinais e sintomas gerados pela ausência da substância no organismo. Esses eventos costumemente geram graves perturbações psicossociais e com isso podem imergir situações comportamentais imprevisíveis, com alto risco tanto para o paciente quanto para quem o está atendendo e/ou acompanhando-o (HOSPITAL SANTA MÔNICA, 2019).

Os estudos apontam que a maioria das mortes por overdose ocorrem dentro da própria comunidade e que, particularmente, quase toda sua totalidade é de indivíduos que estão sozinhos no momento do uso e/ou acompanhados de outros usuários, quase sempre sob as mesmas condições. Mesmo diante da vulnerabilidade no instante da overdose, essas situações podem ser facilmente evitadas pela comunidade não-médica e amenizadas posteriormente pelos profissionais da saúde, com a devida detecção e administração de naloxona concomitantemente com medidas básicas de ressuscitação, caso haja necessidade (STRANG *et al.*, 2019).

Naloxona é um célebre antídoto antagonista e altamente específico de opioides, que desloca ativamente a heroína e outros opioides do receptor  $\mu$  (Muopioide - MOR). Há muito se utiliza deste medicamento nas unidades de atendimento fixos e móveis, devido ao seu alto poder de reverter em poucos minutos diferentes quadros de overdoses, inclusive restabelecer rapidamente a respiração, independentemente do estado de consciência do paciente (STRANG *et al.*, 2019).

Inicialmente aprovada nas apresentações injetáveis intravenoso (IV), subcutâneo (SC) e intramuscular (IM), teve a sua versão Spray aprovada pelo FDA (Food and Drug Administration) no fim de 2015 (MIRANDA, 2018). No Brasil, o uso do cloridrato de naloxona é aprovado pela Anvisa apenas em ambientes hospitalares e ainda não foi permitido o uso do spray (MILLÉO, 2018). A lista da Portaria SVS/MS nº 344/98 foi atualizada em 2020 e segue permitindo o uso da naloxona, porém apenas de forma injetável e sujeitas à receita de controle especial (em duas vias) conforme a Lista C1 (Lista das outras Substâncias sujeitas a Controle Especial) (BRASIL, 2020).

Em entrevista dada ao Jornal Médico em março de 2018, os pesquisadores, John Strang e Rebecca McDonald,

do King's College London, ressaltam as inúmeras vantagens encontradas em seus estudos acerca da administração do spray nasal de naloxona, sinalizam também para a comodidade e facilidade do seu uso somado a inexistência de riscos associados, além de apontarem para excelência do fármaco (JORNAL MÉDICO, 2018).

Mais recentemente foi desenvolvido a transferência de tecnologia para o naloxona gerando a formulação do Take-home Naloxona (THN), uma versão spray vendida em farmácias para a reversão de overdoses em ambientes não hospitalares, indicada principalmente para pessoas leigas. O intuito é aproximar a emergência hospitalar à sociedade e com isso minimizar os riscos e danos causados pelo atraso do atendimento especializado e reduzindo drasticamente o potencial de morte do indivíduo (STRANG *et al.*, 2019).

O THN pode ser viabilizado como parte integrante da atenção clínica integral aos pacientes com histórico de uso de opiáceos, seja na atenção primária ou especializada. Segundo apontam os estudos, tanto os usuários quanto amigos e familiares se disponibilizaram prontamente para estarem aptos e preparados para atuarem como socorristas caso haja necessidade, como na inexistência de atendimento ou durante a espera pela ambulância que prestará o socorro (STRANG *et al.*, 2019 *apud* STRANG *et al.*, 1999; STRANG *et al.*, 2008).

A terapia com naloxona não foi correlacionada com elevações séricas de enzimas, nem a lesões aguda no fígado. Não obstante, pacientes adictos de opiáceos frequentemente possuem doenças hepáticas crônicas subjacentes associadas (como doenças hepáticas devido ao etilismo crônico, hepatites B e C etc.), contudo não foi visualizado nenhuma condição exacerbada das comorbidades pré-existentes durante a terapêutica de naloxona. O antídoto é extensamente metabolizado no fígado, em quase sua totalidade por conjugação com o glicuronídeo, seguido por excreção urinária (LIVERTOX, 2020).

Apesar de mais prático e hábil, a comunidade brasileira em geral, ainda não possui acesso fácil e imediato ao antídoto para reanimar as vítimas de overdose por opiáceos, ato destinado apenas aos profissionais da saúde, especialmente os socorristas (BRASIL, 2020). Mas foi notado que o fornecimento de kits de THN para pacientes em risco reduz as taxas de mortalidade (PAPP, 2019 *apud* WHEELER *et al.*, 2014).



Quadro 2: Título, país e ano de publicação, base de dados do estudo, autores e resultados dos artigos selecionados para verificar a eficácia da aplicação intranasal de naloxona para overdose por opioides.

Título	País/ Ano de publicação	Base de Dados do Estudo	Autores	Resultados
Use of naloxone nasal spray 4 mg in the community setting: a survey of use by community organizations	EUA 2018	BVS	George K. Avetian, Phian Fiuty, Silve Mazzella, Di Koppa, Vivi Heye Pratihba Hebbar	Em 261 tentativas de reversão de overdose por opioide foram relatados 245 casos de sucesso. Heroína foi a droga mais reportada. 248 casos envolveram a administração de 1 ou no máximo duas doses de spray nasal de naloxona 4 mg.
An Innovative Model for Naloxone Use Within an OTP Setting: A Prospective Cohort Study	EUA 2018	BVS	Joanna G. Katzman, Mikiko R Takeda, Snehal e Bhatt, Moni Moya Balasch, Nina Greenberg Howard Yonas	Estudo de coorte prospectivo, onde 244 pacientes de risco inscritos em um programa de educação sobre overdose receberam 2 doses de um kit autoinjeter de naloxona 2 mg via intranasal para levar

				para casa entre abril e julho de 2016. Desses, 31 participantes do estudo relataram reversão de overdose em 38 membros de suas comunidades ou deles próprios.
Descriptive Epidemiology for Community-wide Naloxone Administration by Police Officers and Firefighters Responding to Opioid Overdose	EUA 2018	BVS	Sarah Cercone Heavey, Alan M. Delmerico, Bale Burstein, Cheryll Moore, William f. Wieczorek, Collins R. Lorraine, Chang Yu-Ping e Gregory G Homish	Em 2018 os bombeiros e policiais em regiões do estado de Nova York foram treinados a administrar naloxona intranasal 2 mg em pacientes em situação de overdose por opioides. Entre 2014 e 2016 foram reportadas 800 overdoses por opioide nessa localidade sendo que 81,6% dos pacientes nessa situação reverteram a overdose e sobreviveram.
Basic and Advanced EMS	EUA	BVS	Nazey Gulec, Joseph Lahey,	Foi feita análise para qual de de

Providers Are Equally Effective in Naloxone Administration for Opioid Overdose	2018		James C. Suozzi, Matthew Sholl, Charles D. Maclean e	estatística verificar para verdo se abordagem administração naloxona reversão de o por opioides teria ma
in Northern New England			Daniel L. Wolfson	eficácia. Foram comparados os métodos de aplicação em 3.219 pacientes divididos em dois grupos: atendidos no Suporte Avançado de Vida, com injeção intramuscular 0,4 mg e no Suporte Básico de Vida via administração intranasal 2 mg. A taxa de sucesso de ambos os métodos não teve variação significativa, sugerindo a expansão do modelo de aplicação no Suporte Básico de Vida.
Effect of Intranasal vs Intramuscular Naloxone on Opioid Overdose	Austrália 2019	Google Scholar	Paul Dietze, Marianne Jauncey e Allison Salmon	Um teste clínico randomizado dividiu 197 pacientes de uma unidade médica de suporte a pacientes de injetáveis a uma de duas abordagens: naloxona intranasal 2 mg e injeção de placebo ou injeção de naloxona 0,4 mg e administração intranasal de placebo. Os resultados
				evidenciaram que o spray de naloxona é capaz de reverter overdose de opioides, mas não tão eficientemente quanto a naloxona administrada via intramuscular.
Pharmacokinetics of a novel, approved, 1.4-mg intranasal naloxone formulation for reversal of opioid overdose—a randomized controlled trial	Noruega 2019	Google Scholar	Arne Kristian Skulberg, Anders Asberg, Hasse Zare Khiabani, Jilde Rostad, Ida Tylleskar e Ola Dale	Teste randomizado com 22 voluntários com idade média de 25,8 anos na Noruega foram submetidos a uma das seguintes intervenções: uma dose de naloxona intranasal de 1.4 mg, 2 doses de naloxona intranasal de 1.4 mg, uma dose intramuscular de 0,8 mg de naloxona ou uma dose de naloxona intravenosa 0,4 mg. Os resultados mostraram que

				a concentração plasmática encontrada nos pacientes que receberam uma dose de naloxona intranasal não teve diferenças estatísticas quando
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				comparada aos pacientes que receberam 0,8 mg via intramuscular, sendo, portanto, igualmente efetiva.
Intranasal versus Intramuscular/Intravenous Naloxone for Prehospital Opioid Overdose: A Systematic Review and Metaanalysis	Iran 2019	Google Scholar	Mahmoud e Yousefifard, Mohammad Hossein, Arian Madani, Seyedeh Niloufar, Marzieh Amiri, Alireza Baratloo Peyman Saberian	Meta análise realizada em bancos de dados eletrônicos no final de 2018 com a finalidade de verificar a eficácia do tratamento com naloxona via administração intranasal em relação ao tratamento via injeção intramuscular e intravenosa no atendimento pré-hospitalar de pacientes com overdose por opioides. Os resultados demonstraram a eficácia do tratamento intranasal, considerando-o uma alternativa à naloxona injetável.
Use of Intranasal Naloxone by Basic Life Support Providers	Inglaterra 2017	Medline	Scott G. Weiner, Patricia Mitchell,	Revisão retrospectiva que incluiu 793 pacientes transportados por

			Elizabeth S. Temin, Breanne K. Langlois e Sophia Dyer	ambulância devido a overdose por opioides entre 2006 e 2012. Todos receberam naloxona intranasal no suporte básico, O suporte avançado teve de intervir em 116 casos (14,6% dos pacientes) e 11 casos (1,4% dos pacientes) foram intubados no campo. 64 pacientes receberam dose adicional de naloxona. Os resultados demonstraram a eficácia da administração intranasal de naloxona no grupo de pacientes atendidos, reiterando sua
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				aplicabilidade no suporte básico de vida.
Comparing methods of naloxone administration: A narrative review	EUA 2017	Medline	Shawn E. Fellows, Alexander J. Coppola e Mona A. Gandhi	A eficácia e segurança da naloxona para a reversão da toxicidade de opioides foram revistas nessa pesquisa bibliográfica. Foram comparados a eficácia clínica ou as propriedades
				farmacocinéticas/ farmacodinâmicas apresentadas por naloxona intravenosa, intramuscular e intranasal. A naloxona se mostrou eficaz por todas as vias de administração avaliadas.
A Comparison of Efficacy of Treatment and Time to Administration of Naloxone by BLS and ALS Providers	EUA 2019	PubMed	Kenneth Nugent, Patrick Matthews, Jamie Gissendaner, Mia Papas, Deborah Occident, Avkash Patel, Michelle Johnson, Ross E. Megargel e Jason T. Nomura	Estudo retrospectivo e observacional a partir de dados coletados de fevereiro de 2014 a maio de 2015. Foram avaliados 131 casos de administração de naloxona, 62 no suporte básico de vida e 69 no suporte avançado de vida. Os resultados mostraram que a eficácia da administração intranasal no suporte básico de vida é similar à administração via intramuscular no suporte avançado de vida.

Os dados observados denotam uma terapêutica eficaz e quase que imediata em ambos os protocolos de auxílio a pacientes acometidos por overdose, seja pelo método injetável ou por administração intranasal (FELLOWS; COPPOLA; GANDHI, 2017; HEAVEY *et al.*, 2018; GULEC *et al.*, 2018; DIETZE *et al.*, 2019; SKULBERG *et al.*, 2019; YOUSEFIFARD *et al.*, 2019; NUGENT *et al.*, 2019).

Além de relacionar a praticidade, efetividade e relevância na proposta intranasal, já que em todos os casos em que fora utilizada, propiciou a sobrevida dos acometidos por algum tipo de overdose, demonstrou também as taxas de minimização dos danos gerados posteriormente pela diminuição da atividade fisiológica do indivíduo (FELLOWS; COPPOLA; GANDHI, 2017;

HEAVEY *et al.*, 2018; GULEC *et al.*, 2018; DIETZE *et al.*, 2019; SKULBERG *et al.*, 2019; YOUSEFIFARD *et al.*, 2019; NUGENT *et al.*, 2019).

#### IV. CONCLUSÃO

É evidente que o abuso de substâncias opiáceas proporciona a cada adicto uma reação diferente, quase sempre alarmantes e geralmente graves. A fatalidade deste descomedimento recreativo é a overdose, mas que notoriamente se viu passível de reversão por qualquer indivíduo da sociedade, o que por consequência diminuiu drasticamente os índices de mortalidade.

Apontados como causa no aumento da morbimortalidade, a demora pelo atendimento, a

dificuldade de acesso ao local que quase sempre é periférico, a inexistência de assistência de outrem ou por outros motivos inerentes a precariedade do ambiente de uso dos opiáceos, geram tantas mortalidades após quadros clínicos de overdoses, portanto o acesso imediato a uma tratativa eficiente é imprescindível a qualquer um, visto ousadamente como um direito básico à vida.

Percebemos a necessidade de efetividade das ações de suporte básico à vida, permitindo a inclusão de todos da sociedade em prol da sobrevivência dos indivíduos socorridos. A permissibilidade dada aos próprios usuários ou aos amigos e familiares, permitiu em diversos países a redução dos agravos causados pela heroína, tanto pelos danos ocasionados pela insuficiência a respostas fisiológicas do indivíduo como pela diminuição acentuada dos níveis de morbimortalidade.

A partir deste estudo não se nota significativa alternância dos valores de sobrevivência entre os métodos injetável ou intranasal, porém percebe-se a excelência na terapêutica pelo método com spray pela facilidade de acesso e pela pontualidade da eficiência e da eficácia dele. Seja por profissionais habilitados para técnicas médico-invasivas ou pela comunidade não médica, como bombeiros e policiais, bem como pela população leiga em geral, a utilização da naloxona intranasal minorou de forma extraordinária a mortalidade, o que de forma geral é um excelente indicativo para a sociedade.

Futuras investigações são necessárias para elucidar melhor os benefícios psíquicos, sociais e econômicos ao se permitir que a sociedade em geral tenha acesso ao produto em sua forma intranasal. Indica-se a continuidade dos estudos a fim de mediar a implementação da terapêutica pelo método spray intranasal no Brasil.

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# A novel mathematical modeling to assess the bone mineral density under mechanical stimuli

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Received: 23 Jul 2022,

Received in revised form: 11 Aug 2022,

Accepted: 25 Aug 2022,

Available online: 23 Aug 2022

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**Keywords**— *Bone remodeling, Bone mineral density, Mathematical modeling, Mandible.*

**Abstract**— *Assessing the variation in bone mineral density (BMD) remains as a complex task, given the countless variables and parameters that constitute the boundary conditions. The present study aims to present a novel mathematical modeling to assess the BMD of maxilla and mandible through of bone remodeling under mechanical simulations. The behavior analyze of bone remodeling tissue will be verified by submitting to mechanical stimuli and application of stress on dental implants. The analyze process will use computational tools and mathematical modeling, which should provide the evolution of the density in the bone tissue in the time, considering different mechanical stimuli. The studies on bone remodeling are not specific for the bones that make up the maxilla and mandible. Thereby, the findings don't translate the specific behavior of increased bone density in these regions, reference values are used, however do not demonstrate correlations that are significant between the density of other areas studies with the maxilla or mandible, in view of the fact that bone density may reflect in the responses obtained in relation to orthodontic movements. This study allows determining the appropriate parameters and reference values that correspond to these evaluated regions, whose bone density is variable in the same element and have a great difference in density between the maxilla and the mandible. The use of such suitable reference values in the bone regions may provide a better understanding of the behavior of the bone tissue in the mandibular region as a function of time. The simulations pointed that the loadings can be applied with different types of stimulus. The modeling was able to measure stress loads, indicated to obtain a better response to dental treatments.*

## I. INTRODUCTION

The mechanical resistance of bone tissue is directly related to its mineral density. The behavior of this tissue in relation to its growth, remodeling and resorption, has been the subject of several studies due to its anisotropic characteristic [1]. For this, the study of bone remodeling is based on the Theory of Elasticity [2], for the analysis of structural behavior and variation in bone mineral density (BMD) as a function of mechanical stimuli [3]. Application of mechanical stimuli can induce the cellular activity, which causes the flow of interstitial fluid in the lacuno-canalicular network, and molecular production [4].

Advances in knowledge about bone mineral density associated with the analysis of its regeneration contribute to the implantology treatments [5], which aims to provide an improvement in the condition of oral functions. Nevertheless, the efficiency of an implant is related to its anchorage, which is due to the individual's resistance to occlusion strength. In turn, this condition is related to the mechanical properties of bone on the fixation of dental implants [6].

Bearing in mind that each individual responds in a different way, and that the biological formation of bone tissue depends on the health conditions of each person, the response of bone regeneration may not meet normal clinical expectations. To improve the response to treatment, the application of mechanical stimuli causes an increase in cell activity and bone density, for satisfactory recovery of mandibular functions [7].

In a brief overview of some of the major studies, Wolff was the first to analyze the behavior of the bone tissue structure subjected to loads. From his pioneering work, studies on the modeling and remodeling of bone tissue began. Cowin and Hegedus [2] describe bone tissue as an elastic material that adapts its structure to the load applied. Huiskes and Weinans [8] present a study on adaptive remodeling using energy density as a control variable to determine bone density. Frost [9] introduces structural adaptations of the skeleton to mechanical stress, whose biological, biomechanical and clinical-pathological knowledge was not available in previous studies. Yang et al. [10] propose a method for analyzing a set of elastic constants of the spongy bone, resulting in Hooke's orthotropic law, which depends on the fraction of solid volume for spongy bone. Crupi et al. [11] study on mechanical stimulus, corresponding to the maximum value of the overload stress, through the application of Taylor's theory of crack propagation.

Currently, there are methods capable of providing data to satisfy mathematical equations applicable to assess the variation in bone mineral density (BMD). However, this

assessment is still a complex task, given the countless variables and parameters that constitute the boundary conditions. Computer simulations constitute an alternative, which allows for varying the initial conditions of the problem, generating results in real-time, comparative analyzes, making research less costly, faster and capable of evaluating multiple scenarios.

In this context, the present study aims to evaluate the variation in bone mineral density (BMD) of maxilla and mandible through bone remodeling under mechanical stimuli, considering static and variable loads. Moreover, variation in BMD was also compared to results reported in the literature, available for analysis with static loads.

Results reported in the literature on modeling bone density variation have been based on the Euler method [12], for the integration of the differential equation that describes the behavior of the tissue in response to static stimuli. As a contribution to the advancement in this area of knowledge, the present study introduces a model based on the fifth-order Rung-Kutta method, which provides a more accurate integration, with less computational effort.

## II. MATERIALS AND METHODS

To analyze the evaluate the variation in bone mineral density, a novel mathematical model based on partial differential equations was developed, with an algorithm written in Python language, for simulating static and variable mechanical stimuli. At the beginning of the process, the model simulated the application of static loads, which remains constant for a period of time (equation 1):

$$\frac{d\rho}{dt} = B \left( \left( \frac{\sigma^2}{2C\rho^4} \right) - k \right) - D \left( \left( \frac{\sigma^2}{2C\rho^4} \right) - k \right)^2 \quad (1)$$

where, the value of each constant is given according to Huiskes and Weinans (1992),  $k$  ( $J \cdot g^{-1}$ ) is the limit value for the stimulus,  $B$  ( $g \cdot cm^{-3}$ )<sup>2</sup>  $\cdot$  ( $MPa \cdot time \ unit$ )<sup>-1</sup>, and  $D$  ( $g \cdot cm^{-3}$ )<sup>3</sup>  $\cdot$  ( $MPa^2 \cdot time \ unit$ )<sup>-1</sup> are constants. Bone density is given by  $\rho$  ( $g \cdot cm^{-3}$ ).  $C$  (MPa) is the compression module, as Carter and Hayes [13]. The variation in bone density is expressed as a function of mechanical stimuli [8], where the range of bone density variation is  $0 < \rho \leq \rho_{cb}$ , and  $\rho_{cb}$  ( $g \cdot cm^{-3}$ ) is the maximum bone density.

An algorithm was built to solve equation (1), which corresponds to the variation of bone density over time. As an innovation in this study, equation (2) was modified to analyze the rate of change in bone tissue density, through exposure to various mechanical stimuli using two waveforms: sine wave and wave generated by the linear



combination of sine-cosine. Stress variable  $\sigma$  was replaced by the simple harmonic motion equation, where A is the stress amplitude applied,  $\omega$  is the frequency of the oscillatory motion, t the time, and  $\alpha$  is the initial phase, so that:

$$\sigma = A \cdot \text{sen}(\omega t + \alpha) \quad (2)$$

Replacing the eq. 2 in eq. 1 we have equation 3, which represents the simulation of the variation of bone density as a function of variable mechanical stimuli by periodic waves with sinusoidal shape:

$$\frac{d\rho}{dt} = B \left( \left( \frac{(A \cdot \text{sen}(\omega t + \alpha))^2}{2C\rho^4} \right) - k \right) - D \left( \left( \frac{(A \cdot \text{sen}(\omega t + \alpha))^2}{2C\rho^4} \right) - k \right)^2 \quad (3)$$

In the analysis of the variation in bone density, applying mechanical stimuli with periodic waves, mechanical stimuli were also evaluated when applied through waves with a format generated by the linear combination of sine-cosine. Likewise, the stress  $\sigma$  has been replaced by the simple harmonic motion equation, where A is the stress amplitude,  $\omega$  is the pulsation, t is the time,  $\Phi$  and  $\alpha$  are the initial phase for cosine and sine respectively, so that:

$$\sigma = A \cdot (\cos(\omega t + \phi) + \text{sen}(\omega t + \alpha)) \quad (4)$$

Replacing the eq. 4 in eq. 1 we have equation 5, which represents the simulation of bone density variation as a function of variable mechanical stimuli by periodic waves, due to the linear combination of sine and cosine.

$$\frac{d\rho}{dt} = B \left( \left( \frac{(A \cdot (\cos(\omega t + \phi) + \text{sen}(\omega t + \alpha)))^2}{2C\rho^4} \right) - k \right) - D \left( \left( \frac{(A \cdot (\cos(\omega t + \phi) + \text{sen}(\omega t + \alpha)))^2}{2C\rho^4} \right) - k \right)^2 \quad (5)$$

The application of varied mechanical stimuli in this study aimed to analyze the behavior of bone tissue, when subjected to this type of loading, and to verify whether the change in the form of application of loads offers any benefit for increasing bone mineral density.

Considering the mathematical model of equation (1), an algorithm for the analysis of bone remodeling and adaptation was built, based on the Range Kutta method of order 5, considering the same parameters proposed by Jianying (Li et al., 2007):  $k = 0.004 \text{ Jg}^{-1}$ ;  $B = 1.0 \text{ (gcm}^{-3}\text{)}^2 \text{ (MPa time unit)}^{-1}$ ;  $C = 3790 \text{ MPa (gcm}^{-3}\text{)}^{-2}$ ;  $D = 60.0 \text{ (gcm}^{-3}\text{)}^3 \text{ MPa}^{-2} \text{ (time unit)}^{-1}$ . The constant time interval  $\Delta t$  adopted was  $10^{-4}$ . This very small value of the integration step has the function of avoiding specific errors or

truncation in the process of numerical integration of the partial differential equation. The initial bone density was adopted as  $\rho_0 = 1.0 \text{ g.cm}^{-3}$ .

In the case of variable mechanical stimuli, the following were also considered:  $\omega = \pi / 100$ ;  $\alpha = \text{zero}$ ; and  $\Phi = \text{zero}$ . For a period of  $\pi / 100$ , the frequency will be 0.01 Hz. The definition for a very low frequency was made due to the behavior of the bone remodeling process in relation to different frequency levels. After performing a simulation using frequencies from 1 to 20 Hz, it was found that the density variation does not show growth in the bone mass rate, that is, the higher the frequency, the greater the resorption. This corroborates that, even when the rate of cell activation increases as a function of frequency, the rate of change in bone density is inversely proportional [14].

### III. RESULTS

In the simulation of static mechanical stimuli on a bone sample submitted to a uniaxial load, the model provided the results shown in Figure 1, in which the evolution of bone density variation from different stress levels can be observed.

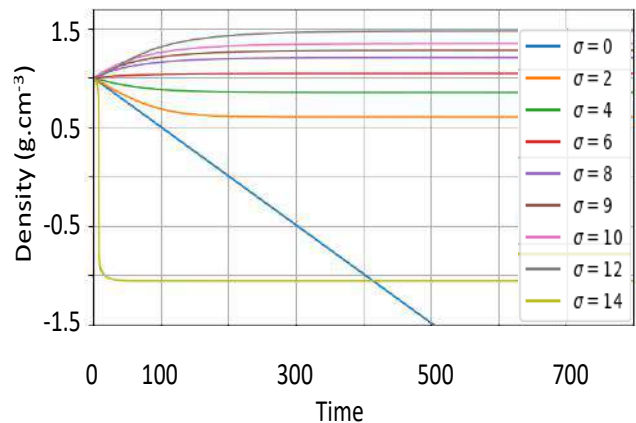


Fig.1. Density variation as response of static mechanical stimuli over time.

Applying a stress from 0 to 4 MPa, we verify that the density decreases indicating loss of mass, when submitted to low or zero stresses. In this stress range, bone loss occurs because the stimuli are not sufficient to cause deformations capable of triggering biochemical processes necessary for bone remodeling. Under 6 MPa it is possible to note a variation in BMD, indicating that from this level of stress occurs stimuli of the tissue to the point of provoking the beginning of biochemical reactions, which activate the cells and the remodeling process. For stresses from 8 to 12 MPa, we observed that the BMD undergoes a considerable increase over the time of exposure to the mechanical stimulus, due to a greater cellular activity. On

the other hand, with higher stresses, from 14 MPa, the BMD decreases abruptly due to the resorption overload. When there is a very high-stress level the behavior of bone tissue responds with loss of density due to tooth resorption [12]. Excessive mechanical stimuli applied to bone tissue present an inversion of the cellular biochemical process, not only canceling the effect of increasing bone density, but also causing rapid and total loss of bone mass. This effect would be close to that of rupture of bone tissue.

Figure 2 presents the results of the variable mechanical stimuli with frequency of sine waves. The effect of stress variations on bone density using this type of waves is due to sinusoidal fidelity. The sine waves enter and leave a linear system in the same way, being able to undergo changes in amplitude and phase, but always maintaining the original frequency.

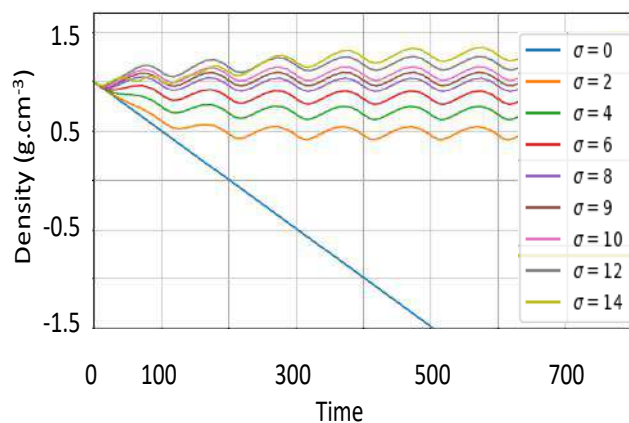


Fig.2. Density variation as response of variable mechanical stimuli, with frequency of sine waves over time.

For a stress of up to 6 MPa, it is noted that BMD decreases, showing bone loss when subjected to a variable tension oscillating in a sine wave frequency. The bone density values for this stress range vary from zero to 0.76  $\text{g.cm}^{-3}$ . Applying a sinusoidal oscillatory stimulus with a frequency of 0.01 Hz, it appears that the stress range keeps the bone tissue at rest, incapable of deformations that trigger biochemical reactions, necessary to increase bone density. Under the action of a stress of 8 MPa, the bone density undergoes little variation, showing a very small density gain, maximum of 1.05  $\text{g.cm}^{-3}$ . From that level of stress, the deformations are sufficient to provoke biochemical reactions. However, still inefficiently to cause an increase in bone density. For higher stresses, between 9 and 12 MPa, we observed that the BMD undergoes a considerable increase over the time of exposure to the mechanical stimulus, whose maximum values reach 1.25  $\text{g.cm}^{-3}$ . From 14 MPa on, BMD increases, reaching a maximum value of 1.35  $\text{g.cm}^{-3}$ , changing the behavior of

bone tissue in relation to a static loading that presents bone resorption. In the simulation of the variable mechanical stimulus for this stress level, there was a change in the behavior of the bone tissue, leaving a resorption condition for a bone density increase regime.

The results obtained with the processing of the algorithm, considering mechanical stimuli with frequency of waves by the linear combination of sine-cosine, are presented in Figure 3.

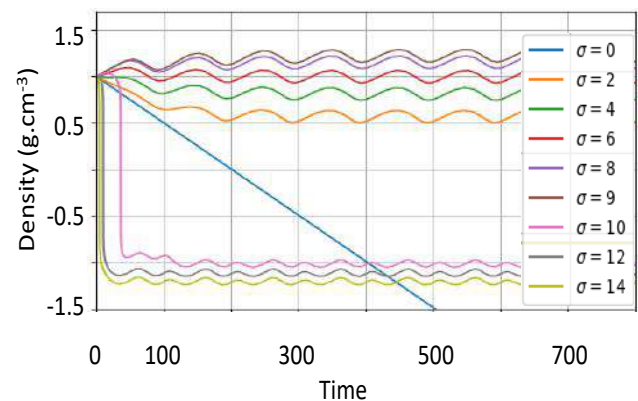


Fig.3. Density variation as response of variable mechanical stimuli, with frequency of sine-cosine waves over time.

Subjecting the bone tissue to a stress from 0 to 4 MPa, we observed that the density decreases, showing resorption when applied low or zero stresses, varying over time according to a wave generated by the linear combination of sine and cosine. The values obtained for this tension range reached 0.74  $\text{g.cm}^{-3}$ . The findings for this stress range shows that even changing the form of application of the mechanical stimulus, whether static, varying like a sine wave or a wave resulting from the linear combination of sine and cosine, the resting region remains the same. Under 6 MPa, the BMD undergoes little variation, showing the beginning of density gain, with a maximum value of 1.10  $\text{g.cm}^{-3}$ . This analysis showed the best result among the simulations performed. Deformations were greater, indicating an increase in biochemical reactions that activate bone density gain. When applied stresses between 8 and 9 MPa, we observed that the BMD increases over time of exposure to the mechanical stimulus, whose maximum values presented were 1.22 and 1.29  $\text{g.cm}^{-3}$ , respectively. In this stress range, the values were slightly higher than those generated by static mechanical stimuli. This result indicates that, in this range, varying the shape of the mechanical stimulus can provide density gain. However, under higher stresses, from 10 MPa onwards, BMD decreases rapidly and abruptly, due to the resorption overload. From this stress level, the load applied

by this type of vibration present deformations that exceed the resistance of the bone tissue, leading to rupture.

#### IV. DISCUSSION

In view of the clinical demand for better treatment conditions, scholars have sought to advance in understanding the variation in BMD [7]. The present study sought to contribute with a mathematical model for computer simulation, based on parameters related to the boundary conditions reported in the literature [8, 11, 12, 15]. The novel model was able to emulate the behavior of bone tissue subjected to static and varied stimuli over time.

##### BONE TISSUE BEHAVIOR

In dynamic load simulations, the frequency of vibration also influenced the behavior of bone tissue, affecting the BMD. The results show that the lower the frequency of vibration, the greater the increase in bone density until reaching the resorption limit. The results show that the behavior of bone tissue can be defined in three states, according to the stress range and type of stimuli (Table 1).

Table 1. Bone tissue behavior as loading ranges (MPa).

Type	Stimuli	First	Second	Third
Static	Constant	$0 \leq \sigma < 6$	$6 \leq \sigma \leq 12$	$\sigma > 12$
Variable	Sine wave	$0 \leq \sigma < 8$	$8 \leq \sigma \leq 14$	$\sigma > 14$
Variable	Sine-cosine wave	$0 \leq \sigma < 6$	$6 \leq \sigma \leq 9$	$\sigma > 9$

The first range consists of the idle zone, in which the stresses are insufficient to cause bone remodeling. In this range, bone resorption occurs, causing a reduction in BMD. The loading values vary according to the type of load application, as well as due to the variation of the application parameters. Therefore, the idle zone does not provide a linear response to the behavior of bone tissue in relation to mechanical stimuli. The simulation with static and varied stimuli, according to a sine-cosine wave, presents the same stress range for the idle zone, between 0 and 4 MPa. In turn, the simulation with loading varied according to a sine wave presents a more comprehensive idle zone, reaching 6 MPa. For this wave pattern, and parameters adopted in the study, the simulation shows that the idle zone can vary in the level of stress capable of causing sufficient deformations, with the capability of changing the flow of canalicular fluid, and trigger the biochemical and cellular response.

The second range contains the stress limits at which bone remodeling can occur, causing an increase in BMD [16]. This range causes the expected effect on the behavior of bone tissue, resulting in increased density and promoting osseointegration. The simulations indicate that the behavior of the bone tissue becomes even more non-linear as the stress level increases. In this range, stresses cause deformations that alter the flow pattern of canalicular fluid to the point of triggering bone remodeling with increasing density. In the varied loading with sine-cosine wave pattern, the bone remodeling range is the one with the lowest amplitude (6 and 9 MPa) among the simulated ones, and in the varied loading with sine pattern this range starts from a higher stress level (8 MPa).

The third loading range has an overload level that does not promote bone remodeling, but causes resorption with loss of bone density. In this range, the deformations can be increased to the point of causing fractures in the bone tissue. The stresses also has no linear behavior for each type of loading. The response of the behavior of bone tissue in relation to the level of overload may vary depending on the type of loading and the form of variation, and increase or decrease the limit of overload of the tissue. The results show that for a static load the overload limit is 12MPa, while for varied loading with a sine wave pattern the overload limit rises to 14 MPa. However, when the sine-cosine wave pattern is varied, the overload limit drops to 9 MPa (Figure 4).

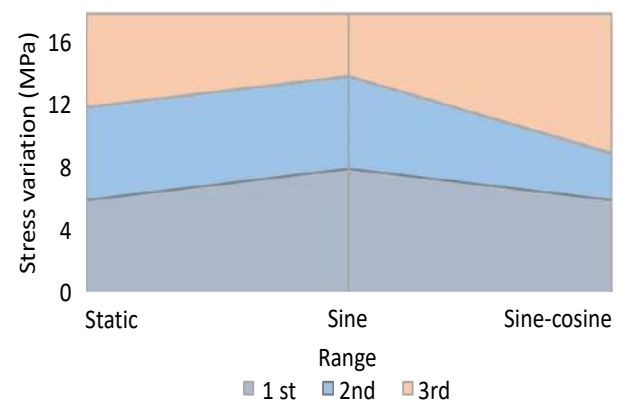


Fig.4. Loading ranges - Stress variation x Stimulus type.

From the above, the simulations point out that the way of applying mechanical stimuli influences the bone density response, being able to alternate between resorption and remodeling for the same loading level. Thus, the model developed can contribute to meeting clinical demands, since it provides the responses of bone behavior as a function of mechanical stimuli.

**VARIATION ACCORDING TO STIMULUS AND STRESS**

Findings show that there is no single condition of mechanical stimulus capable of providing an increase in bone density, but that changing the type of loading allows variable responses to be reached for the same stress levels (Table 2). The reference value used in the simulation for the standard density was 1.0 g.cm<sup>-3</sup>.

Table 4. Variation in BMD according to stimulus and stress.

Stress (MPa)	Variable loading					
	Static loading		Sine wave			
	Density (g.cm <sup>-3</sup> )	Variation (%)	Density (g.cm <sup>-3</sup> )	Variation (%)	Density (g.cm <sup>-3</sup> )	Variation (%)
0	0.00	----	0.00	----	0.00	----
2	0.60	-40	0.41	-59	0.50	-50
4	0.85	-15	0.61	-39	0.74	-26
6	1.04	4	0.76	-24	1.10	10
8	1.20	20	1.05	5	1.22	22
9	1.28	28	1.10	10	1.29	29
10	1.35	35	1.15	15	0.00	-100
12	1.48	48	1.25	25	0.00	-100
14	0.00	-100	1.35	35	0.00	-100

The application of static mechanical stimuli provided a bone density variation with an increase in density between stress levels 6 and 12 MPa, allowing bone tissue development from 4 to 48% by mass. On the other hand, stress levels outside this range (6 to 12 MPa) cause bone loss.

In the varied loading with sine wave pattern, the results show a different behavior. The increase in bone density starts from 8 MPa and goes up to 14 MPa, varying between 5% and 35%. It is worth mentioning that for the stress level of 14 MPa, the simulation pointed out that the type of loading alters the behavior of bone tissue, influencing from resorption to increased density. The simulation with sine-cosine wave pattern resulted in an increase in density between 10% and 29% in the stress range of 6 to 9 MPa. The outcomes show that the density gain is greater than those obtained in other types of loading for the same stress levels.

These findings indicate that the use of different forms of load influences the increase in BMD, but also can cause the increase in bone loss (Figure 5).

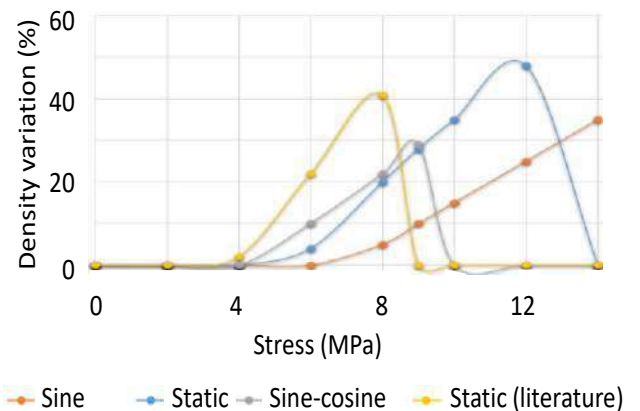


Fig.1 Density Variation x Stress level by type of loading.

Previous results have been based on the Euler method, to emulate the behavior of the tissue in response to mechanical stimuli [12]. As an alternative, this study introduced a model based on the 5th order Rung Kutta (RK) integration method, which provides more accurate results, with less computational effort. The outcomes obtained by Li et al. [12] are presented in Table 5.

Table 5. Variation in bone density in response to loading.

Stress (MPa)	Density (g.cm <sup>-3</sup> )	Variation(%)
0	0.00	-100
2	0.72	-28
4	1.02	2
6	1.22	22
8	1.41	41
9	0.00	-100

Source: elaborated from Li et al. [12].

Analyzing Table 5, it is noted that the authors applied the maximum limit of 9 MPa, with a reference density value for analysis of variation equal to 1.0 g.cm<sup>-3</sup>, the same one adopted in our study. The results of the literature indicate that the first stress range, which represents insufficient levels to activate cellular processes, is between 0 and 2 MPa. The increase in BMD starts from 4 MPa and extends to 8 MPa (second range), with the overload level reached 9 MPa (third range). Table and Figure 6 present a comparison between the results in the literature and those obtained in this study.

Table 6. Comparison of results for static loading.

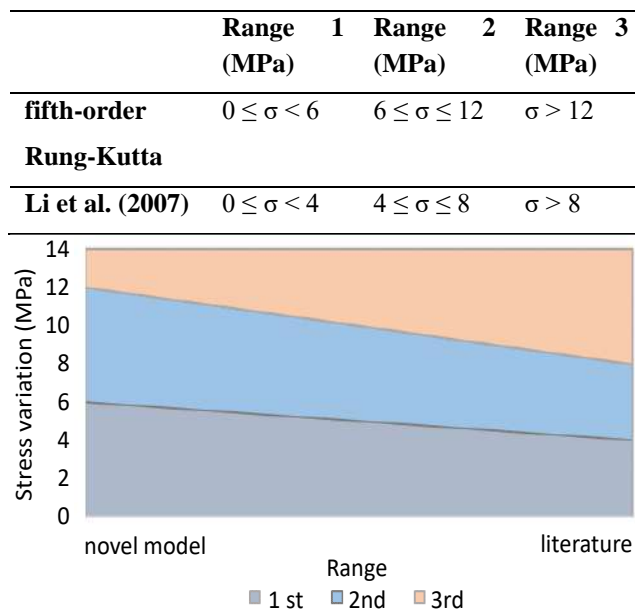


Fig.6. Comparison of results for static loading.

## V. CONCLUSION

Assessing the variation in bone mineral density (BMD) remains a complex task, given the countless variables and parameters that constitute the boundary conditions. This study introduced a novel model developed to analyze the variation in BMD, as a response to the application of mechanical stimuli. From our results, it is highlighted that the behavior of bone tissue doesn't have a linear response to different types of mechanical stimuli, both static and variable. The loading ranges, both for stresses that cause bone resorption, for those capable of promoting an increase in density, or causing fractures in the tissue, may vary according to the type of mechanical stimulus. In conclusion, the results corroborate the promising viability of using mechanical stimuli to increase bone density. The simulations pointed that the loadings can be applied with different types of stimulus. The modeling was able to measure stress loads, indicated to obtain a better response to dental treatments.

## ACKNOWLEDGEMENTS

An acknowledgement section may be presented after the conclusion, if desired.

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# Urban Morphology in Coastal Cities

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Received: 22 Jul 2022,

Received in revised form: 14 Aug 2022,

Accepted: 18 Aug 2022,

Available online: 23 Aug 2022

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**Keywords**— *Architecture, Climate Change,  
Sustainability, Rural Centers.*

**Abstract**— *In a close future, in which cultural heritage will represent a path with historical value and will be studied by the aesthetic, ethnological or anthropological point of view, the urban rehabilitation will appear as a commitment between the past and the present (future) and the sustainable, inclusive and intelligent development. Linking all these elements with all of different characteristics, from an objective point of view, the investigation will not seek miraculous solutions to old difficulties of spatial planning or rapid resolution of emerging problems, because more than expanding the generalist field of knowledge or giving a new academic precision to an empirical approach, the research aims to deepen scientific knowledge about the fishing settlements located on the border line provided by the sea line, and about the rural settlements delimited by the plow wake that once furrowed the land, with resilient particularities achieved in an unique and shared ambience because we will support the investigation in this “living-lab” and reply this research as a model on similar large-scale environments on Earth.*

## I. INTRODUCTION

Coastal cities are prioritized and relevant to climate change, sea-level rise, temperature and natural disaster monitoring, and the development of potential solutions to emerging urban problems. These points are very relevant to our investigation because even though the investigation will not seek miraculous solutions to old difficulties of spatial planning or rapid resolution of emerging problems, it will link the knowledge about the future and anticipate the changes drawing urban plans, planning and rebuilding coastal cities conserving their identity, their genius loci and make advances that in the “time of change” seems to be empirical.

## II. UNITED NATIONS SUSTAINABLE DEVELOPMENT

The 2030 Agenda for Sustainable Development, “adopted by all United Nations Member States in 2015,

provides a shared blueprint for peace and prosperity for people and the planet, now and into the future. At its heart are the 17 Sustainable Development Goals (SDGs), which are an urgent call for action by all countries - developed and developing - in a global partnership. They recognize that ending poverty and other deprivations must go hand-in-hand with strategies that improve health and education, reduce inequality, and spur economic growth – all while tackling climate change and working to preserve our oceans and forests.” [1] We believe that in 2030 we will achieve 17 goals, 169 targets, 3506 events, 1326 publications and 6499 actions. In these objectives are particularly relevant to this investigation the 11<sup>th</sup> and 13<sup>th</sup> goals. The 11<sup>th</sup> goal, as we can overview in fig. 1, has the priority to make cities and human settlements inclusive, safe, resilient and sustainable. It is mandatory that we can build a better world in habitation (safety, accessible price, better sanitary conditions), in transportation, in the protection of cultural and natural heritage, the reduction of

people affected by catastrophes, build better and safer public space, in others. The DRR (disaster risk reduction) in a major part of our future development because we need to build cities and settlements in a solid ground.

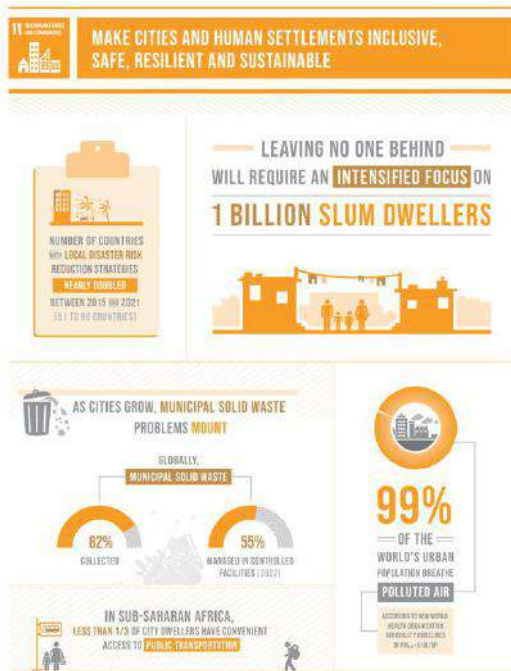


Fig. 1 - Overview of the 11<sup>th</sup> goal of UN

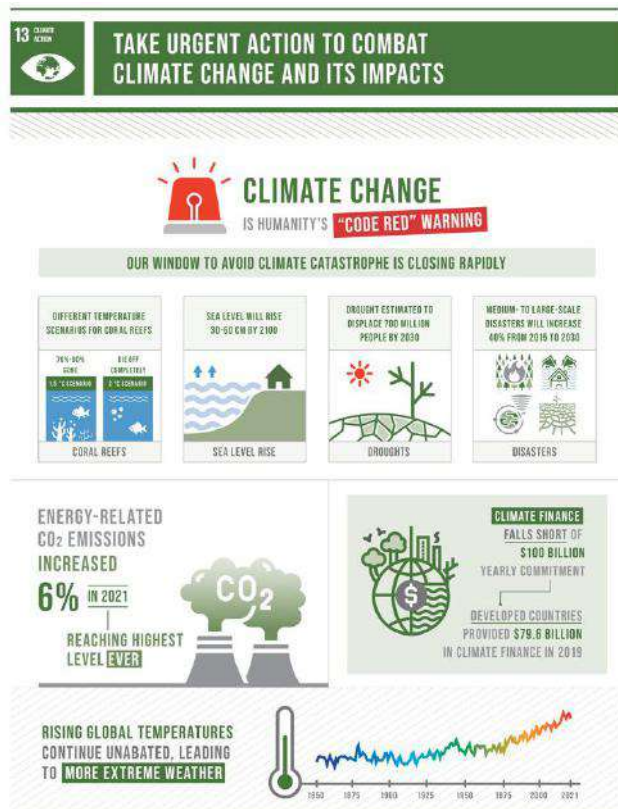


Fig. 2 - Overview of the 13<sup>th</sup> goal of UN

The 13<sup>th</sup> goal, as we can overview in fig. 2, has to take urgent action to combat climate change and their impacts. This goal is particularly important to reinforce the resilience and the capability to adopt to the risks related to climate and natural catastrophes in all countries relating politics with research and strategies e national planning.

It's very important to all countries and municipalities that integrate in education the conscience about the measures of mitigation, adaptation and reduction of impact and earlier alert in what concerns to climate changes and the impact in population life's.

### III. CASE STUDY: MUNICIPALITY OF MATOSINHOS, PORTUGAL

In the Sustainable Development Goals Report 2022 says that "According to the Report, cascading and interlinked crises are putting the 2030 Agenda for Sustainable Development in grave danger, along with humanity's very own survival. The Report highlights the severity and magnitude of the challenges before us. The confluence of crises, dominated by COVID-19, climate change, and conflicts, are creating spin-off impacts on food and nutrition, health, education, the environment, and peace and security, and affecting all the Sustainable Development Goals (SDGs). The Report details the reversal of years of progress in eradicating poverty and hunger, improving health and education, providing basic services, and much more. It also points out areas that need urgent action in order to rescue the SDGs and deliver meaningful progress for people and the planet by 2030." [2]

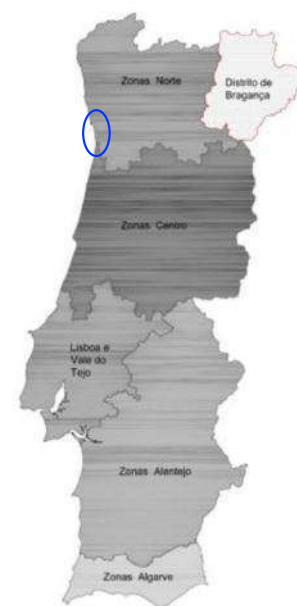


Fig. 3 – Map of Portugal with location of Matosinhos Municipality

With all this knowledge in mind the relevance of the research project with scientific support centered on smart cities, sustainability and urban regeneration, to be developed around the fishing settlements and diffuse rural core, located in the sea coast of North of Portugal territory, in the Union of the Parishes of Perafita, Lavra and Santa Cruz do Bispo, in the Municipality of Matosinhos, pointed in fig. 3, will be understood here in the dialectical perspective of an open work related with high impact of climate change, sea-level rise, developing solutions to emerging problems, recovering the interaction between formal logic and dialectical logic and in between diachronic and synchronous readings, which seek to deepen scientific knowledge about:

1. Coastal places and cores that correspond to the old fishing and rural settlements and the analysis of their morphological and functional characteristics;
2. Meshes and axes that correspond to the growth processes of the primitive cores related to sea-level rise;
3. Connection between urban fishing subsystems, diffuse rural and periurban cores in a perspective of resilience and sustainability developing solutions to design a smart green city;
4. Urban regeneration processes within a framework of strategic convergence that values the development of inclusive citizenship processes responding with solutions to emerging urban problems.
5. Urban regeneration sustained by the development of transportation systems and internet-of-things connectivity.
6. Estimative of the impact of climate changes and the development of different policies and strategies that minimize the risks.

#### IV. SEA LEVEL RISE

This topic included in the 13<sup>th</sup> goal of the UN Sustainable Development underline that “the world is on the brink of a climate catastrophe, and the window to avert it is closing rapidly. Increased heatwaves, droughts and floods caused by climate change are already affecting billions of people around the world and causing potentially irreversible changes in global ecosystems.

To limit warming to 1.5° Celsius above pre-industrial levels, as set out in the Paris Agreement, global greenhouse gas emissions will need to peak before 2025. Then they must decline by 43 per cent by 2030, falling to net zero by 2050, according to the Intergovernmental Panel on Climate Change (IPCC), the United Nations body responsible for assessing the science related to climate change. In response, countries are articulating climate action plans to cut emissions and adapt to climate impacts through nationally determined contributions. However, current national commitments are not sufficient to meet the

1.5 °C target. Under these commitments, greenhouse gas emissions are projected to increase by almost 14 per cent over the next decade. Immediate and deep reductions in emissions are needed across all sectors to move from a tipping point headed to climate calamity to a turning point for a sustainable future.” [3]

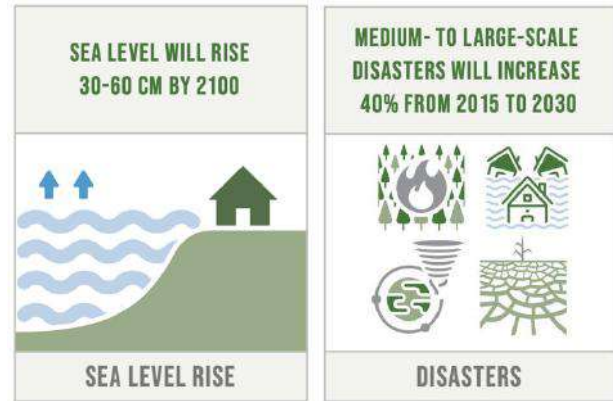


Fig. 4 – Previsions of natural disasters

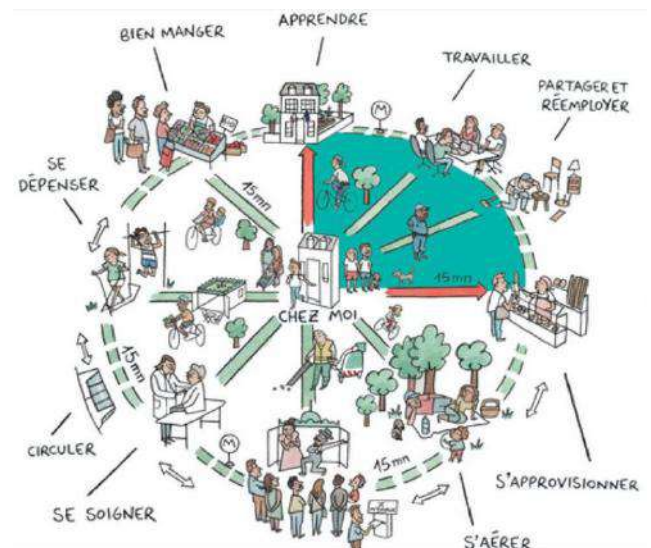


Fig. 5 – City of 15 minutes by Prof. Doutor Carlos Moreno

All this Knowledge allow us to work on these emerging problems developing models that treat coastal places in a very attractive places to live, to invest and to create families and children. It is possible in this case study in Municipality of Matosinhos to create a 15' city with Carlos Moreno [4] principles adding to old fishing and rural settlements the agricultural places very characteristics in that area.

In the wake of the Covid-19 pandemic, our lifestyle, our work, family and leisure routines, among others, were profoundly modified by introducing the online model and in some cases hybrid, which uncovered the time and resources we spend on a daily to move, wasting time to



really have quality of life. These premises, which would take years to be perceived by society, were incorporated by the population at a glance, bringing Carlos Moreno's concept of city to the order of the day. "This is a revolutionary concept. It is the possibility of fighting climate change and at the same time changing our lifestyle. It is the opportunity to have more peace, greener streets, walk or cycle, shop close to home, have access to multiple services, etc. But what is the city of 15 minutes? The idea is to transform the cities we currently have into cities that serve people and not cars. from a central city to a polycentric model, with decentralized services, which people reach in 15 minutes on foot or by bicycle, namely the six essential aspects of our lives, such as working, going to school, medical services, places to do shopping and leisure spaces." [5]

## V. CONCLUSION

This paper reports a work in progress under a research project under the title: Urban Morphology and Sustainability: Piscal and Settlements and Diffuered Rural Nucleous. This work will be developed in three years and the work we are presenting here refers to phase one where we prepare the general framework of the territory in the local and regional context; is secure to affirm that if we don't plan our coastal cities we will loose valuable heritage, but fortunately with all efforts developed under the theme we can predict some future and act before.

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# Banking Credit Risk Analysis with Naive Bayes Approach and Cox Proportional Hazard

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Received: 20 Jul 2022,

Received in revised form: 13 Aug 2022,

Accepted: 17 Aug 2022,

Available online: 23 Aug 2022

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**Keywords**— *credit status, survival analysis, naive Bayes, cox ph, machine learning.*

**Abstract**— *Credit is needed for some people for certain purposes. In credit, it takes a party that can be used as an intermediary such as a bank. The debtor may not be able to make payments according to the original policy or even cause losses where the Bank may lose the opportunity to earn interest, causing a decrease in total income. This problem is included in the case of non-performing loans. In statistics, the duration of time between a person not making a payment on time until a non-current loan occurs can be predicted using survival analysis. Meanwhile, to predict credit status, you can use classification or prediction methods in machine learning to find out how much influence the predictor variable has. In this study, with a different case, focusing on the credit risk case of how a bank decides to provide credit to prospective debtors using the classifier method found in Machine Learning, namely Naive Bayes and Cox regression from survival analysis. Through the evaluation test of the naive bayes classifier model using accuracy values, confusion matrix and ROC, it can be concluded that this model is a model with good performance for predicting credit status. Multinomial naive Bayes in this study has a higher performance value than Gaussian Naïve Bayes and Bernoulli Naïve Bayes which is 92%. Through cox regression, it is obtained that income factors and loan history have a major influence on determining credit status.*

## I. INTRODUCTION

The increasing population growth is directly proportional to the increasing demand and need for consumption such as buying a house, private vehicle or the need to increase business. However, not all needs can be met easily, people need more sources of funds, so most of them need credit. Debtors may not be able to make payments according to the initial policy or even cause losses to the Bank wherein the Bank may lose the opportunity to earn interest, causing a decrease in total income. This problem is included in the case of non-performing loans. Non-performing loans are events when the debtor does not meet the requirements according to the

agreement such as interest payments, repayment of loan principal, increase in margin deposits, and increase in collateral, and so on (Mahmoeddin, 2010).

In statistics, the duration of time between a person not making a payment on time until a non-current loan occurs can be predicted using survival analysis. The survival analysis model is a model that deals with testing the length of the time interval between transition periods. Several methods of survival analysis that can describe the survival of an object and the relationship between independent variables and dependent variables include the life table method, Kaplan-Meier and Cox regression or also called Cox proportional hazard regression. According to

Kleinbum and Klein (2012), Cox proportional hazard is a model used to estimate survival when considering several independent variables simultaneously. The advantage of this model is that it does not have to have a function of a parametric distribution. In addition to using survival analysis to build a predictive model on credit risk, you can also use the Classification method or the Classifier method to determine consumer behavior so that you can determine the credit risk class as consideration for deciding whether members are potential debtors or not. The results of research conducted by Fard (2016) show that the accuracy of the Bayesian method (NB and BN) and the Cox method is quite high, namely 71.5% each; 71.8%; 71.7% used AUC, 64.2%; 67.3%; 65.8% using the accuracy value, and 76.2%; 77.3%; 65.1% using the F-measure value. In this study, it aims to find out how a bank decides to provide credit to prospective debtors using the classifier method found in Machine Learning, namely Naive Bayes and Cox regression from survival analysis. first then the data is broken down into training data and testing data which will then be used in the modeling stage. The variables involved included gender, age, income, loan amount, occupation, credit history (history of bad debts or not), interest rate, total to be paid, and credit status. The results of this study are expected to provide information to the management of a bank about credit analysis that can help make the right decisions in providing credit to prospective debtors so that they can overcome credit problems that can occur.

**II. INDENTATIONS AND EQUATIONS**

**2.1 Data and Data Sources**

The data used in this study is credit data obtained from a bank in East Java. A total of 610 debtor data were obtained from 2015-2019. Information on the variables is used as follows:

*Table 1 :Variables obtained*

No	Variables/features	description
1.	Gender	Gender of debtor
2.	Plafond/ceiling	Amount of loans owned by the debtor
3.	Rate/interest rate	The amount of interest that applies when the loan is realized
4.	Tenor/Time period	Term of the vredit period taken by the debtor, the length of the loan is recorded in months
5.	Realization date	Realization date

6.	Due data	Due date
7.	Job	Debtor's occupation
8.	Income	Debtor's income
9.	Installment (per month)	Deferred installments to debtors
10.	Dependent total	Total dependent along with additional services
11.	Pledge	The security for a loan provided by debtor
12.	Credit history	Other bank loan history
13 .	Credit status (output/target variable)	Good credit or bad credit

**2.2 Research Steps**

The following describes several research methods for solving these problems. This research uses a Python programming application (using Anaconda or Google collaborative software), carried out according to the following procedure.

**1. Problem Identification**

In the first stage, identification of the problems to be discussed will be carried out, starting from looking for topics, literature related to research materials and making research proposals.

**2. Preprocessing Data**

Before the data is processed, the data will be preprocessed. Data preprocessing aims to build the final dataset which is then processed at the modeling stage. Several steps of data preprocessing include selecting tables, records, and selecting data attributes/features/variables as inputs or as targets/outputs. In addition, there are several processes in data preprocessing that will be used in this study, namely:

**a. Data Cleaning**

The process of removing inconsistent or irrelevant noise and data.

**b. Data Integration and Transformation**

The process of combining data from various databases into one new database and changing the data format according to the method to be used

**3. Modeling**

**a. Machine learning method**

Before carrying out the modeling stage, the new data obtained from the preprocessing stage is split by dividing the data into 2 types, namely training data and

testing data. The next stage is model development using Naive Bayes and Bayesian Network methods, using training data. Then the model is tested using data testing.

1). Naïve Bayes method:

- a). Reading training data
- b). Determine the probability of each input variable from the training data by calculating the appropriate amount of data from the same category divided by the number of data in that category.
- c). The probability value obtained is entered into equation (2.1)

$$P(C_i|X) = \arg \max \frac{P(X|C_i).P(C_i)}{P(X)}$$

$$P(y(t_c) = 1|x, t \leq t_c) = \frac{P(y(t_c) = 1, t \leq t_c) \prod_{j=1}^m P(x_j|y(t_c) = 1))}{P(x, t \leq t_c)}$$

b. Survival analysis method

Build cox PH model based on train data and test data

$$h(t) = h_0(t) \times \exp(\beta X_{1i} + \beta X_{2i} + \dots + \beta_p X_{pi})$$

#### 4. Measuring Model Performance

Using a confusion matrix to see the accuracy of the model by paying attention to the value of precision, recall, and F1-score. Furthermore, the ROC curve is also used to measure the performance of the classifier in predicting output.

### III. FIGURES AND TABLES

#### 3.1 Results and Discussion

The data used in this study is credit data using type III censorship, namely borrower data entered into observations at different times.

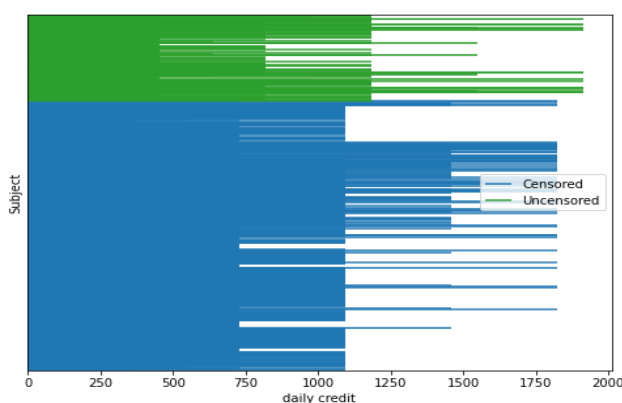


Fig.1: Credit Status Plot (in days)

The characteristic analysis for categorical variables is as follows.

Table 2: Analysis of the characteristics of each variable

Predictors	Categories	Status		Percentage
		0 (good)	1 (bad)	
Gender	male	283	84	60,16%
	female	179	64	39,84%
Job	Trader	198	40	39,02%
	Transport service	135	24	26,06%
	Fisherman	60	14	12,13%
	Shrimp farm	21	32	8,69%
	Stall owner	19	18	6,06%
	Entrepreneur	22	13	5,74%
Ponds owner	7	7	2,30%	
Pledge	SHM (property rights letter)	346	74	68,85%
	BPKB (certificate of ownership of motor vehicles)	116	74	31,15%
Credit history	Good	391	7	65,25%
	Bad	71	141	34,75%

Based on “Table 2”, the majority of people who apply for loans are male, amounting to 60.16%, have jobs as traders or owners of transportation services. The majority of borrowers provide collateral in the form of certificates of ownership (SHM) as bank guarantees rather than BPKB. When viewed from the loan history, debtors who have been in arrears show a greater chance of experiencing bad credit than debtors with a history of current credit.

#### 3.2 Splitting Data (Split Data)

The data split in this study used the train test split technique with a ratio of 80:20 each for train data (x train, y train) and test data (x test, y test) at random. The following is a table of data splitting results.

Table 3 : Train-Test Data

Data	X (shape)	y	
		0	1
Data Train	(488, 18)	365	123
Data Test	(122, 18)	97	25

Based on the comparison of data breakdown according to Table 3 of 610 data, 488 data for train data and 122 data for test data. The train data consisting of x train and y train will be used to build a method or model, while x test is used to find out the prediction label and y test is used to find out how far the prediction label meets the actual label.

### 3.3 Classification with Naïve Bayes

The results of the posterior probability values of each model become the reference value for determining credit status by comparing the probability values of bad and current status. The following shows the prediction results of the top 10 data obtained from the three naive Bayes methods, namely the comparison of credit status predictions with actual data status.

Table 4: The prediction of credit status

No.	id	Gauss prediction	Bernoull prediction	Multinomial prediction	Actual data
1	Dbtr A	Good	Good	Good	Good
2	Dbtr B	Good	Good	Good	Good
3	Dbtr C	Good	Good	Good	Good
4	Dbtr D	Good	Bad	Bad	Bad
5	Dbtr E	Bad	Bad	Good	Good
6	Dbtr F	Good	Good	Good	Good
7	Dbtr G	Bad	Bad	Bad	Bad
8	Dbtr H	Bad	Bad	Good	Bad
9	Dbtr I	Bad	Bad	Good	Good
10	Dbtr J	Bad	Bad	Bad	Bad

### 3.4 Performance measure

The following is a table of performance test measurement tools for Naïve Bayes, confusion matrix images, and ROC curves to see which model is better.

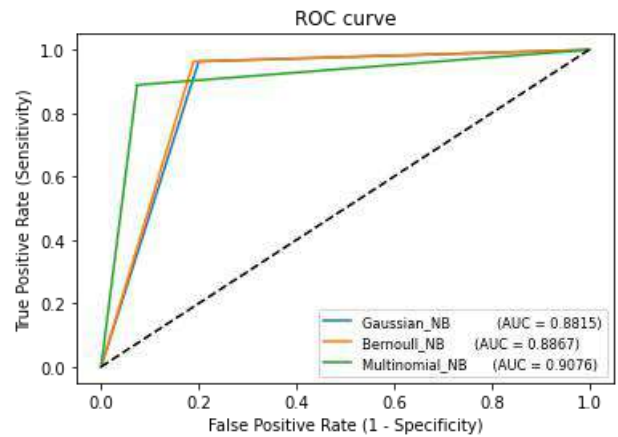


Fig.2. ROC curve of Naïve Bayes

The ROC curve above depicts a graph based on the AUC value, showing that the three methods perform well. The following are the results of the performance test using the confusion matrix. In this test, the prediction results are compared with the 488 training data.

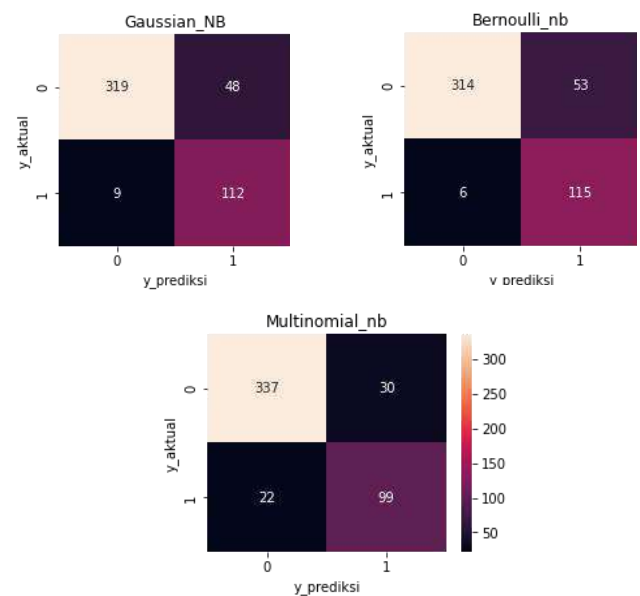


Fig.3. Confusion Matrix of Naïve Bayes

Meanwhile the following are the results of the performance prediction using the confusion matrix. The prediction results are compared with the 122 testing data.

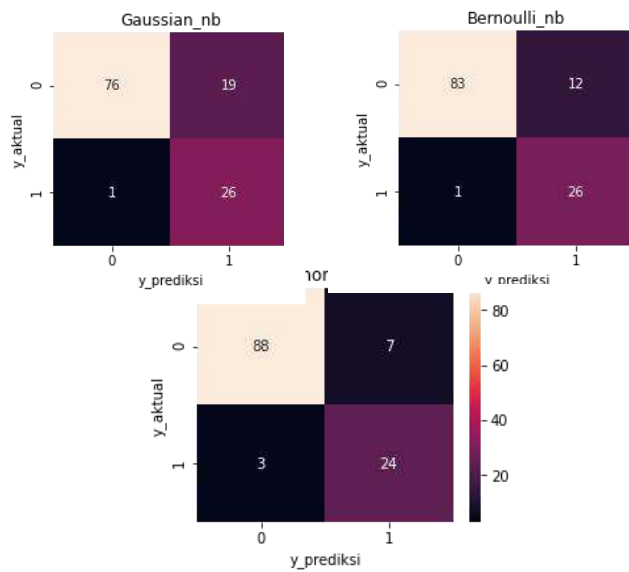


Fig.4. Confusion Matrix of Naïve Bayes

the results of the confusion matrix of the three Naïve Bayes methods and the values of precision, recall, and f1-score

Table 5: Accuracy of model prediction

Metode	status	Precision	Recall	F1-Score
Gaussian NB	good	0,99	0,80	0,88
	bad	0,58	0,96	0,72
<b>Accuracy</b>		<b>0,84</b>		
Bernoulli NB	good	0,99	0,87	0,93
	bad	0,68	0,96	0,80
<b>Accuracy</b>		<b>0,89</b>		
Multinomial NB	good	0,97	0,93	<b>0,95</b>
	bad	0,77	0,89	0,83
<b>Accuracy</b>		<b>0,92</b>		

The naive Bayes method to predict the status of bad loans, the Gaussian, Bernoulli, and multinomial naive Bayes methods show high performance results. However, in the case of predicting credit status, it should be noted that the value of FN (false negative) in multinomial naive Bayes is greater than the other two methods where the debtor which is predicted to be current is actually in bad condition and this can be detrimental to the Bank.

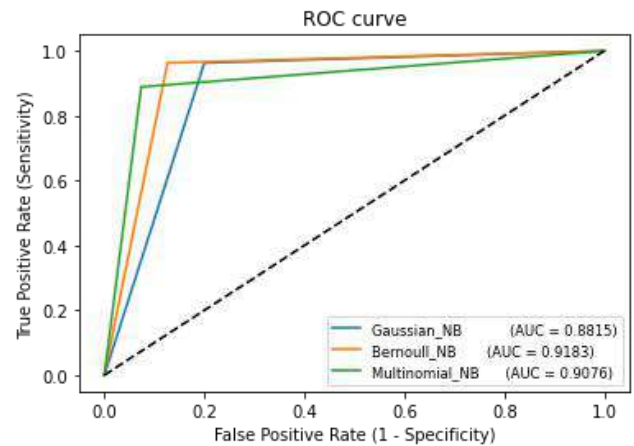


Fig.5: ROC curve of Naïve Bayes

Therefore, the researcher tried to add the binarize=0.1 function in the Bernoulli naive Bayes method to get a higher prediction result. This is done by considering the small false negative values generated in the Bernoulli Nave Bayes confusion matrix. So in this study the best prediction model is Bernoulli naive Bayes with accuracy values, f1-score, and the values of the ROC curve are 84%, 89%, and 91%, respectively.

### 3.5 Cox Proportional Hazard Model

After knowing the prediction of the debtor's credit status, then we want to find out which variables/predictors affect credit status and how big the effect is by using the survival analysis method, namely cox proportional hazard or cox PH. The following is the survival curve of debtor data during the observation time. The following shows the estimation results using the Cox PH method.

	coef	exp(coef)	se(coef)	coef lower 95%	coef upper 95%	exp(coef) lower 95%	exp(coef) upper 95%	cap to	z	P
JK	0.09	1.09	0.22	-0.34	0.52	0.71	1.68	0.00	0.40	0.69
PIH	0.03	1.03	0.03	-0.03	0.09	0.97	1.09	0.00	1.02	0.31
Rate	0.06	1.06	0.02	0.02	0.10	1.02	1.11	0.00	2.69	0.01
Pekerjaan	0.04	1.04	0.06	-0.12	0.20	0.89	1.23	0.00	0.51	0.61
Pendapatan	-0.03	0.98	0.01	-0.04	-0.01	0.96	0.99	0.00	-2.95	<0.005
Tanggungan	-0.04	0.96	0.02	-0.08	0.01	0.92	1.01	0.00	-1.70	0.09
Jaminan	-0.16	0.85	0.21	-0.57	0.25	0.56	1.28	0.00	-0.78	0.43
Riwayatpinjaman	2.47	11.80	0.41	1.56	3.23	5.26	26.45	0.00	5.99	<0.005

Fig.6: Output Cox PH

From the output obtained the model:

$$\hat{h}(t, x(t)) = \hat{h}_0(t) \exp(0,06 \text{ rate} + 0,09 \text{ gender} - 0,03 \text{ income} + 0,04 \text{ Job} - 0,04 \text{ dependent total} - 0,16 \text{ pledge} + 2,47 \text{ credit history})$$

#### IV. CONCLUSION

The classification method in Naïve Bayes machine learning used in this study can be an effective way of predicting events (credit status) by estimating the probability of an event from the training data. Credit status is significantly influenced by income and credit history of the debtor. Debtors with a history of non-performing good loans have 11.82 times greater influence in determining credit status granted by the Bank, while low incomes have a 0.97 times greater effect on grant decisions. bad credit status.

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## Spatial Characterization of Water quality for human consumption from well in the county of Barcarena - PA

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Received: 25 Jul 2022,

Received in revised form: 14 Aug 2022,

Accepted: 19 Aug 2022,

Available online: 24 Aug 2022

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**Keywords**— groundwater, contamination, potability; index

**Abstract**— The exploitation of groundwater in the world assumes an important role due to its low cost, but this facility makes it more vulnerable to contamination. In this context, this study characterized the physical-chemical, toxicological and microbiological aspects of 165 samples of water for human consumption from wells from different sources of supply in the county of Barcarena-PA, which is divided into two regions: Barcarena headquarters and Industrial, in the period from 2017 to 2019. A water quality index was prepared to assess the water quality standard. Total Coliform bacteria were detected in 43.64% and *E. coli* in 15.76% of the water samples, most of which were untreated. Considering the physical-chemical and toxicological parameters, some, such as pH and aluminum, presented average values in disagreement with Brazilian legislation. Thus, a heterogeneity of contamination was observed in the Headquarters and Industrial regions, where the first presented alteration in the physical-chemical and microbiological parameters and the second, greater amount of metals and lower pH values. As for the index, only three categories of water quality were evidenced in the municipality: low, medium and high, which were distributed differently among the studied areas, supporting that environmental contamination occurs for different causes.

### I. INTRODUCTION

The groundwaters are formed by the precipitation that directly or indirectly infiltrates the soil surface. It can be collected for human consumption in a deeper confined or

artesian aquifer which is located between two relatively waterproof layers, that hardens its contamination, or be collected in an unconfined or free aquifer next to the surface, which is susceptible to contamination<sup>[1]</sup>.



In this sense, the groundwater exploration in the world assumes bigger proportions due to the uncountable advantages as the water quality, the costs of exploration and the simplified treatment for consumption, assuming an increasing importance as source of supply and being recognized as alternative to the users for the increasing use in last year's<sup>[2][3]</sup>.

However, the anthropic influence about these water quality, due to the agricultural activities, urban and industry exceeds the natural capacity of the underground and underlying layers evidencing the contaminant effects of these activities<sup>[4]</sup>.

In that way, Barcarena county fits with one of these cities, which economies was based in implantation of big projects that provides the implementation of a industrial complex, and, however, despite the increasing the county has no significant economic development, reflecting the lack of infrastructure, population growth, use and occupation of the soil and the water resources degradation<sup>[5][6]</sup>. As a result, the mining activity in this county has caused environmental impacts, which is related by population and local authorities<sup>[7]</sup>.

Associated with the chemical pollutants from mining activities, it can't be ignored the biological water pollution due to the presence of pathogenic microorganisms, generally originated from fecal material, that reaching the supply network or others potable water sources consumed by population, it can be unchained a epidemic outbreaks of intestinal diseases, affecting a large number of people in short period of time<sup>[8]</sup>.

Therefore, the water consumption security must obey the standards of potability, which demands important conditions to public health and well-being. It has to be as the Brazilian legislation demands to which states the maximum allowed values (MAV) to the bacteriological indicators, organoleptics, physical-chemical and toxicological of water could classify it as potable<sup>[9]</sup>.

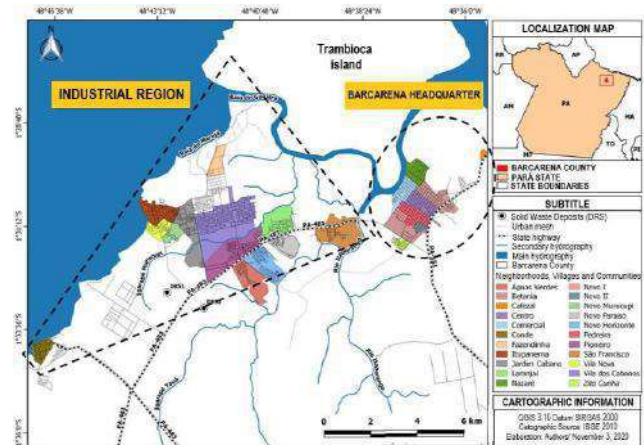
Thus, because of the factors previously cited, the creation of a water quality index through the potable indicators urges the necessity of an appliance which provides information and makes easy the interpretation about water quality due to the large number of variables related<sup>[10]</sup>. The determination of indices to characterize the springs quality, on surface or underground, to the many uses has a function to facilitate the communication with the public and also allow the general determination of the trend of evolution in water quality over time, as well as comparisons between different water sources<sup>[11]</sup>.

Therefore, the mapping of the vulnerability of the aquifers to contamination helps the environmental planning and

management, serving as a decision instrument<sup>[12]</sup>. In this way, the objective of this research was to identify the most vulnerable areas to the population supplied by water from underground wells, whose quality of physical, chemical, toxicological and microbiological parameters compromises and brings risks to the population health in the county of Barcarena/PA.

## II. MATERIAL AND METHODS

**Study area:** The monitored area was Barcarena county, Pará state, located to 01°30'21'' of latitude south and 48°37'33'' of longitude west. 165 samples of water of 22 neighborhoods divided in Barcarena Headquaters and Industrial Area were analyzed (Figure 1), collected from 2017 to 2019, whose results are available in the data base of the Public Health Laboratory of Pará state.



*Fig. 1: Collection points of water samples of human consumption in the county of Barcarena-PA analyzed from 2017 to 2019. Source: Authors, 2021.*

The evaluation criteria of the potable water supply system (WSS), alternative collective solution (ACS) and the alternative individual solution (AIS) of consumption water in Barcarena county, as well as the samples number, strategic sites of investigation, physical, chemical variables, microbiological and toxicological were evaluated according to Brazilian legislation to water potability<sup>[9]</sup>.

**Collection and analysis procedure:** The collection was according to the technical rule NBR 9898 - Preservation and sampling techniques of liquid effluents and receptors bodies. The water samples volumes of the wells were collected directly using sterile bottles. This volume was fractionated in a nasco-type sterile collection bag with an identification stripe, as presented in figure 2<sup>[13]</sup>.



Fig. 2: Collection procedures of water samples of human consumption in the county of Barcarena-PA analyzed from 2017 to 2019. Source: Authors, 2018.

A collector bag of 100 mL was used to pack the samples to microbiological evaluation with sodium thiosulfate tablets in cases of treated water, so the residual chloros could be neutralized.

A collector bag with 532 mL was used to pack the samples to the realization of pH, hardness, turbidity, apparent color, total dissolved solids, chloride content, ammonia content, nitrate content, nitrite content and sulfate content. To the analysis of heavy metals, 15mL of water from the sample was removed. These collectors' bags were transported under refrigeration conditions in a thermal box with recycled ice until its arrival in the laboratory. The physical-chemical, toxicological and microbiological variables were determined by the procedures and recommendations described in the *Standard Methods for Examination of Water and Wastewater*, whose methods are cited in the board 1<sup>[14]</sup>.

Board 1: Methods to determine physical-chemical, toxicological and microbiological parameters in water for human consumption.

Parameter	Analytical Method
Nitrogen Series (nitrate, nitrite and ammonia) and sulfate	Colorimetric
Turbidity	Nephelometric
Total dissolved solids	Conductivity meter
Chloride and hardness	Titration
Apparent color	Spectrometry
pH	pHmetry
Heavy Metals (Al, Ba, Cd, Pb, Cu, Cr, Fe, Mn, Ni, Na and Zn)	Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES)
Total coliforms	Enzyme Substrate
E. coli	Enzyme Substrate with fluorescence

**Index creation:** The creation of the potability index (PI) was based in the mathematical model of change in binary basis values in decimal numeration, according to the calculations below, where n is the binary value of 0 and 1, whose 0 corresponds to the samples variables characterized as unsatisfactory and 1 the satisfactory to the microbiological, physical-chemical and toxicological parameters established in the Brazilian legislation<sup>[15]</sup>.




$$IP = \sum_{i=1}^{23} 2^n * X_i \quad (1)$$

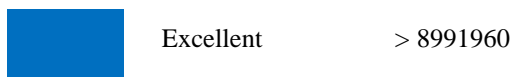
The variable X was the weight given to each variable, that was defined following from the higher weight to the most restrictive from the ordinance until the weight 0 for the more restrictive parameter. Thus, after the calculations of PI, a control diagram for the obtaining of the categorization of the samples was developed. Following, the water quality was estimated by comparison, a procedure of one rule of control which uses a single criteria that was the potability index and a Levey-Jennings graphic, with control limits calculated with  $\mu \pm 1DP$  (mean  $\mu \pm 1$  standard deviation). Thus, it was possible to categorize the samples in 4 quality groups: low, medium, good and excellent. The mean of the Potability Index for each neighborhood was plotted in a map according to the localization of the collection point using the QGIS program.

**Statistical Analysis:** The data from the 165 samples were submitted to parametric test analysis as the descriptive statistic and qui-square (G test), with the data of physical-chemical, microbiological and toxicological parameters.

The descriptive statistic was used to evaluate the accordance in the legislation of the physical-chemical and toxicological parameters, obtaining the values of medium, minimum, maximum and standard deviation. To evaluate if the contamination distribute itself homogeneously in the two areas of the county, it was applied the Mann-Whitney test, and the statistical significance was accepted in 5%. The software used was the Bioestat 5.0 proposed by Ayres et al<sup>[16]</sup>.

Table 1: Water categories for human consumption according to the Potability Index (PI) evaluated in the county of Barcarena - PA analyzed from 2017 to 2019.

Colors	Categories	Weighting
	Low	$\leq 4461311$
	Medium	$> 4461311 \leq 6726636$
	Good	$> 6726636 \leq 8991960$



Source: Authors, 2019

### III. RESULTS

This study analysis revealed that the samples of water for human consumption, 46.06% (76/165) was from the WSS, 17.57% (29/165) of ACS and 36.37% (60/165) of AIS. From these, 46.06% (976/165) was treated and 53.34% (89/165) non-treated. From the collected samples, 69.70% (115/165) was from the industrial area and 30.30% (50/165) of the Barcarena headquarters.

**Microbiological, physical-chemical and toxicological parameters:** Total coliforms (TC) was observed in 43.64% (72/165), and the E. coli in 15.76% (26/165) of the total quantity of analyzed samples. The figure 3 demonstrates the distribution of the presence of these microorganisms in treated and non-treated waters, with origins in WSS, ACS and AIS. TC presence was observed in 64.04% (57/89) in the samples of non-treated water, with origins in ACS and AIS, and in the treated water, from WSS, this bacteria was detected only in 19.74% (15/76). In relation to the E. Coli presence, it was detected in 1.32% (1/76) of the treated water, from WSS, as the detection percentage of this bacteria in the non-treated water samples reaches 28.09% (25/89), a proportion that differs significantly by the binomial test for TC ( $p < 0.0001$ ) and E. Coli ( $p < 0.0001$ ).

In relation to the physical-chemical and toxicological parameters, the non-treated water samples, the pH and aluminum presented differences in relation to the limits established by the Brazilian legislation. About the pH, this was below the range indicated for potable water, demonstrating values mean of 5.22, whose indication of satisfactory must be between 6.0 and 9.5. About the aluminum, the maximum allowed value (MAV) is 0.2 mg/L, however, the measure means demonstrate value of 0.39 mg/L.

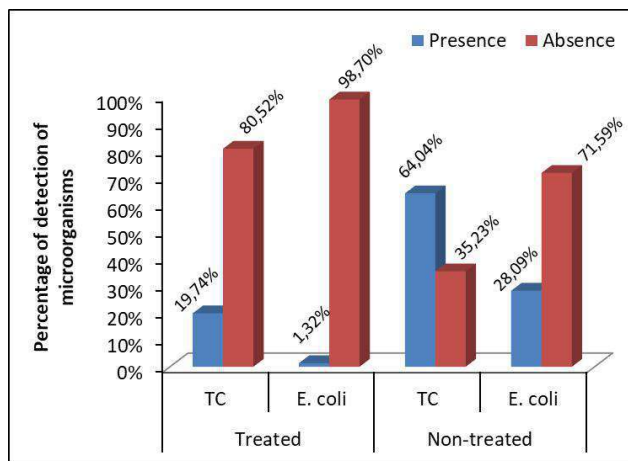


Fig. 3: Microorganisms frequency detected in water samples for human consumption collected from 2017 to 2019 in the county of Barcarena - PA.

**Spatial distribution in Barcarena region:** In relation to the spatial distribution of physical-chemical, toxicological and microbiological parameters, it was observed a heterogeneity of contamination in these waters for human consumption. The basic parameters, such as ammonia, chloride, hardness, pH and SDT presented higher concentrations in the region of Barcarena headquarters associated with the median. On the other hand, the industrial region demonstrates low quantities of these indicators and higher metal contents such as chromium, iron, manganese, sodium and zinc also in relation to the median. These distributions were significant between the headquarters and industrial regions by the Mann-Whitney test (Table 2).

In relation to the microbiological parameters, it was observed distribution statistically different in relation to the presence of E. Coli, when compared to the headquarters and industrial regions ( $\chi^2 = 4.616$ ;  $gl = 1$ ;  $p\text{-value} = 0,0317$ ), being more significant in the region of Barcarena headquarters where it was detected in 26% (13/50) against 11.30% (13/115) of the industrial region (figure 4). In relation to the presence of TC, the proportions verified between the regions do not differ ( $\chi^2 = 1.582$ ;  $gl = 1$ ;  $p\text{-value} = 0,2085$ ).

Table 2. Content comparisons of physical-chemical and toxicological parameters in water samples for human consumption between the headquarters and industrial regions of Barcarena - PA.

Parameter	Barcarena Region		Mann-Whitney test	
	Headquarters (N = 50)	Industrial (N = 115)	Z (U)	p-value
<b>Ammonia</b>				
Sum of ranks	4640.5	9054.5	1.7392	0.0410*
Median	0,12	0,09		
<b>Chloride</b>				
Sum of Ranks	4968.5	8726.5	2.9022	0.0037

Parameter	Barcarena Region		Mann-Whitney test	
	Headquarters (N = 50)	Industrial (N = 115)	Z (U)	p-value
Median	33.50	20.00		
<b>Hardness</b>				
Sum of Ranks	4855.5	8839.5	2.5015	0.0124
Median	50.00	40.00		
<b>pH</b>				
Sum of Ranks	4919.0	8776.0	2.7266	0,0064
Median	6.21	5.49		
<b>SDT</b>				
Sum of Ranks	5889.5	7805.5	6.1678	<0,0001
Median	119.35	51.24		
<b>Chromium</b>				
Sum of Ranks	2823.5	10871.5	4.7034	<0,0001
Median	0.01	0.03		
<b>Iron</b>				
Sum of Ranks	3424.5	10270.5	2.572	0,0101
Median	0.02	0.04		
<b>Manganese</b>				
Sum of Ranks	4670.5	9024.5	1.8455	0.0325*
Median	0.01	0.01		
<b>Sodium</b>				
Sum of Ranks	5414.0	8281.0	4.4818	<0,0001
Median	20.17	6.53		
<b>Zinc</b>				
Sum of Ranks	3311.0	10384.0	2.9748	0.0029
Median	0.01	0.02		

This study also showed that 63.64% (105/165) of the water offered to the population of the county of Barcarena came from the public supply system, whose main source of abstraction is groundwater, where 72.38% (76/105 ) come from WSS, which go through at least two treatment phases (filtration and chlorination) and 27.62% (29/105) come from ACS, they are only captured and distributed in the supply network without treatment. A good part of the population is still not assisted by the water concessionaire, this study estimated that 36.36% (60/165) of the residents obtain water from an individual alternative solution (Table3).

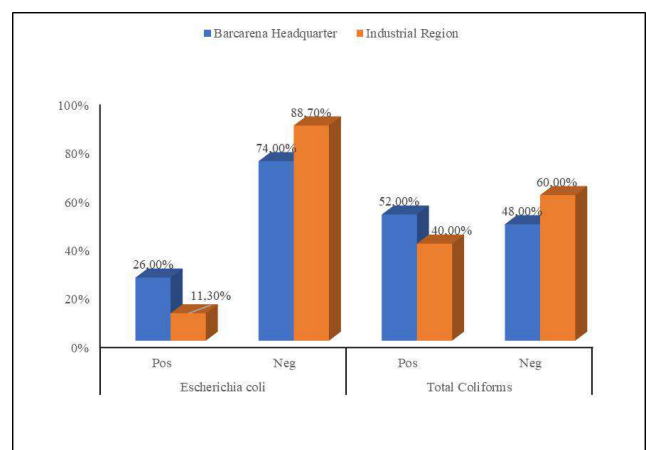


Fig. 4: Comparison of microbiological indicators between the Headquarters and Industrial regions of Barcarena-PA detected in water for human consumption.

Table 3. Distribution of water samples according to the quality categories between the headquarters and industrial regions according to water type.

Sample distribution	Low		Medium		Good		Total	
	N	%	N	%	N	%	N	%
<b>Industrial</b>	13	<b>11,30%</b>	33	<b>28,70%</b>	69	<b>60,00%</b>	115	69,70%
WSS	1	1,92%	8	15,38%	43	82,69%	52	45,22%
ACS	1	4,76%	13	61,90%	7	33,33%	21	18,26%
AIS	11	26,19%	12	28,57%	19	45,24%	42	36,52%
Non-treated water	12	19,35%	24	38,71%	26	41,94%	62	53,91%
Treated water	1	1,89%	9	16,98%	43	81,13%	53	46,09%
<b>Headquarter</b>	13	<b>26,00%</b>	13	<b>26,00%</b>	24	<b>48,00%</b>	50	30,30%
WSS		0,00%	5	20,83%	19	79,17%	24	48,00%
ACS	2	25,00%	1	12,50%	5	62,50%	8	16,00%
AIS	11	61,11%	7	38,89%		0,00%	18	36,00%
Non-treated water	13	48,15%	8	29,63%	6	22,22%	27	54,00%
Treated water		0,00%	5	21,74%	18	78,26%	23	46,00%
Total	26	15,76%	46	27,88%	93	56,36%	165	100,00%

The distribution of the water categories (low, medium and good) revealed significant differences in relation to the areas headquarters and industrial ( $\chi^2 = 9,443$ ;  $GL = 2$ ;  $p$  valor =  $0,0239$ ), where 74.19% (69/93) of the samples of good quality were detected in the industrial region against 25.81% (24/93) of the observed in the headquarter region, this proportional distribution was statistically significant ( $z = 6.5991$ ;  $p$ -valor  $< 0.0001$ ).

In relation to the treatment, most of the samples of good quality was treated (80.26%), significantly differing of the non-treated samples and of low quality (28.09) ( $\chi^2 = 42.2803$ ;  $GL = 2$ ;  $p < 0.0001$ ), however, when comparing the distribution of the supply of treated water in relation to the regions of Barcarena, no statistical differences were observed (Figure 6).

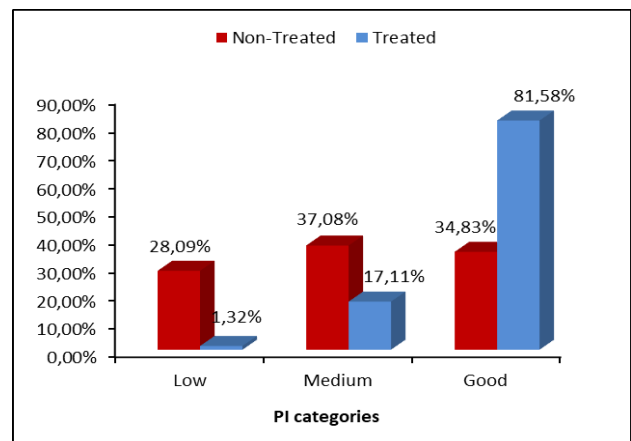


Fig. 6: Frequency of treatment of water for human consumption according to the quality categories in the county of Barcarena-PA collected from 2017 to 2019.

**Potability index (PI):** The mean of the potability index evidences that the county presented only categories low, medium and good of water quality (figure 5).

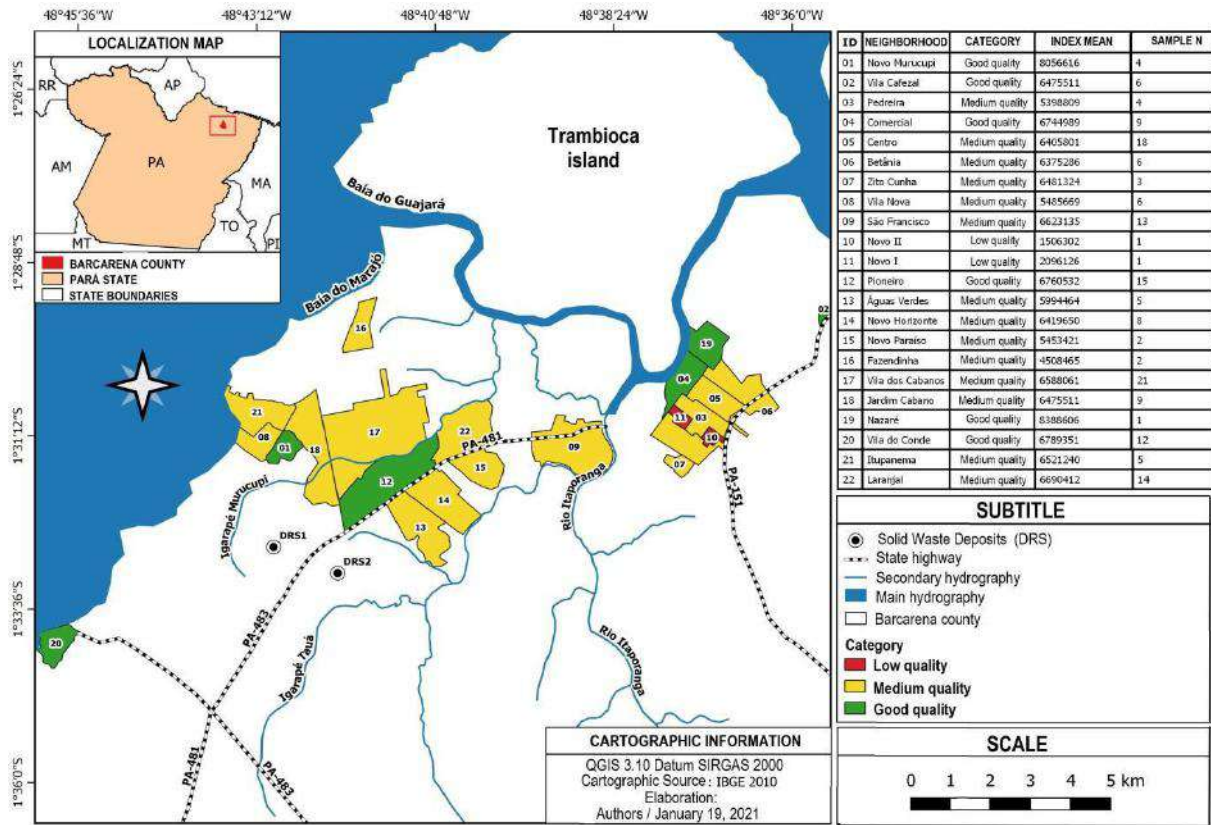


Fig. 5: Distribution of water samples according to quality categories in the Headquarters and Industrial regions in the county of Barcarena-PA.

#### IV. DISCUSSION

Microbiological, physical-chemical and toxicological parameters: The presence of microorganisms, total coliforms (64.04%) and E. coli (28.09%) in the wells waters that provide natural waters (non-treated), were categorized as unsatisfactory for human consumption according to the Brazilian legislation, being explained by the superficial wells (amazon wells) with depth minor than 50 meters, as the majority in this region. These aquifers unconfined are susceptible to contamination<sup>[7]</sup>. However, the depth of these wells wasn't evaluated in this study characterized as a limitation.

The studied wells from alternative individual solution, characterized as non-treated water, the results of physical-chemical parameters were different from the accepted by Brazilian legislation, for example the pH, whose samples was below from the accepted parameters between 6.0 to 9.5. The slightly acidic characteristic are due to the geological aspect of the region, where the natural tendency of the pH is slightly acidic to neutrality and/or the anthropogenic aspects which improved the organic matter decomposition, that results in acidic derivatives as the humic acid, with pH reduction as consequence<sup>[18][19][20]</sup>. The low values of pH in amazon wells were also found in a study by Silva et al<sup>[7]</sup>,

that measured mean values for pH of 4.30 in wells in these same standards in this county. The toxicological aluminum parameter presented an increase in the maximum value, that according to Ferreira Filho<sup>[21]</sup> is explained by the fact that the pH around 4.8 to 6.0, this element becomes soluble in liquid phase.

Therefore, confronting this information with the pH medium value of 5.22 of non-treated water, with the medium value of Al of 0.39 mg/L, it can be noticed that the increase of Al are due to the pH value decrease, needing a correction strategy of pH for the population supply of treated water through prior alkalization at source, as recommended by current Brazilian legislation

The presence of elevated concentrations of Al can be reflected by the contamination of the groundwater due to the existing mining activity in the region, which processes bauxite and kaolin. This increase is even more worrying in samples from non-treated water, whose average value was above that allowed by Brazilian legislation, corroborating studies carried out by Silva et al<sup>[22]</sup>, who demonstrated high levels of metal in the soil of this same region at depths of up to 50m, one explanation being the detection of this metal in wells.

The production of red mud through alumina industries around the world and even in this region constitutes an environmental problem of considerable proportions, due to the volume of this generated passive and its causticity. Red mud is mainly formed by  $Al_2O_3$ ,  $Fe_2O_3$ ,  $TiO_2$  and  $SiO_2$ . And additionally, by the oxides of K, Pb, Cu, Ni, V, Ga, P, Mn, Mg, Zn, Th, Cr, Nb that may be present as trace elements<sup>[23]</sup>. An alumina industry can generate 0.5-2 tons of dry solids of red mud for every ton of alumina produced. Furthermore, up to 2 tons of 5-20 g/L caustic liquor (as  $Na_2CO_3$ ) can accompany each ton of dry mud solids due to the Bayer process used for the beneficiation of bauxite<sup>[24]</sup>. Therefore, it is a factor to consider in the detected increase of this element in the groundwater of this region.

**Spatial distribution in the Barcarena Region:** According to Souza et al<sup>[25]</sup> the aquifers around the industrial pole of Barcarena are highly vulnerable to contamination and this characteristic is mainly due to the fact that the aquifer is free, associated with the lithological characteristics of the unsaturated zone. Since residues are deposited in the area that have soluble substances in their composition, which, in case of leakage, can easily reach the groundwater aquifer, which may explain the results of this study, where the potability indices of the water consumed by this population showed heterogeneous distribution, in which most samples contaminated by metals are located in this Industrial region of Barcarena, differing from the pollution observed in the headquarters region, which concentrates a greater risk of contamination by domestic effluents (sanitary sewage), with the detection of microbiological indicators present.

**Potability Index (PI):** Through the PI, it was possible to observe that locations such as those found in urban centers such as Cabanos village, New Murucupi and Laranjal, which are mostly supplied by WSS, inserted within the Industrial region considered a more recently built and supplied by public systems with treatment based on aeration, filtration, and chlorination, had their categories, within the PI, between medium and good quality.

On the other hand, locations such as New I and II, located in the Barcarena headquarter region, whose supplies are mostly provided by AIS in Amazon-type wells, these samples had their indexes considered of low quality in relation to the criteria of potability, since microbiological indicators were the parameters with the highest weights within the PI calculation because they are considered more restrictive within Brazilian legislation and their presence consequently determines the intake of water outside the standards established for human consumption.

## V. CONCLUSION

The determination of the Potability Index (PI) made it possible to identify that the most vulnerable areas are those that use alternative solution wells because these waters are not properly treated. On the other hand, the areas supplied by the public water system have better potable quality due to the treatment provided.

These vulnerable areas, supplied by groundwater, have high concentrations of Al, in addition to the presence of microorganisms of the total Coliforms group and E. coli, making them unfit for human consumption. These places are fragile due to frequent environmental accidents and the susceptibility to infiltration of domestic sanitary sewage, since little importance has been given to the drilling of wells in communities, with wells built using adequate techniques, thus compromising the quality of the water to be distributed to the population.

Thus, it is up to the health surveillance to guide users and other institutions involved about the need and, above all, the importance of adopting corrective measures, thus seeking greater protection at the source of water supply so that safer water is provided to the population.

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# Amazon Environmental Perspective Presented in Teaching Books used in the Public Network of Porto Velho/RO

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Received: 23 Jul 2022,

Received in revised form: 13 Aug 2022,

Accepted: 18 Aug 2022,

Available online: 24 Aug 2022

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**Keywords— Representation, Textbook,  
Amazon, Environment,**

**Abstract—** This article brings as an object of study the symbolic representations of the Amazon in texts from textbooks used in the public network of Porto Velho/RO. This object inquires the question: How is the Brazilian Amazon portrayed in textbooks distributed in public schools? For that, qualitative research was carried out, legitimized from the Cultural Analysis under the support of Cultural Studies. From a qualitative approach, it is intended to detect the symbolic constructions in the selected texts, to analyze the production of meaning effects regarding ideologies, imaginaries, silencing and discursive formations. In the data analysis, the meanings established in various modes of production (verbal and non-verbal) were questioned, since their materiality produces meanings for interpretation. It is concluded that the symbolic representations of the Amazon in the analyzed texts, assert the discursive effect of a green, uncivilized imaginary. There is a silencing of other regional characteristics to superimpose others, ideological, of a rural character, of an undeveloped place, without progress in “El dorado” without technology and urbanization.

## I. INTRODUCTION

The Didactic Book (henceforth LD) has long occupied space in academic circles, being analyzed and evaluated from different perspectives. Thus, the aim of this work is to discuss how the representation/imaginary about the Amazon region is constituted in textbooks from public schools in Porto Velho/RO, with the Linguagens collection by Editora Saraiva selected for analysis since it was the most used in public schools in Porto Velho.

The LD has the role of mediator and facilitator of the teaching-learning process in the classroom. Its organization is carried out in order to facilitate its handling and maximize its capacity to intervene in the educational

process. Its circulation and classification takes place specifically in and for formal education. Thus, it is observed that L.D still go through themes that make formal restrictions and commonly do not have communicative properties. It is as if there is no interaction, since it only responds to what is previously established. The reader, if not motivated by the teacher, often loses the active role and the possibility of launching discussions and questions, since all the answers are already defined in advance.

## II. METHODOLOGY

This research sought to detect symbolic constructions in selected texts; to analyze the production of effects and

meanings regarding ideologies, imaginaries, silencing and discursive formations. To this end, we carried out research of a bibliographic nature, considering what was established by Chizzotti (2001, p. 89) when he states that: “in the scope of qualitative research, data are collected interactively, in the different stages of the research and in the interaction with its subjects”. The author also adds that this type of research assumes a reality dynamic and not generalizable.

The study was based on Critical Dialectical Analysis within the methodological protocol of Cultural Studies, since its development involves the researcher's ability to deal with situations that seek to extract meanings, taking into account their condition of production and reception; and understanding of the ideological constructions present in the context.

Dialectical-Critical was adopted, because it is concerned with discovering the conflicts of interests that exist in the economic, sociocultural and political fields, present in the textbook. This approach defends the need to know the reality in its concreteness, contextualizing it historically, which allows us to interfere, criticize and talk about what we are looking for. Thus, Gamboa explains to us:

Critical-dialectical research fundamentally questions the static view of reality implicit in previous approaches. This vision hides the conflictive, dynamic and historical character of reality. His markedly critical stance expresses the intention to unveil, more than the “conflict of interpretations”, the conflict of interests. These researches manifest a “transforming interest” in the situations or phenomena studied, protecting their always historical dimension and revealing their possibilities for change (GAMBOA, 2010. p. 107-108).

The first step was the organization of the information that was submitted for analysis and for that we developed indicators that guided the interpretation and formal preparation of the material. According to Williams (2003), Cultural Studies present the interpretations, the historical alternatives and the specific values given to the subjects of a certain period/place, that is, methodologically, it seeks to contextualize this structuring in the “real life expressed by the set of social organization” that :

Any useful cultural analysis begins with the discovery of a characteristic type of patterns, and the general cultural analysis is concerned with the relations between them, which sometimes reveal unexpected identities and correspondences between activities up to now considered separately, and at

other times show unforeseen discontinuities. (WILLIAMS, 2003, p. 58).

And finally, from the selection of texts, we analyze in a detailed way the symbolic representations of the Amazon present in textbooks used in the public network of Porto Velho/RO.

### III. THEORETICAL REFERENTIAL

The North is the largest region in Brazil, made up by the states of Acre, Amapá, Amazonas, Pará, Rondônia, Roraima and Tocantins, and territories of other states that do not make up the political division of the North, making up the Brazilian Amazon region. Besides its large extension, the region borders six South American countries Bolivia, Peru, Colombia, Venezuela, Guyana and Suriname and the territory of French Guyana that make up the international Amazon. To understand the North Region, as an integral part of the Brazilian Amazon and its formation, it is necessary to consider its close relationship with geopolitical objectives and the exploitation of natural resources of the Amazon forest, as well as the relationship with traditional communities.

In this sense, the region is marked by peculiarities, among which we have the high socioeconomic inequality, and also its physical aspects. The means of transportation used by a considerable part of the population that lives along the rivers is the fluvial one. The region still presents an accentuated heterogeneity, including from practically isolated cities to modern urban centers and socioeconomic indicators that range from the best to the worst in Brazil. Within this context, "Environmental and biological diversity are themes recurrently referred to characterize the singularities of the Amazon. This has been the case since ancient times and have often served as justifications for interventions in the region" (VAL, 2009, p. 3), that is, knowing the representations of the Amazon includes considering a universe of ambiguities.

The re-signification becomes real in all fields, and about this Foucault (1997) makes us think about the geographical barriers and the issues involved in power relations present in the correlations of certain regions. These discursive practices built through these relations are active in power practices that, even with the information process that globalization provides, are still found today.

From the moment one can analyze knowledge in terms of region, it can be understood process by which knowledge functions as power and reproduces its effects. There is an administration of knowledge, a politics of knowledge, power relations that pass through knowledge and that naturally,

when one wants to describe them, refer to those forms of domination to which notions such as field, position, region, territory refer (FOUCAULT, 1997, p. 158).

To understand the following argumentation it is necessary to understand the imaginary that throughout the formation of the colonial system that populated the region as well as the rest of the country was based on ethnocentrism / eurocentrism mostly by exposing a prejudiced, arrogant and overbearing view during the cultural constitution of various peoples, because only certain men from certain cultural places would have the right to thought, philosophy and science. This shows us that throughout the formation of the colonial system a true geopolitics of knowledge was constituted that subordinates peoples, knowledge, and cultures (MIGNOLO, 2003).

It is a silence that is not "available" to visibility and, therefore, cannot be easily perceived. It is a silence that passes through words and "(...) slips through the weave of speech." (ORLANDI, 2007, p. 32). Therefore, we consider silence as implicit or explicit concealment of "another", and may even be a strategy of how one intends the region to be seen and understood. And when we move on to the analyses, which in a certain way signify the operation of silence in the formations about the Amazon, we can observe from the texts that the presence of silence as a structuring aspect of the meanings is present in the way the educational materials present the region to their student audience.

#### IV. DISCUSSION

It is common for the Amazon to be constantly related to fauna and flora. This is one of the most important regions in terms of biodiversity, and such representations could not be left out of the LD. It is a fact that there are interests implicit in the content produced in the LD, since the discourse is surrounded by political and economic issues and themes. The definition of a content and the way it is approached does not depend exclusively on the interest of the reader, but on the interest of a responsible group. Thus, the need for consumption defines what is said and also what is not said. When referring to the unsaid, Orlandi says "Every saying is a fundamental relation to the unsaid." (1992, p. 12) Thus, it is understood that the unsaid is part of discourse.

Culture and education are deeply intertwined universes and can only be analyzed from this relationship. It is notorious that the school has always had difficulties in dealing with plurality and difference, often tending to silence and neutralize them. Thus, it is up to all the members of the school community the challenge of

breaking with the homogenizing tendency and freeing spaces for the discussion of cultural issues of post-modern times.

#### 4.1 Text "Still Life or Still Life"

From this topic on, we will make a discourse analysis of the text "Natureza-morta ou Natureza-morta" that deals with the environmental and nature preservation issue exposing the exploitative use that silences the native and traditional peoples.



Fig.1: Text Still life or still life

Source: Portuguese Language Textbook 6th grade  
Language Collection

Let's pay attention to the excerpt "Every day we see and hear news about the devastation of the Amazon", what can be noticed is that the theme, unless it is associated with news of a forest fire or a great flood, ends up diluted, superficial, and fragmented. It is necessary that the environmental theme expresses the human discourse that clarifies the consequences of their actions and directs them to paths of sense of responsibility and contribution to the common good. Thus, the said and unsaid are the discursive processes that need to be understood and unveiled given their discursive heterogeneity. About the diversity of discourses immersed in social practices, Dutra (2009, p.73) contributes: "It is there, on the surface of discourse, and not elsewhere, that we seek to understand the productive plot of meanings".

A more attentive reading of this excerpt shows that it is addressed to a receiver who is being called upon to understand and face the problematic. However, no one is called upon to rethink the molds of the current society in which social inequality dominates. It is essential to reflect on the role that the issue plays in daily life and the need to change behavior models through the negotiation of meanings when information is related to the daily life of those who assimilate it. In this sense, the discourse is

conceived as a process of social construction that needs reflection to cover the range of discourses contained in each person, "the person is an intricate mosaic of different potentials of power in different social relations". Moita Lopes (2002 p. 20)

Notice that the illustration in the text, represents nature on canvas, extinct, displayed in a museum as a work of art. Here we see that the "why" of the problems is not explained, nor is there any talk about how to avoid them. The opportunity to play the educational role by proposing a reflection on the environmental issue is lost, and suggestions of means to favor the necessary changes in order to defeat the current socio-environmental crisis are not effective. For example, approaches such as wastefulness, which harms individuals and the environment, are left aside.

When the content is associated with the reality of those who receive the information, a negotiation of meanings occurs, which causes the receiver to evaluate and even assume different postures in his daily life. Thus, we have the dialog, present in the statements of the communicative system, as Bakhtin approaches, when he states that language tends to be dialogical. Something that goes beyond the "face to face" dialogue between two subjects and is established in the relations of meaning in which the enunciations are established.

Social visions of the world can be of two types: ideological visions, when they serve to legitimize, justify, defend or maintain the social order of the world; utopian social visions, when they have a critical, negative, subversive function, when they point to a reality that does not yet exist. (LÖWY, 2008, p. 14)

This author's vision defines the importance of working with the term "social worldview". In accordance with the educational guidelines that propose the transversality of the themes and on which the document that subsidizes the LD is based for this purpose. Here we have that the studies that are inserted in the issue of the environmental crisis of the planet, no matter how much they seek transversality, are usually presented as mechanistic aspects of science, reducing the phenomena and neglecting the power relations that underlie society, not breaking the transversal bubble to the point of making it clear that this theme is intrinsically linked to territorial, political, economic, and other power relations. And for there to be "salvation" the educational and social basis for dealing with the issue is the preservation of natural resources with regard to the quality and quantity of living beings existing in nature and this includes human beings and their basic needs and demands.

In view of the above, it is a fact that the text should be in harmony with environmental citizenship, being participatory and democratic, in a relationship between theory and practice, and questioning society and its environmental problems. We see that the socio-environmental theme repeats technical themes, contributing for the students to confuse the reuse of a plastic bottle with recycling, consequently, not being able to recognize an abandoned child as a socio-environmental theme. Thus, ideology affects our senses of interpretation "ideology is not concealment, but function of the necessary relationship between language and the world" (ORLANDI, 1999, p.47)

Thus, the LD calls, within the concrete conditions of the school, to address only the problems that the school is authorized to discuss (garbage, fishing of female fish during spawning season), since it does not encourage reflection on the issues and access to natural resources, nor the environmental injustice suffered by social classes with less defensive power.

There is no object that does not appear surrounded, wrapped, and soaked in discourse. Therefore, every discourse that talks about any object is not focused on reality itself, but on the discourses that surround it. Therefore, every word dialogues with other words, is constituted from other words, is surrounded by other words. (FIORIN, 2008, p. 19)

In this sense we must pay attention to the need to problematize the discourses contained in the textbooks, since the environmental theme should be able to awaken this critical consciousness, but it has been performed without proper analysis and understanding of the planetary environmental crisis. Within this context, the student is trained to repeat that "the place for trash is in the trash", but is not sensitive to the environmental injustices to which they are subjected.

#### 4.2 Text: "Brazil still doesn't have a goal to stop deforestation in the Amazon"

Think of the Amazon!", "Lung of the world!", "Tropical forest with the greatest biodiversity on the planet!", "Region that has the largest river on Earth!" "Green hell!", "Holder of one third of the world's fresh water!". These are enough reasons for covetousness and concern from countries, companies, and world organizations. These speeches demonstrate the potential of the region as a source of natural wealth available to satisfy the economic needs of foreign nations. A vision that perceives the region as a grandiose tropical forest, but that neglects or makes unviable the man who lives there.

In the beginning of the text, in the excerpt: "Although the Pact for the Valuation of the Forest and the End of Deforestation in the Amazon, formulated in 2007 by nine NGOs, works with a deadline of seven years, the government is studying a longer term ...", the environmental theme is perceived as an interdisciplinary theme. Thus, the cut presents the politicization of the issue, but erases the existence of a dispute of power over natural resources, placing society as the villain of the environmental problem, when, in most cases, it is a victim.



Fig.2: Text Brazil still doesn't have a goal to stop deforestation

Source: Portuguese Language Textbook 8th grade Language Collection

The excerpt also highlights the government/society/nature relationship, without recognizing that this relationship occurs in different ways. It is not possible to speak of a single relationship between these realities. In fact, it is unfair to suggest that a caboclo from the Amazon or even a rural dweller relates to nature in the same way as an agribusiness mega entrepreneur, for example. Thus, the inclusion of this theme is important, but it is essential to observe the physical and biological factors and, especially, the ways in which the subject interacts with the environment through its various social relationships.

The environmental issue is treated not as a problem of the organization of contemporary society, whose way of producing and consuming sacrifices the health of the natural environment, but as a challenge that includes changing the attitude of a large portion of the population, exempting the major causes of deforestation, in this case the holders of power, be it political, economic, social, etc.

In this way it becomes even more relevant on the environmental theme that we answer questions such as: what does it say? how does it say it? why does it say what it says? and who says and dictates the "modus operandi" as

to environmental preservation and interventions. Moita Lopes (2002, p 55) contributes to these questions when she says that "the perception of the discourse as a social construction (...) includes the possibility of allowing resistance positions in relation to hegemonic discourses, that is, power is not taken as monolithic and social identities are not fixed".

Let's be aware that there is a discourse that tries to convince us that this is a problem in the society/nature relationship and not of those who decide the productive market and interferes in a definitive way in the natural environment, but that we are all responsible in an "equalitarian" way, since it is a problem of the "human hand", which puts the extractivist, the small farmer, the traditional peoples and the big exporter on the same level, distributing unfair responsibilities while imposing a social burden. Therefore, our conclusions point to an official discourse that repeats the usual intentionality, which is the protection of natural resources for the use of the productive market, leaving little room for reflection that seeks a legitimate movement for life.

The fact is that reducing the environment to fauna and flora is definitely a mistake of major proportions (...) in the modern world, where knowledge is fragmented, compartmentalized into areas that often do not communicate, the environmental discussion rescues the holistic sense, the multidisciplinary character that permeates all areas of knowledge, and leads us to a reading of reality where everything is connected, interconnected, related. (TRIGUEIRO, 2003, p.77/78)

The environmentalist theme has become a discursive issue and, from this point of view, carries controversies, disputes within a field of battles for supremacy in the production of meanings, with many who strive daily to be the last voice on ecological issues.

In the Western worldview, Amazonia is represented as underdeveloped and thirsty for a "civilized" group to adapt it to international and national interests. Amazonia today is the result of historically constituted disputes. Thus, the relationship with the "regional other" from a hegemonic epicenter presents polarities. The region carries the image of the fantastic and the exuberant, and at the same time appears as a forgotten, paralyzed, and badly cared for place by the local population.

About this relationship Fraxe et al (2009, p.30) tells us "Although they reproduce so-called traditional manifestations in their daily lives, we cannot affirm that these social groups are not inserted in a progressive process of differentiation and transformation" and still

alert "The Amazon is born and develops in the core and in the dilemmas of the Euro-anthropocentric civilization frame, This concept insists on inferiorizing its form and its relationship with the other and with nature, with natural resources as the protagonist and the obligation to be saved for the salvation of the planet. Hall (1996, p.26) states that there are "systems of representation that different social classes and groups develop in order to make sense, define, symbolize, and give intelligibility to the way society works", emphasizing the complexity of the functioning of societal relations.

According to the vision of these groups, the destruction of natural resources tends to be eradicated by the very economic development sponsored by market forces. It is necessary to preserve nature in order to preserve humanity, but also to question the current production patterns. Thus, the discourse on sustainability that involves society must be seen as a complex issue. The social construction of this discourse/enunciation represents a subjective proposition in which power relations agency the constructed knowledge.

## V. CONCLUSION

Our discussions sought to identify if the symbolic representation in the textbook really considers a range of ways of saying/showing the region. Specifically, we detected the symbolic constructions of the Amazonian identity in selected texts, analyzed the production of effects and senses regarding ideologies, imaginaries, silencing and discursive formations, and noted if there is the appearance of aspects of Amazonian culture in the contents addressed and how they are presented.

In the text presented, whose nomenclature is "still life or still life", the Amazon is constantly related to fauna and flora. This is one of the regions with the greatest emphasis on Biodiversity, and such representations could not be left out of the LD. We note that the environmental theme should be able to awaken this critical consciousness, but it has been carried out without the proper analysis and understanding of the planetary environmental crisis. Within this context, the student is trained to repeat that "the place for garbage is in the garbage", but is not sensitive to the environmental injustices to which they are subjected.

In the second text, the theme is "Brazil still has no target to stop deforestation in the Amazon". The excerpt highlighted the government/society/nature relationship, without recognizing that this relationship takes place in different ways. It is not possible to speak of a single relationship between these realities. In fact, it is unfair to suggest that a caboclo from the Amazon or even a rural

dweller relates to nature in the same way as an agribusiness mega entrepreneur, for example. Thus, the inclusion of this theme is important, but it is essential to observe, above all, the modes of interaction of the subject through their social relationships.

In summary, the Amazon is often represented by an imaginary consisting of the forest and Indians, but its characterization cannot be restricted to these Amazonian elements. Its social, linguistic and cultural diversity should also be highlighted. Unfortunately, we saw that LD contributes to the propagation of this imaginary conception. This region carries the stigma of an uncivilized and wild people. Despite its beauties and its people, amidst this paradox of stereotypes, the misunderstanding transmitted by these prejudices defined since the colonization times reigns.

Therefore, it is valid to know that the DTP is a physical body that, when consumed by several social places (the federal government, the schools, the teacher and the student) becomes a sign loaded with ideological values and meanings, that is, it is a genre composed of several enunciations that arises with the objective of supporting the teaching/learning process and ends up assuming the role of normalizing it. Regarding the LD, we do not intend here to establish any judgment, but to recognize its importance and problematic, because, beyond the divergences, the fact is that the LD is still the main organizing resource of the activities of the teaching/learning process and suggests countless possibilities for research studies.

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# Wavelength and Wave Period Relationship with Wave Amplitude: A Velocity Potential Formulation

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Received: 26 Jul 2022,

Received in revised form: 16 Aug 2022,

Accepted: 22 Aug 2022,

Available online: 29 Aug 2022

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**Keywords**— *Wavelength, wave period, wave amplitude*

**Abstract**— *In this study, the equation that expresses the explicit relationship between the wave number and wave amplitude, as well as wave period and wave amplitude are established. The wave number and the wave period are calculated solely using the input wave amplitude. The equation is formulated with the velocity potential of the solution to Laplace's equation to the hydrodynamic conservation equations, such as the momentum equilibrium equation, Euler Equation for conservation of momentum, and by working on the kinematic bottom and free surface boundary condition.*

## I. INTRODUCTION

The relationship between wave period and wave height has long been recognized. Wiegel (1949, 1964) formulated the relationship through field observations. Silvester (1974) formulated this relationship based on the Pierson-Moskowitz spectrum. The Pierson-Moskowitz spectrum (1964) relates the wave period and wave energy, while wave energy correlates with wave height.

Dean (1991) formulated the dispersion equation of the linear wave theory relating the wave number to the wave period. Just like the fifth order Stokes proposed by Skjelbreia (1960), Stokes' waves of the second order (1847) describe the relationship between wave period and wave number.

From the two relationships describing the relationship between wave period and wave height as well as the relationship between wave number and wave period, it could be hypothesized that in velocity potential, there is a direct relationship between wave number and wave height as well as wave period and wave height.

In this study, the constant of velocity potential for the solution to Laplace's equation is obtained by working on the velocity potential on the kinematic bottom boundary

condition (Dean (1991) and the momentum equilibrium equation.

After the constant of the solution to Laplace's equation is obtained, the potential velocity is calculated on the kinematic boundary condition. Thus, the relationship between the wave number and the wave amplitude is obtained

The velocity potential is done on Euler Equation for conservation of momentum and the wave number is substituted by the relationship between the wave number and the wave amplitude. Therefore, the relationship between wave period with the wave amplitude is obtained.

## II. TAYLOR SERIES ON UNSTEADY FLOW

Taylor series is a statement of the function value at the points around it using the differential of the function. When a function changes over time, the spatial differential likewise changes over time in addition to the function itself. Variables in unsteady flow such as water particle velocity, change across time and space. As a result, the Taylor series for a variable in an unsteady flow should also account for how the differential function changes over time.

The formulation of conservation equations, including conservation of mass and conservation of momentum in



fluid flow is formulated using the first-order Taylor series approximation. As a result, in this study, the first-order Taylor series is formulated to account for the differential variable's change over time.

The first order Taylor series (Arden & Astill), for a function  $f(x, t)$  at time  $t = t$  is,

$$f(x + \delta x, t) = f(x, t) + \delta x \left(\frac{\partial f}{\partial x}\right)^t$$

At time  $t = t + \delta t$ ,

$$f(x + \delta x, t + \delta t) = f(x, t + \delta t) + \delta x \left(\frac{\partial f}{\partial x}\right)^{t+\delta t}$$

However, it is incorrect if  $\frac{\partial f}{\partial x}$  is calculated only at  $t + \delta t$ , besides that this equation is an implicit equation. Then, the mean value is used.

$$f(x + \delta x, t + \delta t) = f(x, t + \delta t) + \delta x \left( \mu_1 \left(\frac{\partial f}{\partial x}\right)^t + \mu_2 \left(\frac{\partial f}{\partial x}\right)^{t+\delta t} \right)$$

$\mu_1$  and  $\mu_2$  are contribution coefficients, where  $(\mu_1 + \mu_2) = 1$ . In the first term of the right-hand side of the last equation, the Taylor series is done,

$$f(x + \delta x, t + \delta t) = f(x, t) + \delta t \frac{\partial f}{\partial t} + \delta x \left( \mu_1 \left(\frac{\partial f}{\partial x}\right)^t + \mu_2 \left(\frac{\partial f}{\partial x}\right)^{t+\delta t} \right) \dots(1)$$

This equation is still an implicit equation. As seen from the function  $g(x, t) = \frac{\partial f}{\partial x}$ .

$$g(x, t + \delta t) = g(x, t) + \delta t \frac{\partial g}{\partial t}$$

$$\left(\frac{\partial f}{\partial x}\right)^{t+\delta t} = \left(\frac{\partial f}{\partial x}\right)^t + \delta t \frac{\partial}{\partial t} \left(\frac{\partial f}{\partial x}\right)^t$$

Substitute to (1)

$$f(x + \delta x, t + \delta t) = f(x, t) + \delta t \frac{\partial f}{\partial t} + \delta x \left( \mu_1 \left(\frac{\partial f}{\partial x}\right)^t + \mu_2 \left( \left(\frac{\partial f}{\partial x}\right)^t + \delta t \frac{\partial}{\partial t} \left(\frac{\partial f}{\partial x}\right)^t \right) \right)$$

Considering  $(\mu_1 + \mu_2) = 1$ ,

$$f(x + \delta x, t + \delta t) = f(x, t) + \delta t \frac{\partial f}{\partial t} + \delta x \left(\frac{\partial f}{\partial x}\right)^t + \mu_2 \delta x \left( \delta t \frac{\partial}{\partial t} \left(\frac{\partial f}{\partial x}\right)^t \right)$$

The first term on the right-hand side is moved to the left and the equation is divided by  $\delta x$ .

$$\frac{f(x + \delta x, t + \delta t) - f(x, t)}{\delta x} = \frac{\delta t}{\delta x} \left(\frac{\partial f}{\partial t}\right)^t + \left(\frac{\partial f}{\partial x}\right)^t + \left( \mu_2 \delta t \frac{\partial}{\partial t} \left(\frac{\partial f}{\partial x}\right)^t \right)$$

For very small  $\delta t$  and  $\delta x$  close to zero, the third term on the right-hand side will be very small close to zero and can be ignored, obtaining:

$$\frac{Df}{dx} = \frac{\delta t}{\delta x} \frac{\partial f}{\partial t} + \left(\frac{\partial f}{\partial x}\right)^t$$

The equation is a total spatial derivative. This equation is substituted for  $\left(\frac{\partial f}{\partial x}\right)^{t+\delta t}$  on (1)

$$f(x + \delta x, t + \delta t) = f(x, t) + \delta t \frac{\partial f}{\partial t} + \delta x \left( \mu_1 \left(\frac{\partial f}{\partial x}\right)^t + \mu_2 \left( \frac{\delta t}{\delta x} \frac{\partial f}{\partial t} + \left(\frac{\partial f}{\partial x}\right)^t \right) \right)$$

Or,

$$f(x + \delta x, t + \delta t) = f(x, t) + (1 + \mu_2) \delta t \left(\frac{\partial f}{\partial t}\right)^t + \delta x \left(\frac{\partial f}{\partial x}\right)^t$$

The time index  $t$  is omitted and defined as  $\gamma_2 = 1 + \mu_2$ . Thus, the first order Taylor series for space and time functions is:

$$f(x + \delta x, t + \delta t) = f(x, t) + \gamma_2 \delta t \frac{\partial f}{\partial t} + \delta x \frac{\partial f}{\partial x} \dots(2)$$

In the same way for a function with three variables  $f(x, z, t)$ , the Taylor series is:

$$f(x + \delta x, z + \delta z, t + \delta t) = f(x, z, t) + \gamma_3 \delta t \frac{\partial f}{\partial t} + \delta x \frac{\partial f}{\partial x} + \delta z \frac{\partial f}{\partial z} \dots\dots\dots(3)$$

Where,

$$\gamma_3 = 1 + 2\mu_2$$

For example, if  $\mu_2 = 0.6$ , then  $\mu_1 = 0.4$ , which gives greater weight to  $\left(\frac{\partial f}{\partial x}\right)^{t+\delta t}$ , So  $\gamma_2 = 1.6$  and  $\gamma_3 = 2.2$ .

### III. CONTINUITY EQUATION FOR UNSTEADY FLOW

Unsteady flow describes the flow of water in a water wave that changes with time. Therefore, a continuity equation that accounts for the change in velocity with time is required.

#### 3.1. Equation of Conservation of Mass

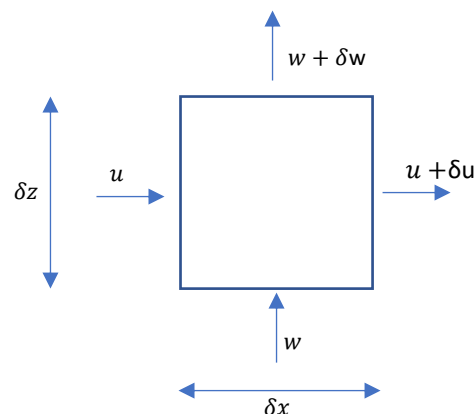


Fig.1 Control Volume to Formulate the Equation of Conservation of Mass

The equation of conservation of mass is formulated using a control volume located in a fluid flow as depicted in Figure 1. The horizontal velocity only changes on the horizontal axis, while the vertical velocity only changes on the vertical axis.  $x$  is the horizontal axis and  $z$  is the vertical axis. Figure 1 presents the velocity of the particle in the horizontal direction is  $u$ , while the velocity of the particle in the vertical direction is  $w$ .

Input-output occurs in the control volume:

Input,

$$I = \rho u \delta z + \rho w \delta x$$

Output,

$$O = \rho(u + \delta u)\delta z + \rho(w + \delta w)\delta x$$

Due to the input and output, at the time interval  $\delta t$  there is a change in fluid mass at the control volume of:

$$\delta m = (I - O)\delta t$$

The input and output equations are substituted in the equation of mass change, and both sides of the equation are divided by  $\delta t \delta x \delta z$ ,

$$\frac{\delta m}{\delta t \delta x \delta z} = -\rho \frac{\delta u}{\delta x} - \rho \frac{\delta w}{\delta z}$$

For a constant control volume, the mass change in the control volume is

$$\delta m = \delta \rho \delta x \delta z$$

An equation is formulated:

$$\frac{\delta \rho}{\delta t} = -\rho \frac{\delta u}{\delta x} - \rho \frac{\delta w}{\delta z}$$

For incompressible flow  $\frac{\delta \rho}{\delta t} = 0$ , then

$$\frac{\delta u}{\delta x} + \frac{\delta w}{\delta z} = 0 \tag{4}$$

This equation is the equation of conservation of mass for incompressible flow

### 3.2. Continuity and Momentum Equilibrium Equation

In the case of the Taylor series, where the horizontal velocity only changes on the horizontal axis and the vertical velocity only changes on the vertical axis, the (2) will be,

$$u(x + \delta x, z, t + \delta t) = u(x, z, t) + \gamma_3 \delta t \frac{\partial u}{\partial t} + \delta x \frac{\partial u}{\partial x}$$

$$w(x, z + \delta z, t + \delta t) = w(x, z, t) + \gamma_3 \delta t \frac{\partial w}{\partial t} + \delta z \frac{\partial w}{\partial z}$$

$\gamma_3$  is used considering  $u = u(x, z, t)$  and  $w = w(x, z, t)$ .

By moving the term to the right-hand side to the left, then

$$\delta u = \gamma_3 \delta t \frac{\partial u}{\partial t} + \delta x \frac{\partial u}{\partial x} \tag{5}$$

$$\delta w = \gamma_3 \delta t \frac{\partial w}{\partial t} + \delta z \frac{\partial w}{\partial z} \tag{6}$$

Substitute (5) and (6) to (4),

$$\frac{\gamma_3 \delta t \frac{\partial u}{\partial t} + \delta x \frac{\partial u}{\partial x}}{\delta x} + \frac{\gamma_3 \delta t \frac{\partial w}{\partial t} + \delta z \frac{\partial w}{\partial z}}{\delta z} = 0$$

The last equation is multiplied by  $\delta z$ ,  $\frac{\delta z}{\delta x} = \gamma_z$ , is used

$$\gamma_z \left( \gamma_3 \delta t \frac{\partial u}{\partial t} + \delta x \frac{\partial u}{\partial x} \right) + \gamma_3 \delta t \frac{\partial w}{\partial t} + \delta z \frac{\partial w}{\partial z} = 0$$

This equation is divided by  $\delta t$  at a very small  $\delta t$  close to zero,

$$\gamma_z \left( \gamma_3 \frac{\partial u}{\partial t} + \frac{1}{2} \frac{\partial uu}{\partial x} \right) + \gamma_3 \frac{\partial w}{\partial t} + \frac{1}{2} \frac{\partial ww}{\partial z} = 0$$

This is the continuity equation for unsteady flow. In this study, the value of  $\gamma_z$  has no effect, thus, it requires no further explanation. This equation is equal to zero if,

$$\gamma_3 \frac{\partial u}{\partial t} + \frac{1}{2} \frac{\partial uu}{\partial x} = 0 \tag{6}$$

$$\gamma_3 \frac{\partial w}{\partial t} + \frac{1}{2} \frac{\partial ww}{\partial z} = 0 \tag{7}$$

Equation (6) explains that the horizontal momentum input in the control volume only causes a change in the horizontal velocity, while the vertical momentum input only causes a change in the vertical velocity. These two equations are named as the equilibrium equation

### IV. VELOCITY POTENTIAL EQUATION.

The Velocity Potential Equation resulted from the solution to Laplace's equation using the variable separation method (Dean (1991)),

$$\begin{aligned} \phi(x, z, t) = & A \cos kx (C e^{kz} + D e^{-kz}) \sin(\sigma t) \\ & + B \sin kx (C e^{kz} + D e^{-kz}) \sin(\sigma t) \end{aligned} \tag{8}$$

Where  $\phi$  is the velocity potential,  $A, B, C$  and  $D$  are the constants for a solution that need to be determined in the form of the equation.  $k$  is the wave number and  $\sigma = \frac{2\pi}{T}$  is angular frequency, and  $T$  is wave period. Even though their respective values are not constant, these two variables are referred to as wave constants.

Based on velocity potential, the horizontal water particle velocity is:

$$u(x, z, t) = -\frac{\partial \phi}{\partial x} \tag{9}$$

While vertical water particle velocity is:

$$w(x, z, t) = -\frac{\partial \phi}{\partial z} \tag{10}$$

(8) shows that velocity potential consists of two components of  $\cos kx$  and  $\sin kx$ . Both sinusoidal functions have a point of intersection where the two functions have the same value. Henceforward, the point of intersection is referred to as the characteristic point. By determining the constants of the solution  $A, B, C$  dan  $D$  at the characteristic point, the values obtained will apply to both velocity potential components.

The first step to getting the equations of these constants is to do the kinematic boundary condition on the flat bottom (Dean (1991)). The kinematic bottom boundary condition is,

$$w_{-h} = -u_{-h} \frac{dh}{dx} \tag{11}$$

Where  $w_{-h}$  and  $u_{-h}$  respectively are bottom vertical and horizontal water particle velocity at  $z = -h$  where  $h$  is the water depth to still water level while  $\frac{dh}{dx}$  is the bottom slope which is zero at flat bottom. Thus, the kinematic boundary condition on the flat bottom is:

$$w_{-h} = 0 \quad \dots(12)$$

Substituting (10) to (12) will obtain:

$$C = De^{2kh} \quad \dots(13)$$

Substituting (13) to (8), velocity potential equation as defined by  $A = 2A$  and  $B = 2B$ ,

$$\Phi(x, z, t) = ADe^{kh} \cos kx \cosh k(h+z) \sin(\sigma t) + BDe^{kh} \sin kx \cosh k(h+z) \sin(\sigma t) \quad \dots(14)$$

In (14) there are the constants of the solution that still need to be determined, they are  $A, B$  and  $D$ . Substitute (14) to (6) will obtain,

$$A = B \quad \dots(15)$$

Velocity potential equation will be,

$$\phi(x, z, t) = ADe^{kh} (\cos kx + \sin kx) \cosh k(h+z) \sin(\sigma t) \quad \dots(16)$$

Substitute(16) to (7) to obtain,

$$ADe^{kh} = \frac{\gamma_3 \sigma}{k^2 \cosh k(h+z)} \quad \dots(17)$$

Velocity potential is done at the characteristic point, and a new constant  $G = 2ADe^{kh}$  is defined. Then, the velocity potential equation will be:

$$\Phi(x, z, t) = G \cos kx \cosh k(h+z) \sin(\sigma t) \quad \dots(18)$$

Where,

$$G = 2ADe^{kh} = \frac{2\gamma_3 \sigma}{k^2 \cosh k(h+z)} \quad \dots(19)$$

$G$  has a double value, or  $G$  is the sum of the energies of the two waves.

### V. THE RELATION BETWEEN WAVE NUMBER $k$ AND WAVE AMPLITUDE $A$

Equation (2) is done to formulate water surface elevation equation  $\eta(x, t)$ ,

$$\eta(x + \delta x, t + \delta t) = \eta(x, t) + \gamma_2 \delta t \frac{\partial \eta}{\partial t} + \delta x \frac{\partial \eta}{\partial x}$$

The first term on the right-hand side is moved to the left and divided by  $\delta t$  for  $\delta t$  close to zero,

$$\frac{D\eta}{dt} = \gamma_2 \frac{\partial \eta}{\partial t} + u_\eta \frac{\partial \eta}{\partial x}$$

This equation is the total surface vertical water particle velocity, it can be written as,

$$w_\eta = \gamma_2 \frac{\partial \eta}{\partial t} + u_\eta \frac{\partial \eta}{\partial x} \quad \dots(20)$$

This equation is a weighted kinematic free surface boundary condition, where  $w_\eta$  is the vertical surface water particle

velocity and  $u_\eta$  is the horizontal surface water particle velocity.

Substitute (19) to (20) and done at the characteristic point,

$$\frac{\partial \eta}{\partial t} = -\frac{Gk}{\gamma_2} \left( \tanh k(h+\eta) + \frac{\partial \eta}{\partial x} \right) \cosh k(h+\eta) \cos kx \sin(\sigma t)$$

For a periodic function:

$$\frac{Gk}{\gamma_2} \left( \tanh k(h+\eta) + \frac{\partial \eta}{\partial x} \right) \cosh k(h+\eta) = \text{constant}$$

Thus, the integration of  $\frac{\partial \eta}{\partial t}$  is done by integrating  $\sin(\sigma t)$ .

$$\eta(x, t) = \frac{Gk}{\gamma_2 \sigma} \left( \tanh k(h+\eta) + \frac{\partial \eta}{\partial x} \right) \cosh k(h+\eta) \cos kx \cos(\sigma t)$$

Wave amplitude  $A$  is defined as,

$$A = \frac{Gk}{\gamma_2 \sigma} \left( \tanh k \left( h + \frac{A}{2} \right) + \frac{\partial \eta}{\partial x} \right) \cosh k \left( h + \frac{A}{2} \right)$$

(19) shows that  $G$  is a superposition of two wave energies. Then, for one wave component:

$$A = \frac{Gk}{2\gamma_2 \sigma} \left( \tanh k \left( h + \frac{A}{2} \right) + \frac{\partial \eta}{\partial x} \right) \cosh k \left( h + \frac{A}{2} \right)$$

This equation is the wave amplitude function equation. In deep water, where,

$$k \left( h + \frac{A}{2} \right) = \theta \pi \quad \dots(21)$$

$\theta$  is a positive number, where

$$\tanh k \left( h + \frac{A}{2} \right) = \tanh(\theta \pi) = 1 \quad \dots(22)$$

Considering conservation law of the wave number (Hutahaean (2020)), (21) and (22) apply to pada shallow water. The wave amplitude function equation will be,

$$A = \frac{Gk}{2\gamma_2 \sigma} \left( 1 + \frac{\partial \eta}{\partial x} \right) \cosh(\theta \pi)$$

The water surface elevation equation will be,

$$\eta(x, t) = A \cos kx \cos(\sigma t) \quad \dots(23)$$

At the characteristic point of space and time on  $\cos kx = \sin kx$  and  $\cos \sigma t = \sin \sigma t$ ,

$$\frac{\partial \eta}{\partial x} = -\frac{kA}{2} \quad \dots(24)$$

The wave amplitude function equation will be,

$$A = \frac{Gk}{2\gamma_2 \sigma} \left( 1 - \frac{kA}{2} \right) \cosh(\theta \pi) \quad \dots(25)$$

Substitute (19) for  $z = \frac{A}{2}$ , the same numerator and denominator cancel each other out, the relationship between wave number  $k$  and wave amplitude  $A$  is obtained.

$$k = \frac{\gamma_3}{(\gamma_2 + \frac{\gamma_3}{2})A} \quad \dots(26)$$

The wave number  $k$  is only determined by wave amplitude  $A$ . Even though the equation is formulated in deep water, since  $kA = \text{constant}$  or  $\frac{dkA}{dx} = 0$ , this equation applies to shallow water. Therefore, the wave number can be calculated if the wave amplitude can be determined in shallow water.

Considering  $k = \frac{2\pi}{L}$ , it is obtained:

$$L = \frac{2\pi(\gamma_2 + \frac{\gamma_3}{2})A}{\gamma_3} \dots\dots(27)$$

This equation is the relationship between wavelength  $L$  and wave amplitude  $A$ . Thus, wavelength is only determined by the wave amplitude. In shoaling, water depth changes wave amplitude. Indirectly, wavelength is determined by water depth.

**VI. THE RELATIONSHIP BETWEEN WAVE PERIOD  $T$  AND WAVE AMPLITUDE  $A$**

The relation between wave period  $T$  and wave amplitude  $A$  is formulated using Euler's momentum equation.

By working on (3) on the horizontal water particle velocity  $u(x, z, t)$  and the vertical water particle  $w(x, z, t)$ , the Euler equation in the horizontal and vertical directions are:

$$\begin{aligned} \gamma_3 \frac{\partial u}{\partial t} + u \frac{\partial u}{\partial x} + w \frac{\partial u}{\partial z} &= -\frac{1}{\rho} \frac{\partial p}{\partial x} \\ \gamma_3 \frac{\partial w}{\partial t} + u \frac{\partial w}{\partial x} + w \frac{\partial w}{\partial z} &= -\frac{1}{\rho} \frac{\partial p}{\partial z} - g \end{aligned}$$

In both equations, the irrotational flow properties are done, where  $\frac{\partial u}{\partial z} = \frac{\partial w}{\partial x}$ ,

$$\gamma_3 \frac{\partial u}{\partial t} + \frac{1}{2} \frac{\partial}{\partial x} (uu + ww) = -\frac{1}{\rho} \frac{\partial p}{\partial x} \dots\dots(28)$$

$$\gamma_3 \frac{\partial w}{\partial t} + \frac{1}{2} \frac{\partial}{\partial z} (uu + ww) = -\frac{1}{\rho} \frac{\partial p}{\partial z} - g \dots\dots(29)$$

Equation (29) is multiplied by  $dz$ , integrated to the vertical axis. The dynamic free surface boundary condition was done where the pressure on the water surface  $p_\eta = 0$ . The pressure equation is:

$$\begin{aligned} \frac{p}{\rho} &= \gamma_3 \int_z^\eta \frac{\partial w}{\partial t} dz + \frac{1}{2} (u_\eta u_\eta + w_\eta w_\eta) \\ &\quad - \frac{1}{2} (uu + ww) + g(\eta - z) \end{aligned}$$

This equation is differentiable at the horizontal axis. The driving force obtained is in the horizontal direction. Next, the driving force is substituted to the right-hand side (28), where the same terms on the left and right-hand sides of the equation cancel each other out,

$$\gamma_3 \frac{\partial u}{\partial t} = -\gamma_3 \frac{\partial}{\partial x} \int_z^\eta \frac{\partial w}{\partial t} dz -$$

$$\frac{1}{2} \frac{\partial}{\partial x} (u_\eta u_\eta + w_\eta w_\eta) - g \frac{\partial \eta}{\partial x} \dots\dots(30)$$

By working (18) on the second term on the right-hand side, it is revealed that in deep water, the term is zero. With the conservation law of the wave numbers (Hutahaeen, 2020) and (21) the second term on the right-hand side is also zero in shallow waters, so (30) becomes:

$$\gamma_3 \frac{\partial u}{\partial t} = -\gamma_3 \frac{\partial}{\partial x} \int_z^\eta \frac{\partial w}{\partial t} dz - g \frac{\partial \eta}{\partial x}$$

$\frac{\partial}{\partial x} \int_z^\eta \frac{\partial w}{\partial t}$  solved by substituting velocity potential (18) to obtain:

$$\frac{\partial}{\partial x} \int_z^\eta \frac{\partial w}{\partial t} = \frac{\partial u_\eta}{\partial t} - \frac{\partial u}{\partial t}$$

Resulting,

$$\gamma_3 \frac{\partial u_\eta}{\partial t} = -g \frac{\partial \eta}{\partial x} \dots\dots(31)$$

This is the horizontal surface water particle velocity equation. Substitute (18) and (23) to (31), where the equal terms between the left and right sides cancel each other obtaining:

$$\gamma_3 G \sigma \cosh k(h + \eta) = gA$$

Wave amplitude  $A$  on the right-hand side is substituted by (25) to obtain:

$$\sigma^2 = \frac{g}{2(\gamma_2 + \frac{\gamma_3}{2})^2 A}$$

Considering  $\sigma = \frac{2\pi}{T}$ ,

$$T = \sqrt{\frac{8\pi^2(\gamma_2 + \frac{\gamma_3}{2})^2 A}{g}} \text{ (sec)} \dots\dots(32)$$

Wiegell (1949,1964) formulate the relationship between wave period  $T$  and the wave height  $H$ ,

$$T_{Wieg} = 15.6 \sqrt{\frac{H}{g}} \text{ sec} \dots\dots(33)$$

Wave height  $H$  is in meter,  $g = 9.81 \text{ m/sec}^2$ . Silvester (1974) describes the relationship between wave period  $T$  and wave height  $H$ ,

$$T_{Silv} = 2.43 \sqrt{\frac{H}{0.3048}} \text{ (sec)} \dots\dots(34)$$

Wave height  $H$  in meter.

**VII. EQUATION RESULTS**

Table (1) represents the results of (27), (32), (33), and (34), with input wave amplitude, assuming a sinusoidal wave, the wave height  $H = 2A$ . The calculation is done using  $\mu_1 = \mu_2 = 0.5$ , where  $\gamma_2 = 1.50$  and  $\gamma_3 = 2.00$ .

Table (1) Shows the Calculation Results Using (27), (32), (33), and (34)

A (m)	L (m)	$\frac{H}{L}$	T (sec)	$T_{Wieg}$ (sec)	$T_{Silv}$ (sec)
0.2	1.571	0.255	3.172	3.15	2.784
0.4	3.142	0.255	4.486	4.455	3.937
0.6	4.712	0.255	5.494	5.456	4.822
0.8	6.283	0.255	6.344	6.3	5.567
1	7.854	0.255	7.093	7.044	6.225
1.2	9.425	0.255	7.769	7.716	6.819
1.4	10.996	0.255	8.392	8.334	7.365
1.6	12.566	0.255	8.971	8.91	7.874
1.8	14.137	0.255	9.516	9.45	8.351
2	15.708	0.255	10.03	9.961	8.803

Calculation of wavelength with (27) produces a wavelength with wave steepness  $\frac{H}{L} = 0.255$ , where this wave steepness exceeds the critical wave steepness of Michell (1893) and Toffoli et al (2010). According to Michell (1893, the critical wave steepness is,

$$\frac{H}{L} = 0.142 \dots\dots(35)$$

According to Toffoli et al. (2010),

$$\frac{H}{L} = 0.170 \dots\dots(36)$$

The wave period resulted from (32) is larger for both the wave period of Wiegel  $T_{Wieg}$  as well as wave period from Silvestre  $T_{Silv}$ , but quite close to  $T_{Wieg}$ . Calculations are carried out using  $\gamma_2 = 1.50$  dan  $\gamma_3 = 2.00$ .

Next,  $\mu_2 = 0.4$  is used, where  $\gamma_2 = 1.40$  and  $\gamma_3 = 1.80$ , which means that a contribution coefficient of  $\mu_2 = 0.4$  for  $\left(\frac{\partial f}{\partial x}\right)^{t+\delta t}$  in (1).

With this weighting coefficient, the wave steepness decreases to  $\frac{H}{L} = 0.249$ . Wave period also decreases, smaller than  $T_{Wieg}$  but bigger than  $T_{Silv}$ , but quite close to  $T_{Silv}$ , see Fig. (2).

Hence, despite the resulting equation giving the results from the weighting coefficients  $\gamma_2$  and  $\gamma_3$ , the equation results are still around  $T_{Silv}$  and  $T_{Wieg}$ . Silvester (1974) formulates (34) using the Pierson-Moskowitz spectrum, while Wiegel (1949,1964) formulates (33) from field observations.

Table (2) Calculation results using  $\gamma_2 = 1.40$  dan  $\gamma_3 = 1.80$

A (m)	L (m)	$\frac{H}{L}$	T (sec)	$T_{Wieg}$ (sec)	$T_{Silv}$ (sec)
0.2	1.606	0.249	2.918	3.15	2.784
0.4	3.211	0.249	4.127	4.455	3.937
0.6	4.817	0.249	5.054	5.456	4.822
0.8	6.423	0.249	5.836	6.3	5.567
1	8.029	0.249	6.525	7.044	6.225
1.2	9.634	0.249	7.148	7.716	6.819
1.4	11.24	0.249	7.721	8.334	7.365
1.6	12.846	0.249	8.254	8.91	7.874
1.8	14.451	0.249	8.754	9.45	8.351
2	16.057	0.249	9.228	9.961	8.803

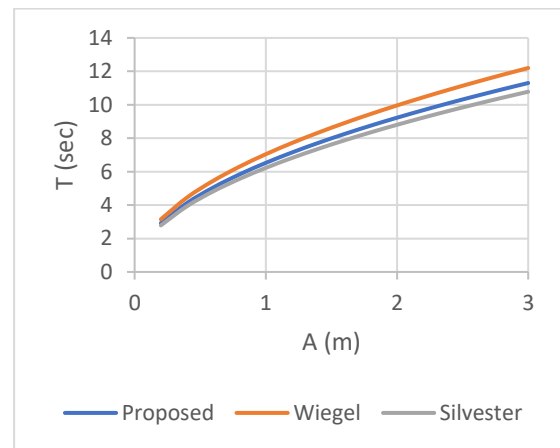


Fig. (2) Relationship between Wave Period and Wave Amplitude

The wave period  $T$  is determined by amplitude  $A$ . In the shoaling, there is an increase in the wave amplitude until breaking occurs, then there is a decrease in wave amplitude. Therefore, during the shoaling-breaking, there should also be an increase and a decrease in the wave period. By using (32) on the shoaling-breaking model from Hutahaean (2022), for deep water wave amplitude  $A_0 = 1.00$  m or deep wave height  $H_0 = 2.00$  m, the change of wave period toward water depth  $h$  is obtained as depicted in Figure 3. The picture illustrates that when the wave-height increases, the wave period also increases, while when the wave-height decreases, the wave period also decreases

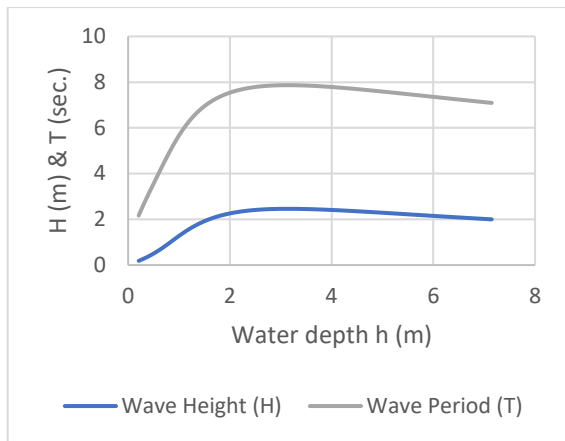


Fig. (3). The Change of Wave Height and Wave Period during Shoaling-Breaking.

### VIII. CONCLUSION

This study proves wavelength and wave period explicit relationship with wave amplitude. To summarize, in the velocity potential equation, only the wave amplitude serves as the input for Laplace's equation. Wavelength and wave period can be calculated using the input.

The equation of the relationship between wave period and wave amplitude also applies to shallow water. However, to obtain shallow water wave amplitude, a shoaling-breaking analysis is required. Therefore, wave period analysis in shallow water requires a shoaling-breaking analysis. On the other side, the shoaling-breaking analysis must also account for the possibility of wave period changes.

Changes in the wave period in shallow water should be taken into consideration in a range of wave calculations, such as wave forces, sediment transport by waves, and other related calculation. The wave period in deep water should not be used for these calculations.

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# Zizwaf Digitalization: The Empowerment of People Economic's Strategy Amidst Covid-19

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Received: 28 Jul 2022,

Received in revised form: 15 Aug 2022,

Accepted: 20 Aug 2022,

Available online: 29 Aug 2022

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**Keywords**— ZISWAF, digitalization, Zakat  
Payment, Zakat Distribution, Covid-19  
Pandemic

**Abstract**—This study aims to analyze the ability of Zakat Management Organizations to utilize technology in supporting transaction activities as well as reporting ZISWAF fund management as a strategy in increasing payments and distribution of ZISWAF funds. The object of this study is the National Amil Zakat Agency (BAZNAS) of Makassar, representing an institution established by the government, and Dompot Dhuafa of South Sulawesi, as one of the institutions established by the community. This study is a qualitative study using a case study approach. Data consist of primary data obtained by conducting direct interviews with informants, and secondary data obtained through observation of the website or application of each organization. This study found that in Dompot Dhuafa of South Sulawesi, the use of IT is maximized by trying to reach millennials, considering that they tend to be more receptive to the use of IT as they found it easy to use. Meanwhile, at BAZNAS of Makassar, the use of IT is maximized on their applications that comply with PSAK 109 concerning Zakat and Infaq/Alms Accounting, considering the muzakki in BAZNAS are mostly either elderly or government employees that really concern about the perceived usefulness of the technology. As a case study, this study is expected to be able to contribute to other organization and the government by providing a comprehensive picture of what should be done in maximizing the use of IT as a strategy to increase the number of ZISWAF payments in Indonesia, in order to empower the people's economic, especially in the current era of the Covid-19 pandemic.

## I. INTRODUCTION

The Covid-19 pandemic which started to become epidemic in Indonesia since the beginning of 2020 has not only had an impact on the recession in the health sector, but also in the economic, especially for the Micro, Small and Medium Enterprises sector (Izzata Bella, 2020). Among all the forms of efforts that have been carried out by the world, including Indonesia in order to reduce the spread of this epidemic are social or physical distancing. But unfortunately, this movement has an impact on the decline in overall economic activity (Iskandar et al., 2020).

Stock markets fell, central banks cut interest rates, industrial production was almost non-existent, there was massive job loss in society, and a financial crisis seemed imminent (Syed et al., 2020). The Minister of Finance of the Republic of Indonesia said that international trade experienced a decline due to restrictions (lockdowns) in various countries to minus 8.3%. The Indonesian economy itself experienced a slump with the value of GDP became 2,590 trillion rupiah in the second quarter of 2020 (kemenkeu, 2021).

This situation is certainly a threat. According to (Syed et al., 2020), the Islamic finance sector has the ability to fight the threats that arise due to crisis situations such as the current Covid-19. This was previously clearly emphasized by KH. Ma'ruf Amin as Chairman of the Board of Trustees of the Sharia Economic Community (IndoTelko, 2019) that the sharia economics must be a trigger for strengthening the national economy because the sharia economics is the basis of the people's economic empowerment. More specifically, the people's economic empowerment and the sharia economics is supporting each other. As a country with the largest Muslim majority population in the world, Indonesia certainly has a great opportunity in improving the people's economic through the Islamic economic sector, especially with Islamic social finance.

Study conducted by (Iskandar et al., 2020) found that the solution that can be offered within the framework of the concept and system of Islamic economics and social finance is the distribution of direct cash assistance from Zakat, Infaq, and Alms (ZIS) both from Zakat Collection Units as well as from the community. ZIS funds are philanthropic funds that continue to increase despite the economic crisis caused by the Covid-19 pandemic so that they can be used as a source of financing in overcoming poverty problems (Humas BAZNAS, 2020a). The second solution that can be offered (Iskandar et al., 2020) is through strengthening waqf both with cash and productive schemes. So far, waqf is known to have a very large role in the development of infrastructure, public facilities, and people's economic empowerment. According to (Latifah & Lubis, 2020), Zakat, Infaq, Alms and Waqf (ZISWAF) are Islamic social financial instruments that allow the distribution of wealth, flows from the hands of the rich to the poor. Conceptually, zakat can help mustahik to increase consumption and production which then contributes to increasing economic growth, especially in the era of the Covid-19 pandemic (Nurhidayat, 2020).

Despite being a country with the largest Muslim majority population in the world, the problem that arises in Indonesia is that there is a very large gap between the potential and the realization of ZISWAF. Based on a study conducted by the National Amil Zakat Agency (BAZNAS) in collaboration with the Bogor Agricultural Institute (IPB), the National Committee for Sharia Economics and Finance (KNEKS), the Ministry of Religion of the Republic of Indonesia (Kemenag RI), and Bank of Indonesia (BI), it was found that the potential for zakat in Indonesia reaches 233.8 trillion Rupiah, while the receipt of zakat, infaq, and alms nationally in 2019 through the official Zakat Management Organization (ZMO) reaches 10 Trillion Rupiah or still 5.2% of the total zakat potential. In addition, other problems are also found in the distribution process that has not been maximized (Latifah &

Lubis, 2020). (Syed et al., 2020) emphasized that to be able to make ZISWAF as an alternative that can help to improve the community economic during the current Covid-19 pandemic, solutions are needed for the problems both in the collection and distribution process.

The use of digital technology is believed to be maximally utilized to increase Islamic finance while still paying attention to the sharia principles and the benefit for the community (IndoTelko, 2019). According to (Winosa, 2020), with the Covid-19 outbreak that affects the economic sector, Islamic financial institutions are rapidly increasing the use of technology. The majority of Islamic financial Institutions conduct transactions through their digital platform which allows financial transactions to be carried out safely and very efficiently without any physical exchange of documents. The crisis makes a greater demand from the perspective of Islamic finance because of the need of transparency. The use of information technology is then also considered as a solution that can be used to facilitate the collection and distribution of ZISWAF. The finding of study conducted by (Iskandar et al., 2020) recommend that the development of Islamic financial technology can facilitate the liquidity of online market players in a sharia manner, while at the same time some efforts are also needed to increase focus on social finance (zakat, infaq, alms and waqf) in addition to commercial finance.

The use of technology in the ZISWAF collection has been carried out by BAZNAS. Bambang Sudibyo as Chairman of BAZNAS stated that among the strategic things developed to invite, donate and give satisfaction to muzakki, innovation and breakthrough were needed (Humas BAZNAS, 2020b). For this reason, BAZNAS is serious in developing digital fundraising as part of the spirit of digitizing zakat. Besides BAZNAS, several other Zakat Management Organizations (ZMO) have also used technology to collect and distribute ZISWAF, especially during this Covid-19 pandemic. Budi Gandasoebrota, the managing director of GoPay explained that since the Covid-19 pandemic, there has been a change in people's consumption patterns which tend to switch to the digital sector, including paying their ZISWAF (Damayanti, 2020). Vincent Iswara, the CEO and Founder of DANA also emphasized that with the convenience and security offered, digitalization will also encourage more people to pay their ZISWAF (Rini, 2020). In addition, this method is also a solution to avoid crowds in the midst of the Covid-19 pandemic, in accordance with government recommendations.

Despite all the conveniences offered by technology in collecting and distributing ZISWAF, not a few people still choose not to use this alternative. (W. N. A. W. M. Salleh et al., 2019) argues that in contrast to the concept of charity, the use of digital media in collecting and distributing zakat is still



not common in the public, because an in-depth study is still needed on the adoption of this technology by official ZMOs, especially about their compliance with sharia principles. According to (Syed et al., 2020), the distribution of zakat is very important and must be considered because it cannot be given to anyone, but only to those who meet the requirements in accordance with the rules set by sharia. One of the biggest challenges for ZMO in the use of digital media is their ability to prove the transparency, accountability, and reliability that earns the interest and trust of the muzakki (Rejeb, 2020).

Another study conducted by (Suginam, 2020) found that the accountability of information technology-based ZISWAF fund management must still comply with Islamic sharia principles and provisions, produce quality reports, optimize ZMO management in carrying out their activities, provide good services and programs, distribution and useful news, and provide literacy about zakat activities. (Latifah & Lubis, 2020) emphasized that not only in collecting and distributing ZISWAF, the use of technology is also optimized for management and as a tool for zakat education.

As a novelty from previous studies, through a case study approach, this study analyzed the perspective of the Zakat Management Organization (ZMO) in utilizing Information Technology to support transaction activities and the reporting of ZISWAF fund management as their strategy to encourage people to make ZISWAF payments. This study tried to examine the strategy carried out by adopting the Theory of Acceptance Model (TAM), where the acceptance behavior of information technology by muzakki is identified based on perceived usefulness and perceived ease of use. Given the large gap between the potential of ZISWAF payments and the realization, analysis the perspective of ZMO in the use of Information Technology adapted to the Theory of Acceptance Model is important to provide a comprehensive picture of what should be done to increase the number of ZISWAF payments in Indonesia, in order to empower the people's economic, especially in the current era of the Covid-19 pandemic.

## II. RESEARCH DESIGN AND METHOD

This study is a qualitative study using a case study approach. The study was conducted at the official Zakat Management Organization (ZMO) in Makassar that utilizes Information Technology such as websites or applications in collecting, managing and distributing ZISWAF funds. The study was conducted on two Zakat Management Organizations, namely the National Amil Zakat Agency (BAZNAS) of Makassar representing institutions established by the Government, and Dompot Dhuafa of South Sulawesi representing institutions established by the community. The

data of this study consisted of primary data and secondary data. Primary data was obtained by conducting direct interviews to find out their strategy in utilizing technology in collecting, managing and distributing ZISWAF funds. Secondary data was obtained through observations of the websites or applications of each of these ZMOs, regulations, articles, and related news.

This study focused on analyzing the use of Information Technology by ZMO in collecting and distributing ZISWAF. It is important considering that ZISWAF funds can be used to improve the people's economic, especially during the pandemic, while there is still a large gap between the potential of ZISWAF payments and its realization. By adopting the Theory of Acceptance Model (TAM), the researcher examines the strategies adopted by the two objects of the study in utilizing IT to increase the ZISWAF payments by muzakki. The Theory of Acceptance model is a theory developed by Davis who found that technology acceptance by a person is influenced by two factors, namely perceived ease of use and perceived usefulness (Afiful Ichwan). Data analysis in this study was carried out in four stages, namely: 1) data collection, where researchers collected data through interviews and observations of websites and applications from the two objects of study, 2) data reduction, researchers selected basic information from all data collected. obtained by focusing on important things according to the study theme, 3) data presentation, researchers organize information systematically and presented in narrative form, and 4) draw conclusions, researchers draw conclusions based on the results of data analysis (Sayidah & Assagaf, 2019).

## III. RESULTS AND DISCUSSION

The researcher carried out the data collection stage by conducting observations on the website of both BAZNAS of Makassar and Dompot Dhuafa of South Sulawesi. The data collection process was then continued by conducting direct interviews with employees from each of these ZMOs. In the interview process, the researcher also tried to confirm the information obtained from the website. The data reduction process is then carried out by selecting information that is considered relevant to the purpose of this study, which is then presented in the form of a narrative that provides an overview of the study results as follows:

### 3.1 Digitalization of Zakat Management Organizations

From the management aspect, Zakat Management Organizations have already been digitized to improve good governance processes and increase accountability and efficiency by using the latest technologies (Ninglasari & Muhammad, 2021). At BAZNAS of Makassar, the use of Information Technology can be seen from the official

website platform that can be freely accessed by public to obtain ZISWAF services and management information. BAZNAS of Makassar is also active in using social media such as Facebook and Instagram, as well as instant messaging applications such as WhatsApp Messenger. This was stated by Mr. Badal Awal, Head of Administration and General Affairs of BAZNAS of Makassar that:

“In BAZNAS of Makassar, we combined a manual system and technology. The technology is mostly used for promotional and educational purposes. We use website, Instagram, and also Facebook. We use it as a media for socialization.”

Based on the interview, BAZNAS of Makassar has realized the importance of using IT to reach the community, although it has not completely cut off the manual system. From the interview, it is known that the use of websites, Facebook and Instagram at BAZNAS of Makassar is indeed more focused on socialization and education efforts regarding zakat, infaq, and alms. The result of the interview is as stated by (Latifah & Lubis, 2020) that the use of Information Technology in Zakat Management Organizations is not only for collecting and distributing funds, but can also be optimized for management and tools to provide zakat education. The same thing was done by Dompot Dhuafa of South Sulawesi, which also uses Facebook, Instagram, the official website as promotional media, ZISWAF fundraising and information, and WhatsApp as a communication tool. Aswar Habir, the digital marketing employee of Dompot Dhuafa of South Sulawesi stated,

“digitalization is a very effective way to attract people’s interest to become muzakki in Dompot Dhuafa of South Sulawesi, especially for millennials. This Information Technology is used optimally by placing advertisements on social media such as on Instagram and Facebook so that the public can find out information on activities and assistance being programmed by Dompot Dhuafa of South Sulawesi. If people are interested in becoming muzakki, then the admin of each platform will direct the prospective muzakki to the official website of Dompot Dhuafa of South Sulawesi.”

From the interview, Dompot Dhuafa of South Sulawesi clearly understands the behavior of millennials who are very active in using information technology, especially social media. This is then used by Dompot Dhuafa of South Sulawesi as an effective way to attract the interest of these millennials to become muzakki through socialization carried out via social media. It helps the millennials to easily get the information and knowledge about ZISWAF. The Director of the National Committee for Islamic Economics and Finance through the zakat and waqf literacy

class of the Ministry of Religion of the Republic of Indonesia revealed that social media has become the main strategy used by the ZISWAF Institution in the midst of the Covid-19 pandemic, and has proven to be very helpful in meeting the needs of ZISWAF transactions along with the development of Information Technology and changes in people's lifestyles (Juwaini, 2020).

Detailed information regarding the management and distribution of ZISWAF funds, both carried out by BAZNAS of Makassar and Dompot Dhuafa of South Sulawesi through their respective websites, is a form of accountability and transparency for these two Zakat Management Organizations to muzakki who have entrusted their ZISWAF funds. The study conducted by (Suginam, 2020) found that accountability for managing information technology-based ZISWAF funds must still adhere to Islamic sharia principles and provisions, produce quality reports, optimize management in carrying out their activities, provide good services and programs, distribution and news that are beneficial, and provide literacy on zakat. In line with the study, Dompot Dhuafa of South Sulawesi also provides access for the public to download their performance reports. It certainly supports the principles of accountability and transparency in the management of ZISWAF funds.

The accountability and transparency in managing ZISWAF funds is also carried out by BAZNAS of Makassar through the use of BAZNAS Management Information System (SIMBA). The BAZNAS Management Information System (SIMBA) is a system built and developed for the purpose of storing data and information owned by BAZNAS (BAZNAS, 2012). SIMBA is a website-based application that is integrated from City/Regency BAZNAS, Provincial BAZNAS, and the central BAZNAS. SIMBA has quite important features, such as recording the collection of ZISWAF funds, distribution and use of ZISWAF funds, asset recording, printing the proof of zakat deposit, issuance of Zakat Payer Identification Number (NPWZ) cards, budget management, and printing of 89 standard types of reports. Through SIMBA, the muzakki’s data is being well managed by BAZNAS of Makassar. Mr. Badal Awal, Head of Administration and General Affairs of BAZNAS of Makassar stated that:

“We have a special reporting system for BAZNAS. The application is called SIMBA. This SIMBA connects the reports made by BAZNAS in all regions in Indonesia to the head office of BAZNAS. So, what we input in SIMBA is immediately read by the head office. Sure, we can say it is transparent. The head office of BAZNAS can directly monitor the reports we made.”

This shows that the use of Information Technology by BAZNAS of Makassar has supported the principles of accountability and transparency which has been a challenge for the digitization of ZISWAF process. In addition, from interviews conducted, it is known that SIMBA helps BAZNAS of Makassar in making more reliable Financial Reports, considering that the Financial Statements made through this application are in accordance with PSAK 109, as also stated by Mr. Badal Awal:

"What's good about SIMBA, what makes our muzakki more confident is that the reports we make through this application are in accordance with PSAK 109. So, it is transparent, and the other hand it also makes it easier for us to make reliable reports, in accordance with the provisions. that's what the muzakki expects."

Based on the interview, we can conclude that the use of technology by BAZNAS of Makassar through the application called SIMBA is able to meet the challenges of ZISWAF digitalization as described in the background of this study. According to (Rahman, 2015), PSAK 109 refers to several MUI fatwas, namely MUI fatwa no. 8 of 2011 concerning Amil Zakat, No. 13 of 2011 concerning the Law of Zakat on Haram Assets, No. 14 of 2011 concerning Distribution of Zakat Assets in the Form of Managed Assets, as well as No. 15 of 2011 concerning Withdrawal, Maintenance, and Distribution of Zakat Assets. In addition, the integrated system allows all records that have been made to be directly reviewed by the central BAZNAS, so that the potential of fraud can be minimized. This proves that the management of ZISWAF funds at the BAZNAS of Makassar has followed Islamic principles and rules, supporting the study conducted by (Rahman, 2015) which reveals that to show that ZISWAF funds have been properly managed, an information system that can provide a transparent overview regarding activities related to the management of these funds is needed. The information system must also be able to provide information that is sufficient, reliable, easy to understand, relevant for users, and remains in the context of Islamic Sharia.

In addition to considering the compliance with Sharia principles, as well as the demands to meet the principles of transparency and accountability, the use of Information Technology as a strategy of each Zakat Management Organization that being the object of this study, needs to also consider what motivates muzakki to be interested in using the adopted technology. In this case, the researcher tries to analyze it based on the Theory of Acceptance Model (TAM). Based on the Theory of Acceptance Model (Davis, 1989), there are two factors that motivate a person to use information technology. The first factor is perceived ease of use, which is a person's level of belief that by using a

particular system/technology, the effort required to do something is reduced. The second factor is perceived usefulness, where a person believes that by using a particular system/technology, performance will increase. In other words, the technology shows tangible benefits for the work to be done. The strategy of the two objects of this study based on Theory of Acceptance Model can be seen in the ZISWAF Fundraising process.

### 3.2 Utilization of Information Technology in ZISWAF Fundraising

The use of an external platform is one of BAZNAS of Makassar strategies to increase ZISWAF payment from muzakki. From the observation conducted on their website, this study found that BAZNAS of Makassar collaborates with DANA digital wallet service provider to facilitate infaq payments. By using the Quick Response Code Indonesian Standard (QRIS) from Bank Indonesia, the public can easily make infaq payments. Only by scanning the barcode that is available on the BAZNAS of Makassar website, muzakki will be connected to the DANA digital wallet, and make infaq payments using their DANA balance.

The ease of making transactions can be a consideration for prospective muzakki in making ZISWAF payments. Based on the Theory of Acceptance Model (TAM), when someone believes that the use of a particular system can reduce a person's effort in doing something, it will be easier for them to accept the system. The results of the study conducted by (Mohd Yusoff & Hanapi, 2016) found that the availability of online payment facilities was one of the factors that could encourage muzakki to pay zakat. The results of this study are supported by (Bulutoding et al., 2020) which also found that muzakki tend to be influenced to make zakat payments if the online zakat system facilitates them in making zakat payments. However, the BAZNAS of Makassar revealed slightly different view from the results of these studies. Although it provides digital payment facilities for infaq payments, as well as transfer services for zakat payments, BAZNAS of Makassar does not provide online zakat payment features on their website. In the interview conducted, Mr. Badal Awal revealed that:

"the decision was taken after studying the behavior of the majority of muzakki at BAZNAS of Makassar. They tend to prefer to use the zakat pick-up service, by contacting the zakat collection division directly through the whatsapp contact listed on the BAZNAS of Makassar website. This could be influenced by the fact that the average muzakki in BAZNAS of Makassar are not millennials who are more comfortable using the latest technology."

The results of this interview indicate that the age factor of muzakki can cause differences in decision making to use information technology. The average age of muzakki at

BAZNAS of Makassar who are not millennials makes them more careful in accepting the use of information technology as a media for paying ZISWAF. Muzakki need to feel the real benefits of this information technology. In accordance with the Theory of Acceptance Model (TAM), perceived usefulness is a determining factor for someone to accept technology. Therefore, the use of information technology in collecting zakat by BAZNAS of Makassar relies more on their own application which is able to convince muzakki regarding its usefulness. In this case, providing what the average muzakki wants, like how transparent the reporting is.

Study conducted by (Antonio et al., 2020) found that the transparency of zakat management has a significant influence on the interest of muzakki to pay zakat through the Zakat Management Organization. This was confirmed by BAZNAS of Makassar. In the process of collecting ZISWAF, the zakat collection division is able to increase the trust of muzakki through transparent transactions. Mr. Badal Awal from BAZNAS Makassar stated that:

“One of the efforts made by BAZNAS of Makassar is to take advantage of the features of SIMBALite. SIMBALite is a SIMBA application designed to be used on Smartphones which then makes it easier for the zakat collection division of BAZNAS of Makassar to record ZISWAF payment transactions when carrying out zakat pick-up services. Through the SIMBALite application, the zakat collection division of BAZNAS of Makassar inputs data and muzakki payments into an application that is integrated into the head office of BAZNAS, and prints the proof of transactions directly in front of the muzakki. According to the division of zakat collection, muzakki considers the digital transaction evidence to be much better and more reliable than manual evidence.”

Based on the results of the interview, muzakki feel more able to entrust their ZISWAF payments, if the Zakat Management Organization is able to prove the transparency of its management and reporting. This can then be facilitated by BAZNAS of Makassar through their internal application. In addition, one of the advantages for BAZNAS of Makassar which makes their zakat collection quite stable even during the pandemic is the existence of a collaboration program with government institutions by implementing automatic zakat collection from employee salaries. However, the use of social media such as Facebook and Instagram gave quite good results in increasing the acceptance of bound infaq payments at BAZNAS of Makassar. During the Covid-19 Pandemic, BAZNAS of Makassar was active in raising funds/donations through their social media. Fundraising is also usually done to help the community when a disaster occurs. Assistance received in this form is recognized as a bound infaq. For the acceptance of the bound infaq, Mr. Badal Awal explained:

“The increase in infaq payments begin when we started using Facebook to raise donations. So, when there is a disaster, we open the donations via Facebook, we call the donations as bound infaq. We actively started doing it since the beginning of the pandemic and the results were quite significant.”

From this statement, a significant increase was seen in the bound infaq funds carried out by BAZNAS through the use of technology. This increase was more pronounced when at the beginning of the pandemic, BAZNAS was more active in using Facebook to collect donations which were difficult to be done directly.

Slightly different from BAZNAS of Makassar, the collection of ZISWAF funds by Dompot Dhuafa of South Sulawesi can be accessed directly on a special website built for ZISWAF fundraising. This website was built since the Covid-19 Pandemic expanded in 2020, with the aim of making it easier for the public to make online ZISWAF payments. This finding supports the study conducted by (Ninglasari & Muhammad, 2021) which reveals that facing the social distancing policies during the Covid-19 pandemic, potential zakat collection that cannot be done directly can be optimized through the digitization of zakat. Mr. Aswar Habir from the digital fundraising team of Dompot Dhuafa of South Sulawesi stated that:

“we have a donation channel, so our goal is to pay zakat as easy as checking out at shopee. So, we have a website for payments, muzakki just need to click and click, and they are directly connected to Dompot Dhuafa of South Sulawesi, it's almost the same as shopping in a market place. Our principle is we stay updated on the media that mostly used by many people. We are targeting to increase zakat payments from millennials, so we try to be available on all platforms as much as possible, then the information is easier to spread. that is what our marketing done to reach more muzakki.”

From the results of the interview, it is known that Dompot Dhuafa of South Sulawesi maximizes the use of technology for ZISWAF payments by being active on various platforms, including creating their own payment website to facilitate the dissemination of information and payment processes. By targeting millennials to increase ZISWAF payment acceptance, Dompot Dhuafa of South Sulawesi is actively involved in using popular technology, including social media.

Similar to BAZNAS of Makassar, Dompot Dhuafa of South Sulawesi also provides a zakat pick-up service that can be accessed through its website. However, the Dompot Dhuafa of South Sulawesi website has more complete features. During the Covid-19 pandemic, Dompot Dhuafa of South Sulawesi acknowledged that there had been a major

change in the ZISWAF payment model by muzakki. Mr. Aswar Habir stated:

"Before the pandemic, Dompot Dhuafa of South Sulawesi could serve around 100 muzakki who made payments directly at the office, during the pandemic we only served about 10 muzakki. This does not mean that the ZISWAF payments at Dompot Dhuafa of South Sulawesi has decreased, it's just that more muzakki choose to make ZISWAF payments online. In the past, muzakki came directly and paid for themselves at the office, now we can pick them up, via transfer, or through our donation channel"

The results of the interview show that the availability of several alternatives in making ZISWAF payments in Dompot Dhuafa of South Sulawesi has proven to be able to increase the acceptance of ZISWAF payments, especially among millennials. Aswar Habir added:

"Since we have our special website as a donation channel, more and more millennials are interested in making ZISWAF payments. This website was just built after the pandemic, its main feature is making it easy to pay ZISWAF. This year, there was an increase in ZISWAF fundraising by 60%-70%, exceeding the target of 50%."

From the interviews, it is proven that by targeting millennials, Dompot Dhuafa of South Sulawesi is able to increase ZISWAF payments through the use of technology. In accordance with the Theory of Acceptance Model (TAM), where technology acceptance can be driven by perceived ease of use, Dompot Dhuafa of South Sulawesi builds a strategy by trying to reach millennials who find it easier to use technology. The convenience offered through the use of Information Technology has proven to be able to increase ZISWAF fundraising on Dompot Dhuafa of South Sulawesi. These results also support the study conducted by (Hidayat & Mukhlisin, 2020) which found that the online zakat payment system on Dompot Dhuafa is a new breakthrough in terms of zakat payments and has had a good impact in the form of growing zakat collection. The special website that used as a donation channel by Dompot Dhuafa of South Sulawesi is still being developed. The digital fundraising team of Dompot Dhuafa of South Sulawesi, stated:

"We are targeting by 2022 to use a full-digital system in the collection and management of ZISWAF funds. One of the features being prepared is automatic notification for muzakki when a ZISWAF payment has been in the Dompot Dhuafa account. We keep on continue to make a

development in Information Technology by utilizing various existing platforms"

This statement is in line with the results of the study conducted by (Moenir et al., 2021) which revealed that the development of a database server on Dompot Dhuafa has proven to manage ZISWAF muzakki funds by simplifying and accelerating the transaction process and submitting reports to muzakki.

### 3.3 ZISWAF Distribution to Increase the People's Economic amidst the Covid-19 Pandemic

Based on the Fatwa of the Majelis Ulama Indonesia (MUI) Number 23 year of 2020 concerning the Utilization of Zakat, Infaq, and Shadaqah Assets to overcome the Covid-19 Outbreak and its Impacts, the MUI allows the use of funds collected from muzakki to be used to help communities affected by the pandemic. This then became the basis for the Zakat Management Organization to carry out special programs in order to help the mustahik who were economically affected by the Covid-19 outbreak, including BAZNAS of Makassar and Dompot Dhuafa of South Sulawesi. The zakat distribution by Dompot Dhuafa of South Sulawesi is conducted through a consumptive and productive zakat program. The zakat distribution program carried out by BAZNAS of Makassar and Dompot Dhuafa of South Sulawesi is almost the same, which is focused on five pillars, namely da'wah and advocacy, health, economy, education, and social/humanity. According to the study conducted by (Amanda et al., 2021), during this pandemic, the management of ZISWAF funds is prioritized to be able to deal with the pandemic through economic, health, and social assistance.

In the health sector, based on the observation result on the website of Dompot Dhuafa of South Sulawesi, they built a free clinic for the poor. During the Covid-19 pandemic, Dompot Dhuafa of South Sulawesi tried to improve their services in the health sector through the Free Ambulance Service. This Free Ambulance Service Car is equipped with oxygen cylinders, regulators, infusion devices, first aid kits, and a medical stretcher. This vehicle has helped many people who are sick but underprivileged. In addition, another program carried out by Dompot Dhuafa of South Sulawesi is quarantine nutrition assistance for underprivileged families who are confirmed positive for Covid-19. Through this program, Dompot Dhuafa of South Sulawesi provides assistance in the form of medicines and daily necessities for nutritional intake. BAZNAS of Makassar also has a similar program in the health sector. During the pandemic, the healthy house of BAZNAS of Makassar through the Halo Ambulance program carried out socialization and education about the impact and prevention of Covid-19 to the community. This program is accompanied by the distribution of masks with the

aim of providing awareness to the public to continue to follow government suggestion.

In the social sector, many disasters that have occurred in recent years have prompted Dompot Dhuafa of South Sulawesi to undertake fundraising efforts to help communities affected by the disasters. For example, providing assistance to fire victims in Makassar by establishing a station and providing food and drink needed by the community at the fire site. Since the Covid-19 pandemic broke out, Dompot Dhuafa of South Sulawesi has often provided assistance by spraying disinfectant in several mosques and providing free masks to the poor. At BAZNAS of Makassar, social assistance during the pandemic is provided through the "BAZNAS of Makassar Dhuafa Package Cares for Covid-19" program. Through this program, BAZNAS of Makassar distributes packages contains of basic necessities for small merchants who have to keep selling in the midst of the Covid-19 outbreak. Assistance is also given to the poor who are experiencing the impact of the economic downturn. This assistance is a form of consumptive zakat distribution carried out by BAZNAS of Makassar. This finding supports the results of study conducted by (Harmelia et al., 2020) dan (Anovani, 2021) which found a significant effect of the distribution of consumptive zakat on economic empowerment during the pandemic.

In the economic field, efforts to develop and strengthen the business potential of strategic economic groups should be oriented towards empowerment, so that independent and strong local economic actors are formed, for example by providing capital assistance that is strengthened by mentoring, so that the results can be accounted for (Iskandar et al., 2020). This is what Dompot Dhuafa of South Sulawesi has done. In the interview, Aswar Habir revealed:

"In the distribution of ZISWAF, we provide more productive zakat assistance. We do this in order to maximize the economic improvement of the mustahik. Our principle is, instead of directly giving a fish, it is better to give a hook that can be used to catch that fish."

The results of the interview are in accordance with the results of study conducted by (Anovani, 2021) who found that through productive zakat, the development of zakat funds given to mustahik can be more efficient because it allows the circulation of funds in mustahik's businesses so that they are better able to improve the economy of the mustahik. One of the efforts made by Dompot Dhuafa of South Sulawesi during the pandemic was trying to assist the poor to be able to establish productive businesses, by providing training and business facilities that could lift the economy in the area. The increasingly difficult economy during this pandemic has forced many MSMEs and farmers to go out of business, so Dompot Dhuafa of South Sulawesi is trying to revive its economy. Aswar Habir added:

"For example, during this Covid-19 period, we use productive zakat to provide assistance to Letta coffee farmers in remote area in Pinrang Regency by providing a greenhouse. This greenhouse helps Letta coffee farmers to dry coffee beans more easily. In addition, the Dompot Dhuafa of Sout Sulawesi mentoring team also provided training on how to prevent coffee beans from spoiling quickly and how to choose good coffee beans to sell. This assistance has succeeded in making the economy of letta coffee farmers in Pinrang Regency develop and be able to rise during the pandemic. We then educate and collect zakat from coffee farmers whose incomes have risen so that they can be distributed back to MSMEs or other farmers who also need similar assistance."

BAZNAS of Makassar is also trying to focus on distributing productive zakat during the pandemic. One of the efforts made is to provide fund assistance for 10 SMEs in Makassar. BAZNAS of Makassar explained in the interview:

"This fund assistance is given to retail merchants who have been greatly impacted by the Covid-19 pandemic. Since 2020, we have conducted a survey and direct review of 25 SMEs, and found 10 SMEs that meet the criteria for assistance. The amount of business fund provided is adjusted to the type of business and the needs of each beneficiary. In addition to the fund assistance, we also assist the businesses of these 10 SMEs so they can rise up in the midst of the pandemic."

The results of this interview show the efforts made by BAZNAS of Makassar in providing assistance to small business through productive zakat. what is being done is in accordance with the results of previous studies that examined the effectiveness of the distribution of productive zakat on prosperity of the MSME (Naimah & Soenjoto, 2018) that proved a positive impact on the economy of MSME through the provision of productive zakat assistance in the form of business fund carried out by BAZNAS. Similar study conducted during the pandemic (Usman & Sholikin, 2021) also showed the same results, as seen from the income of mustahik which had increased.

Besides affecting the health, social and economy sector, the Covid-19 pandemic has also had an impact on the mustahik education sector. Therefore, both BAZNAS of Makassar and Dompot Dhuafa of South Sulawesi also have zakat distribution programs for mustahik affected by the pandemic in the education sector. Dompot Dhuafa of South Sulawesi provides two programs that give trainings for teachers in remote schools, namely the School of Master Teacher (SMT) and Empowerer Teachers, as stated in the interview:

“We have a program for the education sector. The School of Master Teacher (SMT) provides training and education for three months for teachers in elementary schools whose students are mostly poor. The aim is to improve the teaching quality of teachers. In this educational program, we are trying to help teachers adjust to the situation during the Covid-19 pandemic by providing training to utilize Information Technology so that the teaching process during this pandemic can run optimally. The assistance is also in the form of providing several smartphones and internet access in several reading parks.”

From the results of the interview, it is known that Dompot Dhuafa of South Sulawesi has distributed zakat which focuses on the impact of the pandemic. In addition to SMT, Dompot Dhuafa South Sulawesi also provides scholarships for students or college students affected by Covid-19. The provision of this scholarship is a way to reduce students who drop out of school because they cannot pay their school fees. The scholarship program for the poor affected by the pandemic was also carried out by BAZNAS of Makassar. As stated in the interview:

“This assistance comes from infaq and alms of muzakki who entrust their funds to BAZNAS of Makassar. The provision of this assistance is part of the Smart Makassar of BAZNAS Program which is intended for underprivileged students, especially during the pandemic.”

From the interview, it can be seen that through the program carried out by BAZNAS of Makassar and Dompot Dhuafa of South Sulawesi, the ZISWAF funds collected by the two Zakat Management Organizations have been well distributed to help mustahik affected by the Covid-19 pandemic. BAZNAS of Makassar and Dompot Dhuafa of South Sulawesi have made several efforts to help improve the prosperity and economy of the people during the pandemic by utilizing ZISWAF funds. These results also support the results of study conducted by (Iskandar et al., 2020) which reveals the solutions that can be offered within the framework of the concept and the Islamic Financial Economic System are the distribution of direct cash assistance from ZISWAF, as well as through business capital assistance for the MSME sector.

#### IV. CONCLUSION

Digitalization at BAZNAS of Makassar can be seen from the use of internal platforms such as websites as media for socialization and education, SIMBA and SIMBALite applications to help record ZISWAF fundraising and reporting that is integrated and in accordance with PSAK 109, as well as the use of external platforms such as QRIS in collaboration with DANA and Facebook and Instagram to

facilitate the collection of infaq. In Dompot Dhuafa of South Sulawesi, by targeting millennials to increase ZISWAF collection, the use of the website is maximized by providing complete features, one of which is the creation of a special website, namely the Dompot Dhuafa of South Sulawesi donation channel.

Based on the research results, the digitalization of the two Zakat Management Organizations is in accordance with Islamic principles, also supports the accountability and transparency in the management of ZISWAF funds. The principles of accountability and transparency are very important in building public trust to pay ZISWAF through the Zakat Management Organization (M. C. M. Salleh & Chowdhury, 2020).

In Dompot Dhuafa of South Sulawesi, the use of IT was maximized in the process of collecting and reporting ZISWAF funds by trying to reach millennials, considering that they tend to be more receptive to the use of IT as they found it easy to use. Meanwhile, at BAZNAS of Makassar, the use of IT is maximized on the reporting of ZISWAF fund which carries the principles of accountability and transparency, with the use of their applications that comply with PSAK 109 concerning Zakat and Infaq/Alms Accounting, considering the muzakki in BAZNAS are mostly either elderly or government employees that really concern about the perceived usefulness of the technology. Through the use of IT, the two ZMO were able to increase the number of ZISWAF payments which were then distributed through the similar program to improve the people's economic during the Covid-19 pandemic.

As a case study, this study is expected to be able to contribute to other ZMO and the government by providing a comprehensive picture of what should be done in maximizing the use of IT as a strategy to increase the number of ZISWAF payments in Indonesia, in order to empower the people's economic, especially in the current era of the Covid-19 pandemic.

Due to the limited time, this study was only conducted on two Zakat Management Organizations in Makassar. Considering that the Zakat Management Organizations in Makassar are not only BAZNAS and Dompot Dhuafa, further researchers can conduct the next study in several other Zakat Management Organizations. As we found that the age factor can influence a person's decision to use technology in this study, the next study can consider another research theory or model to provide a better strategy for Zakat Management Organization and the Government to increase ZISWAF payments by muzakki

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# Analysis of environmental risks and impacts of an energy storage system: An applied case study of a photovoltaic plant in the Northeast of Brazil

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Received: 28 Jul 2022,

Received in revised form: 19 Aug 2022,

Accepted: 24 Aug 2022,

Available online: 30 Aug 2022

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**Keywords** — *Li-ion Batteries, Energy Storage System, Risk Analysis and Environmental Impacts.*

**Abstract** — Batteries have been increasingly used as energy storage tools associated with the generation of solar and wind energy, contributing to the reduction of negative environmental impacts. However, as much as there is a reduction in impacts, when compared to other forms of energy generation, it is still relevant to analyze the environmental risks and impacts that may be linked to Energy Storage Systems (ESS). This study presents an analysis of environmental risks and impacts related to ESSs, based on lithium-ion (Li-ion) batteries, of a photovoltaic plant located in the Northeast of Brazil. The applied methodology involved two techniques: the Bow Tie method, for the analysis of environmental risks, and the Interaction Matrix method, for the analysis of environmental impacts. Within the scope of the Bow Tie method, diagrams of the situations relevant to this study were generated, identifying causes and consequences, as well as prevention and mitigation actions for each risk. The main environmental risks found were of fire and/or explosions and environmental contamination. In the event that these risks occur, the environmental impacts associated with the physical, biotic and anthropic environments, as well as with the phases of the Li-ion ESSs (operation and decommissioning), were also identified through the Interaction Matrix, which confirmed the importance of applying preventive and appropriate measures for the listed risks, in order to, as much as possible, avoid a wide range of impacts on the environment. Through this study, it was possible to highlight both the importance of the appropriate care for the protection of the environment and for the safety of the plant's employees and the surrounding community.

## I. INTRODUCTION

Electrochemical energy storage systems, batteries and supercapacitors are increasingly presented as potential storage tools with several applications in the Brazilian energy sector. They can be used both in residential and industrial establishments, providing different services, including for compensation of the variability of wind and solar generation. Therefore, such equipment fosters the renewable energy market, reducing some negative environmental impacts such as greenhouse gas emissions, e.g. The application of technologies aimed at storing energy through batteries, in several countries, occurs, in principle, because they prove to be economically and environmentally effective; characteristics which are strongly related to the purpose of the circular economy [1; 2].

Li-ion batteries are among the most widely used technologies in the world for energy storage. The advantages of Li-ion batteries, including having a high electrochemical potential and low maintenance, contribute to large-scale production of stationary storage systems using this type of technology. Although Li-ion batteries are more costly when compared to other “battery” type energy storage devices, they offer the capacity to store renewable energy at a competitive normalized cost of storage in many applications [3].

A typical Li-ion battery is composed of a graphite negative electrode and a lithium metal oxide positive electrode (LiCoO<sub>2</sub>, LiMnO<sub>2</sub>, LiNiO<sub>2</sub>). The electrolyte is formed by a solution of lithium hexafluorophosphate salt (LiPF<sub>6</sub>) dissolved in an organic solvent. Additionally, at the cathode and at the anode, collector interfaces made of aluminum and copper, respectively, are used [4].

Lithium-iron phosphate (LFP, LiFePO<sub>4</sub>) is another commercially available cathodic material. The LFP battery offers good electrochemical performance with low resistance. This is possible with the nanoscale phosphate cathode material. Its main benefits are high rated current, long service life, as well as good thermal stability and increased safety and tolerance in heavy use. Furthermore, it is more tolerant under full load conditions and less stressed than other Li-ion systems, if kept at high voltage for a prolonged time [5; 6].

The electroactive materials of the electrodes are fixed on collector metallic strips made of aluminum for the cathode and of copper for the anode. The organic compound polyvinylidene fluoride (PVDF) or the copolymer polyvinylidene fluoride hexafluoropropylene fluoride (PVDF-HFP) are used as fixative and binding material for the particles of the active materials. The positive and negative electrodes are electrically insulated

by a polyethylene or polypropylene microporous separator film in batteries that employ a liquid electrolyte; a polymer gel electrolyte layer in lithium-polymer batteries or solid electrolyte in solid-state batteries [7].

Also used as electrolytes are lithium salt solutions, such as lithium perchlorate (LiClO<sub>4</sub>), lithium tetrafluoroborate (LiBF<sub>4</sub>) and lithium hexafluoroarsenate (LiAsF<sub>6</sub>), dissolved in organic solvents, such as propylene carbonate (PC), ethylene carbonate (EC), di-methyl carbonate (DMC), ethyl-methyl carbonate (EMC) among others, or a mixture of these organic solvents [7].

Currently, several Li-ion battery technologies are available on the market, containing different chemical compositions and employing various combinations of anodic and cathodic materials. Each chemical compound has its own electrical and economic characteristics.

It is important to highlight that in order to develop a more sustainable and competitive battery industry, it is essential to use responsibly sourced materials (using hazardous substances as strictly necessary), recycled materials (as much as possible), a minimal use of labels and batteries that have greater durability and performance, as well as having collection and recycling targets [8].

Thus, achieving a circular economy with a neutral climate impact requires the full mobilization of the industrial battery sector. In this context, the European Union (EU), e.g., has been adopting the circular economy as an economic model, in which the value of products and materials are maintained as long as possible in the economy through a reduction on the generation of waste and on the use of resources, as well as the constant valorization process for the reuse of a product until the end of its useful life. The transition is being implemented gradually and constitutes an indispensable element of the new EU industrial strategy, making Europe less dependent on primary raw materials [9].

Worldwide, the annual level of raw material extraction tripled between 1970 and 2017, and continues to rise, posing a huge global risk. About half of greenhouse gas emissions and more than 90% of biodiversity loss and pressure on water resources comes from the extraction resources and their transformation into materials, fuels and food. The industrial process remains highly linear and depends on the extraction of new raw materials, which are later traded and transformed into goods and, finally, disposed as waste or emissions. In the EU, industry has initiated the change, but it is still responsible for 20% of the EU's greenhouse gas emissions. [10].

Hence, the continuous decarbonization of the energy system is essential to achieve the climate targets established for 2030 and 2050. Renewable energy sources

will play a fundamental role, and the smart integration of renewable energies, energy efficiency and other sustainable solutions in all sectors will contribute to achieving this decarbonisation at the lowest possible cost [9].

In this scenario, the growth in photovoltaic energy generation in the world has been noticeable, both for economic and environmental reasons, and thus the battery market has also taken on considerably large proportions. Thus, in order to develop technological knowledge of the behavior of photovoltaic plants in interconnected systems and to support future commercial generation projects, Petrobras, together with Lactec and other partner institutions (Federal University of Minas Gerais – UFMG and Federal University of Rio de Janeiro – UFRJ), started a Research and Development project (P&D 0553-0046/2016 by the National Electric Energy Agency – ANEEL) called “Technical and commercial arrangements for the inclusion of energy storage systems in the Brazilian energy sector”. The project consisted in building a pilot energy storage plant connected directly to the electricity distribution network, with the purpose of testing the capacity of energy storage plants (by Li-ion batteries) to mitigate power intermittence, improving the frequency and voltage stability of electrical networks connected to photovoltaic plants.

One of the steps of that project was to identify and analyze possible environmental risks and impacts related to the operation and decommissioning of the Li-ion-battery Energy Storage System (ESS) of a photovoltaic plant. Thus, the objective of this study is to present the analyzes that were projected for the operation and decommissioning phases of this ESS, in order to contribute with information on the possible environmental risks and impacts that can be generated by this type of ESS.

## II. CASE STUDY AREA

The case study was carried out at the Alto do Rodrigues Photovoltaic Plant (UFV-AR) located in an area of 4.16 ha (Fig. 1) of the Vale do Açu Thermoelectric Plant (UTE-VLA), owned by Petrobras, also called Termoçu.

This plant is located in the municipality of Alto do Rodrigues, in the state of Rio Grande do Norte, Brazil, and has a nominal power of 1.1 MWp. The ESS (1 MW/0.49 MWh) is internally connected to the UFV-AR, which has been connected to the electricity distribution network of Rio Grande do Norte State Energy Company (COSERN) since 2014. The ESS has been in operation since November 2021.

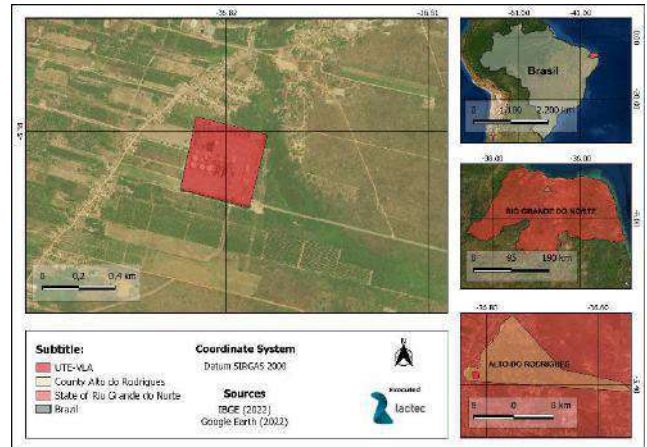


Fig.1: UFV-AR inserted in the land of UTE-VLA.

## III. METHODOLOGY

We sought to analyze the regulations aimed at batteries and photovoltaic solar energy as a whole. In the international scenario, the project had as reference the policies established by the European Union, which is currently one of the most renowned and a pioneer on these matters, i.e., the European Ecological Pact, in order to explore more deeply the concepts of circular economy and decarbonization of the world energy system. The Brazilian legislation at the federal and state level was also consulted and referenced, also mentioning the main normative resolutions of ANEEL on the subject of this case study.

The Emergency Response Plan (ERP) of the UTE-VLA of Petrobras was also used as a basis, through which it was possible to verify the existence of protective and mitigating measures in case of accidents such as fires, explosions, among others. A brief socio-environmental characterization of the area in which the photovoltaic plant, together with its ESS, is located was also carried out, compiling the main physical, biotic and socioeconomic characteristics.

The characterization of the ESS of this case study was also performed, including all the components connected to the batteries and also their structures, from the container, in which the module is stored, to its electrocenter.

The environmental risk and impact analysis methodology applied in this case study essentially involved two techniques: 1) Bow Tie Method and; 2) Interaction Matrix Method, respectively. Both were employed in order to provide a systemic view of the activities involved in the processes that were assessed (operation and decommissioning of the ESS).

The Bow Tie method was used for the analysis of events of possible risk caused by another event called imminent danger. The central part of the “tie” divides the

analyzed scenario between pre and post-event, allowing the verification of causes and their consequences. This methodology became popular in the 90's, when applied by the Shell group [11; 12]. For this study, the free version of the BowTie XP software was used to generate diagrams of both pre- and post-event scenarios in both phases of the ESS (operation and decommissioning).

As for the Interaction Matrix method, it was adopted within the scope of environmental impact assessment in order to identify possible interactions between the components of a project and the elements of the environment (impacts on the physical, biotic and anthropic environments) [13]. In this study, Excel software was used to generate the impact interaction matrix.

From the generation of Bow-Tie and Interaction Matrix diagrams, it was possible to visualize and understand the situations analyzed here, and the results were presented and discussed for each of the methods applied in this study.

## IV. RESULTS AND DISCUSSION

### 4.1 Socio-environmental Characterization of the Surrounding Area

Regarding the socio-environmental characterization of the area where the UFV-AR is located, there is a predominance of herbaceous caatinga (with plants up to one meter, such as bromeliads and grasses) and arboreal (plants of up to two meters, such as leguminous plants), and there are also areas with exposed soil with drought-adapted deciduous species. The fauna of this region is characterized by some species of lizards, amphisbaenids, snakes and turtles. Local biodiversity is adapted to the semi-arid climate [14].

Regarding the hydrography, the UFV-AR is located around 1.9 km from the Piranhas River, which belongs to the Piancó-Piranhas-Açu river basin, which has a drainage area equivalent to 43,681.50 km<sup>2</sup>, covering 47

municipalities in Rio Grande do Norte. It should be noted that in the surroundings of the plant, there are no surface water bodies [15].

With regard to socioeconomic aspects, according to the last demographic census [16], the municipality of Alto do Rodrigues had a population of 12,305 people. Currently, it is estimated at 14,923 inhabitants. Land use for the agricultural sector represents 50% of municipal land use, mainly for agricultural activities. Forest areas represent the second most expressive land occupation, with emphasis on the savannah biome [17].

Next to the Petrobras plant (about 100 m) there is a village called São José, which is home to approximately 1,000 people.

### 4.2 Application of the Bow Tie Method for Analysis of Environmental Risks Related to the Operation and Decommissioning of the ESS

A total of two Bow Tie diagrams were generated for this case study, through the BowTie XP software, in view of two possible environmental events/risks that were previously selected, based on the bibliographic research that was carried out for this type of battery technology, and associated with the operation and decommissioning of the UFV-AR ESS, namely: Fire and/or Explosion (Fig. 2, with pre and post-event information) within the scope of the ESS operation and; Environmental Contamination (Fig. 3, with pre-event information and Fig. 4, with post-event information) within the scope of the ESS decommissioning. Both diagrams provided a more representative and understandable analysis of the hazards involving the operation and decommissioning of the ESS, listing the possible causes of the identified events, the prevention barriers, the mitigation barriers and the possible consequences linked to the occurrence of these events/risks. In both diagrams, the perspectives of three different environments (physical, biotic and anthropic) were covered.

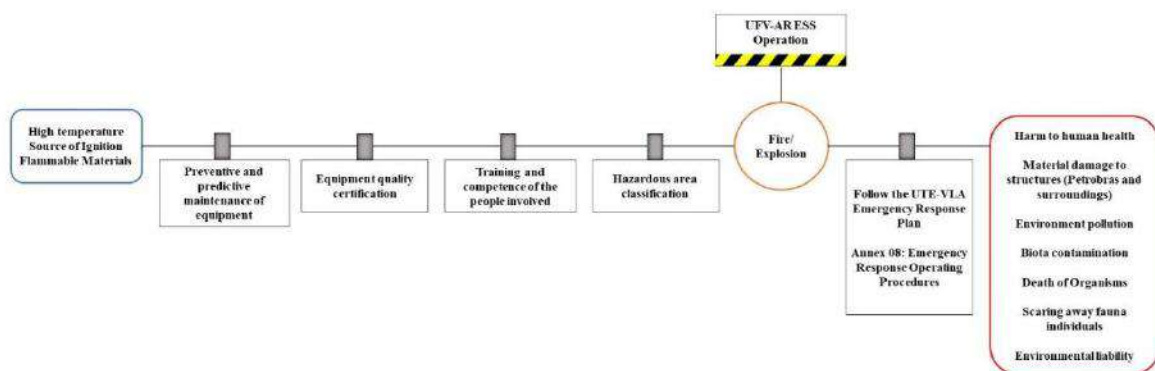


Fig. 2: Bow Tie Diagram (Pre and Post-Event Scenarios) - UFV-AR ESS Operation

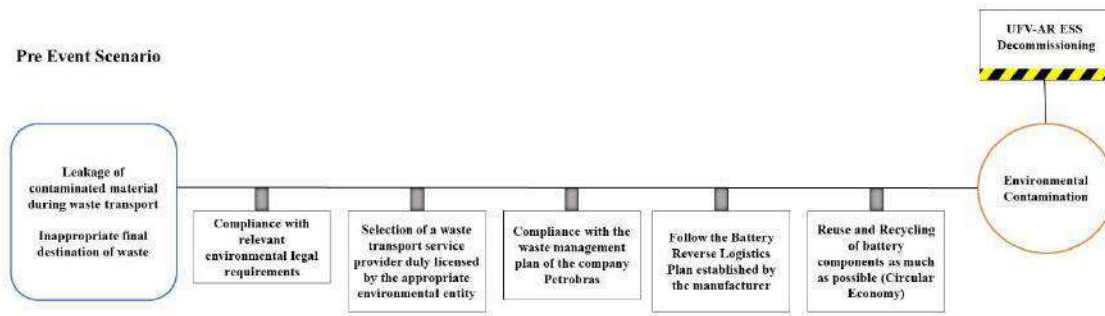


Fig. 3: Bow Tie Diagram (Pre-Event Scenario) - UFV-AR ESS Decommissioning

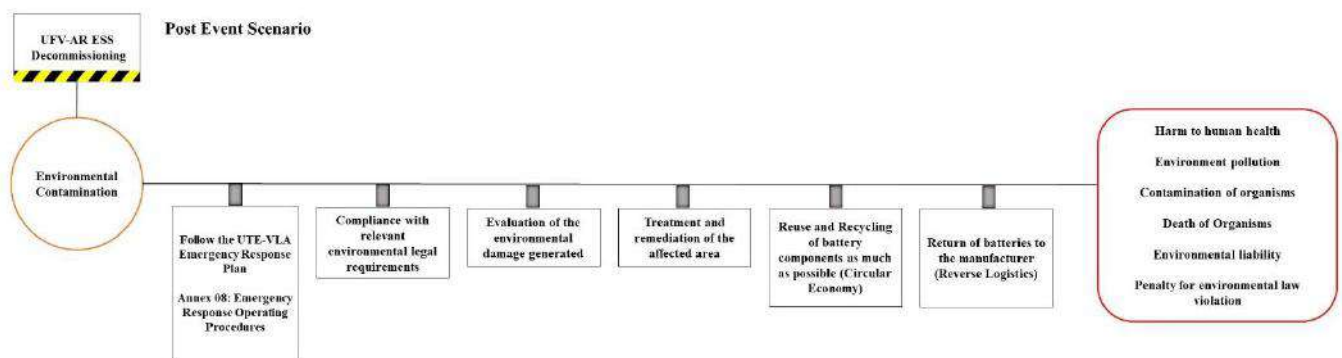


Fig. 4: Bow Tie Diagram (Post-Event Scenario) - UFV-AR ESS Decommissioning

Finally, the perspectives for each environment are detailed below, in order to provide more technical support compared to what was listed in the Bow Tie diagrams (Fig. 2, Fig. 3 and Fig. 4). Such perspectives were also based on the bibliographic research carried out for this study, as well as on the ERP of Petrobras' UTE-VLA.

**4.2.1 Physical Environment**

Energy storage systems have evolved over time, as is the case with Li-ion batteries. There are three known categories of failures related to Li-ion batteries: mechanical, electrical and thermal failures, which are associated with potential hazards such as gas release, fire and explosion. Battery plant fires share similarities with plastic fires, including thermal radiation, convective gas flow, and release of toxic chemicals. Still in relation to possible fires, the main damage envisaged is to the lives of the people involved and to property, especially when there is spread and the flames reach other structures [18].

Risks involve the relationship between impact and probability of occurrence. Also, working or living near an energy storage system is less dangerous than driving a vehicle 10 hours a week, smoking, or working in areas

such as construction and agriculture [19]. In order for these facilities to continue providing safety to all, mitigation and control barriers must be designed in order to minimize and mitigate possible impacts. As technology evolves, these tools and their developers must increasingly seek to make work environments safer.

Li-ion batteries are designed to work within the so-called operational window, that is, in predetermined ranges of values within operational parameters (e.g. voltage and temperature). Hazardous situations are not to be expected when the battery system is operating within its operating windows.

The evolution of a hazardous situation in a Li-ion cell is typically characterized by an increase in cell temperature. When the thermal threshold is exceeded, the rate of heat dissipation may be less than the rate of heat generation. This will cause a thermal avalanche that could lead to solvent evaporation, pressure build-up and local fire. When the thermal avalanche from a single cell propagates to the next, inside a module or battery set, the so-called uncontrolled thermal propagation occurs, which can lead to serious consequences such as additional pressure increase, casing rupture, hot, corrosive and toxic

gas venting, fire and, in specific circumstances, explosion. In principle, the greater the amount of chemicals and energy stored in a system, the greater the consequences [20].

However, safety systems are designed to ensure minimum safety conditions during battery life [20]. For stationary applications, the safety of battery systems is not regulated. However, there are international standards that can be used. Safety assessment in industrial applications (including stationary applications) is primarily based on the international standard IEC 62619:2017. This standard refers to overload conditions and is specific to lithium-ion batteries [20].

When considering the reuse (second use) of batteries, questions arise about the safety level of batteries at the end of their first life and how to ensure the safety of the systems used, especially in case of unknown history of use. In fact, the safety of batteries at the end of first use still needs further research. In addition, reused batteries will be subjected to different operating conditions and therefore will have to be tested according to standards appropriate to the new application. A new work proposal was established by IEC TC 21 (Secondary cells and batteries) for IEC 63330 ED1 "Requirements for reuse of secondary batteries". The scope of the document specifies the procedure for assessing the performance and safety of used batteries and battery systems for reuse purposes [20].

For recycling an ESS, information on how to access and remove critical and hazardous components must be available. The type of information depends on the product, the components to be removed (e.g. solid, liquid and/or gas) and the techniques available for recycling. Some removal operations are automated; others require manual disassembly, access and manipulation. To optimize recycling operations and prevent damage to components, a disassembly procedure, including information on battery chemistry (hazardous, valuable, rare), is necessary. Also, it is important to note that disassembly must be carried out in discharged units [20].

Facilities used for the purpose of storing batteries (repair, reuse, remanufacturing, recycling or disposal) must comply with local fire and building codes of practice and rules regarding the storage of hazardous materials. Monitoring and controlling the temperature and possibly the humidity of the storage rooms is critical, as well as recording information about the battery, such as charging or discharging, and the open circuit voltage at the start and end of storage [20].

Another situation that should offer an adequate level of safety is the transport of batteries. For example, in Europe, second-use battery systems are required to comply with

applicable transport regulations as required for new batteries. When the test criteria described in regulation UN 38.3:2019 "Recommendations on the Transport of dangerous goods, Manual of test and criteria" are satisfactorily met, the battery can be transported as a Class 9 regulated battery – Miscellaneous hazardous substances (lithium batteries, etc.) [20].

Battery-based energy storage systems have a finite lifespan, although users do have some criteria as to deactivation time based on factors such as safety and performance. The decommissioning process involves dismantling the energy storage system and removing it from site in compliance with applicable federal and local regulations governing the safe transportation and disposal of used equipment and waste. Basic processes and end-of-life management considerations are described by ESA [21], along with an assessment of current technology and market status regarding end-of-life options, including recovery for second use and recycling.

According to the ESA [22], the disposal of Li-ion batteries in landfills is not permitted by law and the prospects for reconditioning/recovering batteries for second life applications are still very limited. Although the Li-ion battery recycling industry is in its early stages, in terms of capacity and scale, more efficient and sustainable recycling processes are under development. Therefore, recycling batteries currently qualifies as a best practice for end-of-life management.

The scope of decommissioning depends on the specific conditions of the project, the type of system and the chosen means of disposal. In some cases, the battery modules are removed, while the rest of the system (controls and cabinets) remains and is reused with new battery modules. In other cases, systems are completely replaced in an integrated manner. Once a used battery is removed and intended for end-of-life management it is designated as "Universal Waste", a special category of hazardous waste under U.S. EPA (Environmental Protection Agency) regulations. These rules generally require record keeping, labeling and storage methods that keep material out of contact with the environment. The energy storage system as a whole can represent a significant amount of materials, including cinder blocks, steel cabinets, cabling and a host of electronics. Concrete and steel are readily recyclable and many cabinets can be reused (particularly if the site is receiving new batteries). Inverters, control systems and other electronic equipment share many of the challenges of e-waste, but useful materials can often be recovered [22].

When batteries are submitted to recycling, the process begins with the disassembly of electrically discharged

batteries. The current variety of Li-ion battery types, sizes and chemicals makes automating the process difficult, thus it is largely manual. The steps consist of removing the battery housing, separating the connectors, disassembling the modules from the racks, separating the cells from the modules, and removing the electrolyte. In addition to manual separation, some recyclers employ ultrasound and/or mechanical agitation to remove cathodic material. After crushing, or milling and pre-treatment, the cells undergo one or two types of recycling processes currently available: pyrometallurgical and hydrometallurgical. These processes recover different amounts and types of materials from batteries, which are sold in *commodity* markets. It should be noted that while the market re-introduction of recovered materials can generate environmental benefits, such as reduced use of raw materials, this must be compared to energy use and emissions from the recycling processes themselves, which can compromise these benefits [22].

It is important to highlight the structuring, implementation and operation of the reverse logistics system. In Brazil, Federal Decree no. 10,240/2020 [23] establishes that companies can create contract measures and agreements between themselves, in order to provide an environmentally appropriate disposal of solid waste. Also, Federal Decree no. 10.936/2022 [24] regulates Law no. 12.305/2010 which establishes the National Solid Waste Policy and the National Reverse Logistics Program. It is worth considering that Solid Waste Management Plans (SWMP) provide for the disposal of Li-ion batteries, including the transport procedure, government levels involved and licensing or other relevant legal requirements.

For this case study and analyzing the Bow Tie diagrams generated for the ESS of UFV-AR (as previously presented by Fig. 2, Fig. 3 and Fig. 4), as well as considering the concern with possible negative effects resulting from both the operation and decommissioning of this ESS, the ERP, prepared for the context of Petrobras' UTE-VLA, presents a fire fighting system, with appropriate escape routes in cases of risk, as well as a Map of Surroundings Characterization, including the location of the UFV-AR and its ESS [18].

In cases of chemical product leaks, this same ERP provides kits for controlling leaks for universal use. These kits include absorbent cords and blankets, gloves and disposal bags, among other equipment. There are also kits for working at heights, a first-aid clinic and material for isolating areas, if necessary [18].

Regarding medical emergencies due to intoxication and/or burns, victims must be removed from the scene and

then the appropriate responsible bodies must be called (such as the Mobile Emergency Care Service - SAMU, ATP-ARG Emergency Brigade, or the UTE Occupational Health office – the latter, for less severe cases). In the event of a chemical product leak, the strategy includes calling the Emergency Brigade, blocking possible sources of ignition close to the affected area, and containing the leak and collecting the product that was leaked.

In cases of fire, in general, after activating the Emergency Brigade, some measures of its action are provided for in the respective ERP: i) check if there are victims at the scene and arrange for their medical attention; ii) fight the fire, activating the respective systems mentioned above; iii) contain/block rainwater drainage systems and local streams with physical barriers; iv) in case of electrical systems, de-energize equipment/system on site; v) turn off power sources near the affected location.

With regard to other possible negative effects, in the event of decommissioning of the ESS, considering the event of environmental contamination, it is essential to emphasize the importance of meeting the relevant environmental legal requirements (as a way of mitigating or containing a certain contamination), carrying out the treatment and remediation of the affected area (following appropriate regulations for each case), assessing the possible environmental damage generated by any contamination, investigating the possibility of reuse or recycling of some battery components or returning the batteries to the manufacturer (reverse logistics).

Much more than just ensuring that the appropriate assessments, mitigations, and remediations are carried out, in case of a certain event (post-event scenario), it is important to previously analyze the environmental impacts that may be generated, upon any event, and to adopt all appropriate measures in a pre-event scenario.

It should be noted that currently in Brazil, the batteries used are usually imported, as there is no such type of production in the country, which leads to difficulties in reverse logistics, in returning to manufacturers, for environmentally appropriate disposal of the batteries.

As ways to prevent fire/explosion risks and environmental contamination of the UFV-AR ESS, several actions can be listed, such as: maintenance personnel and service providers trained on the safety procedures and processes associated with risk activities; control of electrical ignition sources and instrumentation through hazardous area classification, correct specification of equipment and maintenance thereof.



#### 4.2.2 Biotic Environment

In the present study, analyzing the possible situations of anomaly in its operation and decommissioning phases, fire/explosion events and environmental contamination can lead to the death of organisms, and/or environmental degradation, affecting the biota and its health conditions, behavior and survival over time. The chemical elements that make up batteries cause drastic and in some cases lasting impacts in ecosystems.

In addition, in the event that the batteries are improperly disposed of or in the event of breakage/leakage, most of the metals that compose them are insoluble, being discharged into the environment in an unnatural way. Metals dispersed in the soil do not degrade and cannot be recovered from the soil. A study carried out on the topic showed that unless they come in contact with acid rain, metals remain stationary in the soil and therefore metal pollution gathers in the surface layers, compromising crops that grow in the soil [25].

The effects that arise from chemical contamination are based on many factors. Not only do they depend on the chemical they come in contact with, but the effects are also determined by the "concentration of the element in the environment and the duration of exposure". Since many of these toxic chemicals progressively accumulate in the body (or in the ecosystem), "long-term exposure to low concentrations can lead to adverse effects when the toxic dose is reached" [25].

Still in the scope of the biotic environment, another situation that can occur is the scaring away of individuals of the fauna in the occurrence of any fire/explosion event. Fauna species such as birds and mammals have the ability to move to more distant locations. However, other faunal groups with low displacement capacity, such as amphibians and reptiles, may be directly affected. As to the flora, the vegetation present in the bordering areas can be affected in the event of the spread of flames, and the vegetation of the caatinga is more susceptible to burning in periods of drought in the region.

#### 4.2.3 Anthropogenic Environment

Predicting the anthropic impacts generated, the possible risks and forms of mitigation, with regard to the operation and decommissioning of the ESS in question, is important both for Petrobras and for the surrounding community.

Considering the specifications of the present study, it was found that improvement in technology, inclusion of renewable energy and supply of electric energy to the COSERN grid are the most relevant positive anthropic impacts of this project. Photovoltaic technology has the

potential to be the most used energy matrix in the world, having had a significant increase in its research and implementation, mainly in Brazil [26]. The Brazilian Northeast holds 70.7% of centralized photovoltaic projects and 18.9% of the country's distributed photovoltaic generation [27]. Brazil has levels of solar irradiation higher than those of countries where projects for the use of solar energy are widespread, and the photovoltaic generation capacity in the country corresponds to 8.9 GW [28].

On the other hand, with regard to the negative effects, situations such as increased risks of occupational accidents and of flow of vehicles not belonging to the locality may occur. Such increased flow can cause accidents involving both people and animals, and accidents with other vehicles [29]. These threats can be minimized by studying possible routes, where there is not a large flow of people, for the operation and decommissioning of Li-ion batteries, training and awareness of the company's drivers for defensive driving practices and dialogue with those responsible for signaling and maintenance.

Another identified risk is the fire/explosion of battery containers. Potential hazards are burns from overheated cells, injuries from overheated cells or explosions, injuries from fire, exposure to toxic or corrosive gases or liquids from the battery or its decomposition products [30]. If lithium is burning, both employees and the surrounding population must take distance and avoid exposure to toxic gases from its combustion. In the event of an accident such as an explosion, fire and contact with chemical substances, it is extremely important that the ERP of the plant is followed.

Regarding the possible damage to human health, mentioned as consequences in the Bow Tie diagrams for this case study (Fig. 2, Fig. 3 and Fig. 4) are bodily injuries to both Petrobras' employees and the local population around the area, due to the proximity to residences in the village of São José. The fire/explosion event can affect homes and residents, causing various physical injuries (superficial or serious), as well as loss of structures, if these events cause damage to both Petrobras facilities and nearby residences and surrounding public infrastructure (public roads, squares, among others).

#### 4.3 Application of the Interaction Matrix Method of Environmental Impacts related to the Operation and Decommissioning of the ESS

In Fig. 5, the Interaction Matrix of negative environmental impacts associated with the operation and decommissioning of the UFV-AR ESS is presented. The associated risks were based on the two events listed for this case study, through the application of the Bow Tie

method (Fire/ Explosion and Environmental Contamination) and the related environmental impacts (in the event of occurrence of these risks) were divided between the environments: i) physical: contamination of environmental resources (soil and water), emission of

polluting gases, and generation of solid waste; ii) biotic: several impacts on fauna and flora; iii) anthropic: noise generation; generation of solid waste, and impacts on human health.

O PHASE		D PHASE	UNIT PHASES AND ACTIVITIES	ENVIRONMENTAL IMPACTS	PE			BE		AE		
ESS Operation	ESS Maintenance	Batteries disposal			Contamination (soil and water)	Emission of polluting gases	Generation of solid residues	Impacts on fauna	Impacts on flora	Noise Generation	Generation of solid residues	Impacts on human health
			ENVIRONMENTAL RISKS									
			Fire/Explosion									
			Environmental Contamination									

Key:  
 Non-Applicable  
 Applicable  
 O Phase: Operation Phase  
 D Phase: Decommissioning Phase  
 ESS: Energy Storage System  
 PE: Physical Environment  
 BE: Biotic Environment  
 AE: Anthropic Environment

Fig. 5: Interaction Matrix of environmental impacts related to the operation and decommissioning of UFV-AR ESS

Observing the interactions (Fig. 5) between the risks and the environmental impacts that can be generated, in the event of the occurrence of the listed risks, it was possible to show that both for the Fire/Explosion risk (in the ESS operation phase), as for the Environmental Contamination risk (ESS decommissioning phase), all environmental impacts were considered on all environments (physical, biotic and anthropic), with the exception of the impact of noise generation (anthropic environment) for the risk of Environmental Contamination, which ended up not being considered.

Therefore, it was verified the importance of the application of preventive and appropriate measures for the listed risks, in order to avoid, as much as possible, a wide range of impacts on the environment.

### V. CONCLUSION

Li-ion batteries are increasingly used internationally, due to their advantages related to efficiency and portability. Its application fits the circular economy model, contributing to a lower generation of negative environmental impacts. In addition, on a global scale, standards increasingly regulate the use and disposal of batteries, encouraging manufacturers and consumers to optimize their use in relation to their useful life.

Energy storage systems require constant supervision and maintenance, and their operation and decommissioning must take place according to technical guidelines from the manufacturing company. The SWMP in these operations must include the appropriate return procedures, so that reverse logistics can be applied. It is the role of the plant manager, together with the manufacturer, to verify the procedures involved regarding

the environmentally appropriate and safe transport and disposal, at the end of the useful life of these batteries, since this is already provided for by several international, as well as Brazilian regulations (incipiently: Federal Decree no. 10.240/2020 [23] and Federal Decree no. 10.936/2022 [24]).

One of the most important points that this case study brings to light, considering that the use of batteries as a form of energy storage tends to grow both in Brazil and in the world, is the importance of applying adequate reverse logistics, reconciling with what each country establishes in terms of regulations on this subject, as well as with the most sustainable techniques for disposal and/or recycling of batteries.

Regarding the village located in the vicinity of the project, as well as the vegetation and fauna present in this area, they are the most susceptible, mainly in cases of fire/explosion and/or environmental contamination. Therefore, it is essential to adopt efficient and effective prevention and mitigation measures, and, where necessary, to monitor possible environmental impacts. In this case study, it is emphasized that Petrobras already has an ERP to be followed, in case the risks assessed in the ESS of UFV-AR occur.

Still with regard to the community close to the plant, it is suggested that, through the relationship channel between the village of São José and Petrobras, the community is officially communicated about the operation of the ESS and its importance in the context of photovoltaic energy storage generated at UFV-AR.

The use of the Bow Tie method in this case study made it possible to visualize the causes and consequences, as well as the prevention and mitigation actions for each type

of event, both in the operation and decommissioning phase of the ESS, in a very intuitive and clear way, which can facilitate the dynamics of future Petrobras internal training, as well as a more assertive communication regarding the environmental risks identified in this ESS, as a way of raising awareness among employees who are directly involved in the activities of this plant.

As for the Interaction Matrix method applied in this case study, crossing the environmental risks identified for the operation and decommissioning of the ESS, with the environmental impacts that may occur in the physical, biotic and anthropic environments (in the event these risks actually occur), it was possible to note the importance of applying preventive measures, in order to avoid, as much as possible, the chances of a wide range of impacts on the environment.

Both the Bow Tie diagrams and the Interaction Matrix used in this case study are subject to updates, as new needs are identified by the employees involved in the operation and decommissioning activities of this ESS.

Finally, one concludes that the use of the two methods to analyze environmental risks and impacts of energy storage systems, not only Li-ion, but other technologies, is very practical and easy to understand. In this manner, one can ensure that all those involved in the possible environmental risks and impacts linked to a particular plant are aware and know how to proceed in cases where such events may occur.

### ACKNOWLEDGEMENTS

The authors wish to thank the National Electric Energy Agency (ANEEL) and Petróleo Brasileiro S.A. (PETROBRAS) for funding the R&D project ANEEL PD-00553-0046/2016 “Technical and commercial arrangements for the inclusion of energy storage systems in the Brazilian energy sector”, of which this work was a part. They are also grateful for the contribution of the other Lactec researchers involved in this project.

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# Social Responsibility in Government Relations

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Received: 25 Jul 2022,

Received in revised form: 18 Aug 2022,

Accepted: 23 Aug 2022,

Available online: 30 Aug 2022

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**Keywords**— *Social Responsibility, lobbying  
regulation, accountability, compliance*

**Abstract**— *Democracies considered advanced have legislation regulating lobbying activities as an important element in the representation of interest groups, but the relationship of these groups with the State integrates elements of corporate social responsibility. What has not been considered is how public servants view this regulation as an interested party. The present study observes the perception of the Federal District Legislative Chamber employees on the elements necessary for effective social responsibility in government relations.*

## I. INTRODUCTION

Brazil has been going through a moment of weakening public opinion before its rulers, this is due to the successive political crises that have been reported.

One of the elements common to these news is the involvement with so-called lobbyists, which creates a certain repulsion in the population when there is talk of this type of professional.

According to the Michaelis dictionary, lobbying is “the activity of pressure on the part of an organized group in order to influence the vote of parliamentarians, according to certain interests”

Since the 1988 constitution, the Brazilian parliament has been discussing the regulation of lobbying, all without exception failed to be approved by the National Congress. That said, it leads us to the idea that Brazil would need specific legislation to aggregate the interests of all in the definitive resolution of this activity.

Considering that for the full functioning of a democracy it is necessary the performance of this professional, much has been discussed the regulation of this profession, aiming at mitigating risks to society and the treasury.

Given this scenario, we question what would be the effects or impacts of lobbying regulation and what is the level of transparency of the activities of interest groups with legislators and bureaucrats and, finally, how does the integration of agendas, political agents and interest groups take place?

This article aims to observe in the Legislative Chamber of the Federal District how the servers of this house face the possible changes of rules arising from a regulation. That said, we must observe what elements are necessary for a practice of transparency and compliance in the offices of district deputies.

## II. METHODOLOGY

Knowing that it is very important, that the researcher has in mind, which principles to be followed, to achieve a certain result. In this context, it is necessary to follow certain axioms-principles, as they will guide the researcher to achieve the desired result in the best possible way.

The method used was inductive, in this way we reached conclusions based on particular to general facts and in order to confront transparency practices.

The research was carried out in the Legislative Chamber of the Federal District located in the city of Brasília, capital of the Federative Republic of Brazil.

The Universe surveyed is 24 heads of cabinets, all district deputies' offices.

The research is quantitative and the universe is of 24 chiefs of staff, so we have a sample for convenience.

It is determined with inclusion criteria to occupy the position of chief of staff or another substitute servant in one of the 24 offices, it is noteworthy that another servant of the office may respond to the questionnaire if delegated by the chief of staff.

As exclusion criteria, forms delivered after the deadline and incomplete forms were excluded, so we had 22 volunteers, and two offices refused to participate in the research

The data collected by the research will be grouped by category of information, thus a ranking was created by category of each cabinet of the Legislative Chamber. Simple descriptive statistics and the presentation of data through graphics were also used for better understanding.

The field research was developed through a questionnaire prepared on the Google Forms platform and applied in person by the researcher to each person in the population, which was carried out from September 1 to 30, 2018.

### III. RESULTS AND DISCUSSIONS

The applied questionnaire contains questions and the first questions are not the object of analysis, it only consists of a validation mechanism from the person to the sample.

The first question, "name" will not be disclosed to maintain the confidentiality of the researched person, as well as the questions that are respectively "which parliamentarian do you work for?" and "email". It is noteworthy that the latter has its relevance for the dissemination of results to those surveyed.

The second question asks "position you hold in the cabinet" which has two answers, the first being the chief of staff and the second others. This question aims to answer that, in order to have the universe researched, the respondents must necessarily be the chief of staff or someone designated by him.

Within the 24 offices, which consists of the universe, we obtained 22 responses with only two offices that will refuse to answer the questionnaire. Fifty percent of those interviewed held the position of chief of staff and the other 50 percent were appointed by the chief of staff, an

interesting fact is that the advisor appointed in all cases was a press officer.

Thus, we have that 64% of the occupants are in their first term and 36% have already held the position for more than one term.

Questions that aim to observe the degree of autonomy that the chief of staff exercises in relation to the deputy's political mandate, considering a scale from 0 to 10, where zero means no autonomy and 10 means full autonomy? separated into two questions in order to establish the difference between administrative autonomy and political autonomy.

The questions aimed at identifying whether there is a specific mechanism for receiving people and for scheduling a hearing with the parliamentarian.

The question below assesses the perception of mandate transparency that the chief of staff attributes to the mandate on a scale of 0 to 10, where zero means no transparency and 10 means full transparency.

The question that wants to observe how pressure groups try to interact with parliamentarians even if they have a divergent political agenda. This data shows us that the cabinets receive information that is contradictory to the parliamentarian's thinking.

The question asks whether there is a policy of transparency on the matters dealt with in the hearings held in the cabinet.

It is observed that 64% of the offices do not have any transparency policy in the hearings held in the offices.

The perception if there is a need to have clear rules (norms/laws) that determine transparency policies for the cabinet is the objective of the question.

In the question below, the scale from 0 to 10 is again applied to observe what would be the positive impact on the parliamentary mandate if there was a detailed transparency policy. It is noteworthy that the focus is on the positive, as we understand that increased transparency can also have a negative impact.

We observed that 73% of respondents believe in the greater scale of positive impact and the other 27% still have a high expectation of positive impacts.

The following question raises the possibility of passing lobbying regulation and assesses whether the cabinet would require the presentation of corporate responsibility and transparency policies to receive in the cabinet.

73% of respondents point out that the possibility of requiring social responsibility policies to be received in the cabinet could be a reality if lobby regulation is approved.

The following question resumes the discussion about self-regulation or specific legislation, so should the existence of transparency rules in the public service also require transparency from the lobbyist?

Finally, it directly questions whether self-regulation would be sufficient for pressure groups to act or whether legislation would be the most appropriate.

We can infer that the chief of staff presents himself in most cases as a political adviser to the parliamentarian and less as an administrator of the cabinet.

The first interesting fact that the research showed us was that fifty percent of the interviewees held the position of chief of staff and the other 50 percent were appointed by the chief of staff, and all those appointed were press officers, which shows us that the The term of office of the district deputies has a high degree of concern with communication, making it possible to infer that there is a probable hierarchy within the cabinets, placing the press officer as of a high degree of importance.

This data allows us to make a preliminary inference that the cabinets have a high degree of concern with accountability issues.

We can infer that the chief of staff in most cases mainly performs the role of political adviser and the strictly administrative functions have a much greater dispersion, that is, it depends a lot on the parliamentary style.

Thus, we have that the relationship of society or pressure groups in relation to the cabinet is greatly influenced by the performance of the chief of staff.

These data show us how a good accountability policy can generate compliance mechanisms on the part of pressure groups if well-detailed procedures are required from civil servants in the application of this first filter of access to parliamentarians, given the importance of civil servants in guaranteeing or hindering access to the parliamentary.

In the same way, the research observed that in most offices there is a policy of transparency of the hearings held, which indicates that the filter that the offices exercise in holding the hearings is directly linked to the fact that these hearings tend to be published, probably through of social networks.

Having considered the approval of the lobbying regulation, the advisors demonstrated that they could require pressure groups to present social responsibility policies to be received in the cabinets.

Firstly, in the perception of the employees of the Legislative Chamber of the Federal District, there is no

difference between pressure groups and/or citizens. This observation is consistent with the perception that groups arise from individual interests without the need for anchoring in a larger representation, that is, their origin does not define them as a pressure group.

A primeira abordagem discutida refere-se à teoria dos grupos, ancorada nos trabalhos de Bentley (1908) e Truman (1951) e caracterizada pela ideia de que organizações surgem espontaneamente dos interesses individuais. A segunda abordagem é a de Olson (1965), o qual afirma, enfatizando as motivações individuais para a ação, que, mesmo não havendo obstáculos, a existência de interesses na sociedade não acarreta, necessariamente, a sua organização em grupos. (REZENDE, 2018, p. 173).

On the other hand, we have a significant divergence regarding its effectiveness. We have a tradition of pointing out that organization in groups is more effective in claims before public bodies, but our data indicate that the interests of district deputies are little influenced by pressure groups, given that the cabinets cannot perceive any difference between the claim of a citizen or pressure group.

Dois pontos dominaram a discussão empreendida. O primeiro diz respeito às características dos grupos associadas com maiores oportunidades de influência. Nesse sentido, Olson (1982) afirma que pequenos grupos em uma sociedade, geralmente, terão maior poder de lobbying, enquanto evidências trazidas por Aragão (1994) ressaltam que a capacidade de influência depende de um número representativo de componentes. Ademais, é corrente a afirmação de que grandes grupos são mais influentes. Diante das aparentes contradições e da análise dos resultados de um survey, alguns elementos para a pesquisa vieram à tona. Para além de um problema de número, outros fatores devem ser considerados, esperando-se que grupos com maiores recursos financeiros e mais estruturados organizacionalmente tenham mais facilidade em superar os dilemas associados à ação coletiva e, por conseguinte, maiores oportunidades de influenciar o processo decisório. O segundo ponto a ser destacado refere-se a uma problematização da ideia presente em Bentley (1908) e Truman (1951), segundo

a qual o sistema político configura-se como um processador neutro dos interesses que emergem da sociedade. (REZENDE, 2018, p. 173)

We have strong indications that the political system works as a neutral processor of interests, which has the perception that groups are indifferent from the perspective of the parliamentary cabinet, however, no indication of preference was presented that justifies that any group has a greater opportunity for influence.

No entanto, não é este o cenário que advém de nossas arenas decisórias. São distintos, entre os grupos, os recursos, as oportunidades de acesso aos tomadores de decisão e a capacidade de influenciar o jogo político, caracterizado por demasiada assimetria. Os pontos supracitados se conectam, justificando a relevância da pergunta apresentada e o diálogo que se estabelece com duas importantes perspectivas do estudo dos grupos de interesse. (RESENDE, 2018, p. 174).

That said, it puts us in check on what could generate this distortion, it seems to us that the fact of the relationship between private agents as actors that finance the candidacies could determine the degree of influence of pressure groups.

É possível deduzir que, em muitas situações, os parlamentares representam os interesses daqueles que, pela via econômica, viabilizaram a campanha eleitoral para que estes pudessem ocupar o cargo de legisladores. Para tanto, em muitas situações, os legisladores atendem prioritariamente aos interesses de grupos econômicos que os auxiliaram com doações as campanhas eleitorais. Logo, os grupos econômicos, por meio do financiamento das campanhas eleitorais, trocas de favores e outros atos espúrios, têm interferência e influência direta no processo legislativo. E, em muitas situações, o interesse público é ignorado, embora este seja uma das principais premissas à representatividade da população no Congresso Nacional. (MELO, FRITZEN, FERNANDES, SIEDENBERG, ALLEBRANDT, 2018, p. 101)

However, this factor was not considered in this research due to the change in the electoral legislation that prohibited corporate campaign financing, which puts us

with two possible scenarios, the first of having a migration of campaign financing money to pressure groups. and the second is that the interests that pressure groups may have in the Legislative Chamber of the Federal District are significantly lower than in the National Congress.

Visando ao financiamento da próxima eleição, o político acaba sendo influenciado a seguir orientações que podem não servir ao clamor da população; porém, na visão dele ou do próprio partido, são necessárias para a garantia de sua reeleição, mesmo que a notícia se mostre negativa para os seus eleitores. Uma solução possível para o caso seria a aprovação de lei que regulamentasse o lobby e a sua prática, tornando o processo o mais transparente possível. (MELO, FRITZEN, FERNANDES, SIEDENBERG, ALLEBRANDT, 2018, p. 101)

Considering that this relationship between private agents and political agents was, at least in theory, mitigated by the prohibition of financing and we do not have any indication of reduced influence of companies in the legislature, we believe that there is another factor that influences the political agenda.

Ao longo do exposto aqui, tentamos abarcar o lobby da CNI via Agenda Legislativa. Assim, foram esboçadas aqui questões atinentes aos grupos de interesses, suas influências na democracia, bem como o lobby, cada vez mais presente em nossa realidade brasileira. Ambos os temas, lobby e grupos de interesses, foram relacionados de forma a construir um conhecimento acerca de como um está vinculado ao outro. Com isso, foi possível perceber a importância que os grupos de interesses têm para a democracia, à medida que garantem uma participação dos cidadãos no debate público, além de permitir uma maior capacidade de influenciar na agenda governamental. Ademais, não se pode pensar em grupos de interesses sem pensar em lobby, em atuação política. (PINA, 2017, p. 54).

This puts us into questioning where the agenda power of the district deputies would be, in our research it was clear that their administrative structure makes the first filter, thus, it is noted that the levels of governance of the cabinet directly influence the construction of the schedule.

Além de tratarmos sobre o lobby, objeto principal de estudo deste trabalho, falamos



sobre o sistema corporativista brasileiro no qual tanto o lobby quanto a própria CNI existem. Portanto, debruçar-se sobre o sistema corporativista, suas mudanças e como está o cenário atual foi de grande relevância para uma compreensão holística sobre o motivo que leva a CNI a ser tão importante. O que por sua vez, também é fruto das mudanças que ocorreram no ambiente econômico e político após o fim da ditadura militar, o que mudou o Brasil e mudou a forma de atuação política dos grupos de interesses, incluindo a CNI; período quando o lobby começou a se proliferar no cenário político nacional. Justamente neste período se insere a Agenda Legislativa da Indústria, fruto da ação da CNI para fomentar uma produção legislativa que fosse mais positiva para o setor. (PINA, 2017, p. 54).

We observed that the literature points to the need to regulate lobbying, but our research indicates that this would be a secondary path, being necessary first to regulate the performance of public servants in relation to pressure groups due to their power of agenda and their understanding of that self-regulation by the lobby would be sufficient to mitigate possible corruption risks.

#### IV. CONCLUSION

This article observed that for the execution of a good policy of transparency on the part of the offices of district deputies, a high degree of communication on the part of the communication area of the office is necessary, with a main focus on communication through social networks, however it became clear that there are no rules for compliance by these offices.

We also observed that changes in legislation regarding lobbying regulation do not have practical effects on the interaction of cabinets with pressure groups.

We have no indications that the absence of regulation would bring any gain in the activities of the Legislative Chamber, but we can infer that due to the potentially harmful nature of lobbying activity, its regulation may be welcome.

Likewise, from the public servants' perspective, the regulation would not generate any change in the behavior of pressure groups in relation to the offices.

Also, there is no clear link between the agenda of the legislature on aspects of corporate social responsibility,

however, in this case there is a latent need for regulation in order to have an impact.

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# Use of information and communication technologies in the processes of technological training in sustainable agriculture in the Brazilian context a literature review

## Uso das tecnologias da informação e comunicação nos processos de capacitação tecnológica em agricultura sustentável no contexto brasileiro uma revisão de literatura

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Received: 25 Jul 2022,

Received in revised form: 18 Aug 2022,

Accepted: 23 Aug 2022,

Available online: 30 Aug 2022

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**Keywords** — ICTs, Technological Capacity Building, Sustainable Agriculture, Territory, Development.

**Palavras-chave** — TICs, Capacitação tecnológica, Agricultura sustentável, Território, Desenvolvimento.

**Abstract**— The digital transformation in agriculture is underway and has increasingly attracted several segments that perceive the potential of technologies to leverage agricultural production, through the use of technological resources that enable rural planning, cost reduction allied to the preservation of resources. natural resources, such as precision agriculture. This article aims to identify the contributions of technological training in sustainable agriculture made possible with the use of information and communication technologies [ICTs] in the Brazilian context and its implications for the economic and social development of the territories. The perceived problem is that the lack of adoption of ICTs by social and economic agents delays the process of territorial development. Based on the hypothesis that the use of ICTs in technological training in sustainable agriculture can contribute to the economic and social development of the territories, a literature review of articles published in journals was carried out, from 2017 to May 2022. The main observed results highlight that the use of ICTs requires greater engagement of social and economic agents from different territories, in order to guarantee the implementation of public policies that expand connectivity and the training of actors.

**Resumo**— A transformação digital na agricultura está em curso e tem atraído cada vez mais diversos segmentos que percebem o potencial das tecnologias para alavancar a produção agrícola, por meio do uso de recursos tecnológicos que viabilizam o planejamento rural, a redução de

*custos aliados à preservação dos recursos naturais, a exemplo da agricultura de precisão. O presente artigo visa identificar as contribuições da capacitação tecnológica em agricultura sustentável viabilizadas com o uso das tecnologias da informação e comunicação [TICs] no contexto brasileiro e suas implicações para o desenvolvimento econômico e social dos territórios. O problema percebido é que a ausência da adoção das TICs pelos agentes sociais e econômicos retarda o processo de desenvolvimento do território. A partir da hipótese de que o uso das TICs na capacitação tecnológica em agricultura sustentável pode contribuir para o desenvolvimento econômico e social dos territórios, foi realizada uma revisão de literatura de artigos publicados em periódicos, no período de 2017 a maio de 2022. Os principais resultados observados destacam que o uso das TICs requer um maior engajamento dos agentes sociais e econômicos dos diferentes territórios, a fim de garantir a implementação de políticas públicas que ampliem a conectividade e a capacitação dos atores.*

## I. INTRODUÇÃO

O desenvolvimento sustentável tem sido amplamente difundido e defendido por diferentes instâncias preocupadas com o futuro do planeta. De acordo com Ribeiro (1997), o conceito é polissêmico e assume diferentes definições para grupos diversos, a exemplo de ecologistas, economistas, ativistas ambientais, populações locais, entre outros. O autor ressalta a necessidade de proposição de uma “estratégia de desenvolvimento” que considere a natureza e as necessidades das futuras gerações e propõe ainda “o descobrimento de tecnologias com maior capacidade para reduzir impactos ambientais negativos” (Ribeiro, 1997, p. 53). Nesse contexto, as Tecnologias da Informação e Comunicação [TICs] se apresentam como importantes aliadas na promoção do desenvolvimento sustentável integrado aos aspectos econômico e social.

Nesse sentido, Gliessman (2001, p.13) destaca que “a agricultura do futuro deve ser tanto sustentável como altamente produtiva”, considerando o crescimento da população humana e a necessidade da produção de alimentos. Gliessman (2001) propõe ainda que a agricultura sustentável deveria considerar o uso racional da água, de modo a possibilitar a reposição dos aquíferos, e os seguintes aspectos:

ter o mínimo de efeito negativo no ambiente; preservar e reconstruir a fertilidade do solo; fazer uso dos recursos dentro do agroecossistema; conservar a diversidade biológica; garantir a equidade no acesso às práticas agrícolas, apropriadas, ao conhecimento e à tecnologia, assim como permitir o controle local dos recursos agrícolas (p. 13).

Em contrapartida a essa possibilidade de uso da tecnologia para a promoção da agricultura sustentável, conforme proposto por Gliessman (2001), ainda se observa a ausência de políticas públicas que garantam a conectividade nos diversos espaços, principalmente, no meio rural, a exemplo do Programa Nacional de Banda Larga, que foi instituído pelo Decreto nº 7.175, de 12 de maio de 2010 e previa, entre os objetivos específicos, a massificação do acesso a serviços de conexão à internet em banda larga; a aceleração do desenvolvimento econômico e social e a promoção da capacitação da população para o uso das TICs (Decreto nº 7.175, 2010). Porém, o texto foi substituído pelo Decreto nº 9.612, de 17 de dezembro de 2018, que dispõe sobre políticas públicas de telecomunicações, mas não garante a universalização da conectividade para o meio rural, conforme análise contida no relatório produzido pelo Tribunal de Contas da União [TCU] intitulado “Cenários e perspectivas para o agro”, que traz uma análise da cobertura por banda larga 4G no território nacional e aponta alguns gargalos na efetivação do Programa, entre eles, a falta de governança da política pública e a falta de coordenação interfederativa e multissetorial (TCU, 2018).

De acordo com o Ministério da Agricultura, Pecuária e Abastecimento [MAPA], somente 25% do espaço agrícola brasileiro possui algum nível de cobertura pela internet. Entre os problemas relatados está a falta de conectividade e a necessidade de investimentos em infraestrutura, seja pelas empresas de telecomunicações, governos ou fazendeiros (MAPA, 2021). Porém, segundo o MAPA, essa realidade não impossibilitou a consolidação do país como “potência agroambiental” no cenário mundial. Uma matéria veiculada pelo Ministério salienta que a ampliação da conectividade nas áreas rurais provocará uma grande transformação na produção no

campo e “criará novos paradigmas para o setor” (MAPA, 2021).

Esse cenário vem se transformando ao longo do tempo e a “agricultura digital” tem sido fortemente discutida, em decorrência, entre outros fatores, do crescente uso das tecnologias de informação e comunicação nas relações sociais e de mercado. Segundo dados do Instituto Brasileiro de Geografia e Estatística (IBGE), houve um crescimento significativo da conexão de domicílios na área rural (Ministério das Comunicações, 2021).

Em resposta a esse contexto, o MAPA tem investido em estudos, em parceria com a Escola Superior de Agricultura Luiz de Queiroz, sobre a conectividade rural do país e iniciado a proposta de um plano nacional de conectividade no campo, o qual, de acordo com o diretor do Departamento de Apoio à Inovação para a Agropecuária do MAPA, Luis Claudio Rodrigues de França, pretende elevar a produção agropecuária (MAPA, 2021).

Uma plataforma denominada “Visão de Futuro do Agro Brasileiro” desenvolvida pela Empresa Brasileira de Pesquisa Agropecuária [EMBRAPA] e atualizada no ano de 2022, apresenta oito megatendências para o futuro da agricultura até 2030, são elas: 1) sustentabilidade; 2) adaptação à mudança do clima; 3) agrodigital; 4) intensificação tecnológica e concentração da produção; 5) transformações rápidas no consumo e na agregação de valor; 6) biorrevolução; 7) integração de conhecimentos e tecnologias; e 8) incremento da governança e dos riscos (EMBRAPA, 2022).

As megatendências apontam para uma forte presença das TICs na agricultura e as encaram com uma tendência global que provocará uma nova revolução. Para além do uso de hardwares e softwares no monitoramento, controle, planejamento e gestão de atividades agrícolas, a “digitalização da agricultura” também impactará em operações financeiras e educacionais no meio rural, o que exigirá a capacitação de pequenos e médios produtores e demais atores da agricultura (EMBRAPA, 2022).

Bolfe (2019) destaca que países como a França, Itália, Portugal e Espanha já desenvolvem há décadas estratégias científicas, tecnológicas, políticas e mercadológicas para valorizar alimentos tradicionais, orgânicos, regionais ou típicos. No entanto, no Brasil, apesar da diversidade de produtos agroalimentares, somente a partir da década de 1980 iniciaram-se as políticas públicas que contribuísem para o reconhecimento e promoção desses alimentos.

Em entrevista concedida à Revista Fapesp, o físico, Silvio Crestana, diretor-presidente da Embrapa entre 2005 e 2009, destaca que “o uso de tecnologias da informação e comunicação terá o poder de separar quem será bem-sucedido ou não na produção agropecuária nos próximos anos” (Crestana *apud* Zapparolli, 2020). Atual pesquisador da Embrapa Instrumentação, que se dedica ao estudo do impacto das atividades agrícolas nos recursos naturais, Crestana afirma que a digitalização levará ecoeficiência ao campo, permitirá a rastreabilidade da produção e dará poder ao consumidor para penalizar quem não adotar práticas sustentáveis (Crestana *apud* Zapparolli, 2020).

De acordo com o pesquisador, para além dos benefícios econômicos, o uso das TI é uma “questão de sobrevivência”. A tecnologia permite ao agricultor considerar todas as características biofísicas envolvidas na produção e fazer o uso adequado dos recursos”, segundo Crestana, o agricultor precisa ter acesso aos dados e se comunicar (Crestana *apud* Zapparolli, 2020).

O pesquisador ressalta ainda a relevância de políticas públicas que viabilizem a conectividade do/a agricultor/a de baixo poder aquisitivo e não possui recursos para investir em tecnologias, visto que a agricultura 4.0 poderá aumentar a desigualdade no campo. Sendo necessária também a capacitação desse agricultor, a exemplo do que ocorre em países desenvolvidos como a Alemanha, a China, entre outros. No entanto, destaca também a necessidade de protagonismo do agricultor na realização de investimentos em tecnologias a partir de associações ou em cooperativas (Crestana *apud* Zapparolli, 2020).

Diante do exposto, pretende-se identificar as contribuições da capacitação tecnológica em agricultura sustentável viabilizadas com o uso das TICs no contexto brasileiro e suas implicações para o desenvolvimento econômico e social dos territórios. Para isso foi feita uma breve introdução ao tema, a partir do conceito de desenvolvimento aliado à tecnologia e à agricultura sustentável, abordando, de maneira sucinta, as políticas públicas que têm sido implementadas para apoiar esse processo. Na sequência, é apresentado o material e métodos, destacando o percurso metodológico para a realização do levantamento bibliográfico. Em seguida, os resultados e discussão, abordando as principais contribuições de diferentes pesquisadores sobre a relevância das TICs para a agricultura sustentável, com foco na capacitação tecnológica; e por fim, as considerações finais.

## II. MÉTODO

Para responder ao problema de pesquisa proposto no presente artigo foi realizado uma pesquisa exploratória de caráter qualitativo, por meio do levantamento bibliográfico de artigos científicos publicados em periódicos nacionais e internacionais, disponíveis nas bases de dados do Google Acadêmico, Portal de Periódicos da CAPES e Scielo, com recorte temporal de publicações dos últimos 5 anos, portanto o período de 2017 a maio de 2022, de qualquer idioma.

Para a busca foram utilizados os descritores “TICs”, “Capacitação tecnológica”, “Agricultura sustentável”, “Desenvolvimento”, “Território” conectados pelo operador booleano “and”, a fim de restringir a amplitude das publicações a serem analisadas. Entre os periódicos pesquisados estão: *Indian Journal of Computer Science and Engineering* [IJCSE], *Array*, *Revista Metropolitana de Sustentabilidade*, *Revista Espacios*, *Revista Científica Multidisciplinar*.

Na base de dados *Scielo* não foram localizados artigos publicados nos últimos cinco com os descritores selecionados para o presente estudo. Em relação ao Portal de Periódicos da Capes foi encontrado apenas um artigo, indiretamente, relacionado ao contexto explorado no presente artigo.

A partir do levantamento de trabalhos publicados na base de dados Google Acadêmico, foram encontrados 2.300 resultados, dos quais somente 10 artigos publicados em periódicos indexados foram selecionados, já que, após a leitura do título e resumo, verificou-se que se aproximavam do problema de pesquisa proposto.

Os 2.289 trabalhos excluídos da análise não abordavam o escopo do presente estudo, portanto, não apresentavam as ideias centrais elencadas para o presente artigo, a saber: tecnologias da informação e comunicação, agricultura sustentável e capacitação tecnológica para o desenvolvimento dos territórios, abordando de forma isolada ou bastante tangencial, o que não contribuiu para as discussões propostas.

## III. RESULTADOS

A partir da hipótese de que o uso das TICs na capacitação tecnológica em agricultura sustentável pode contribuir para o desenvolvimento econômico e social dos territórios no contexto brasileiro, foi realizada a busca de artigos de periódicos em bases de dados, por meio das seguintes plataformas de busca: Google Acadêmico, Portal de Periódicos da Capes e Scielo. O Quadro 01 apresenta os resultados obtidos.

*Quadro. 1: Relação dos artigos selecionados do Google Acadêmico, Portal de Periódicos da Capes e Scielo para a pesquisa, período entre 2017 e maio/2022.*

Portal de busca	Título do artigo/Autor/a[es/as]/Ano	Objetivo
Google Acadêmico	TICs na agricultura familiar: os usos e as apropriações em regiões do sul do Brasil (Felippi, Deponti & Dornelles, 2017).	Investigar o uso e as apropriações das tecnologias da informação e da comunicação [TICs] no contexto da agricultura familiar, com destaque para a nova mídia.
Google Acadêmico	A exclusão digital como uma estratégia engendrada pelo capital para restringir o desenvolvimento territorial do campesinato (Rosa, 2017).	Discutir a exclusão digital como uma estratégia engendrada pelo capital para restringir o desenvolvimento do território [material e imaterial] camponês.
Google Acadêmico	<i>A literature review on impact of information and communication technology tools on rural society of India</i> (Newase, Sheetlani & Patil, 2017).	Apresentar uma revisão dos vários estudos sobre as implicações das ferramentas de TIC nas sociedades rurais da Índia.
Google Acadêmico	Análise de capacitações como ferramenta de aprendizagem para agricultores familiares de um assentamento em São Gonçalo-RJ (Carmo, Nascimento, Dutra, Rabello & Leal-Toledo, 2018).	Avaliar a capacitação de agricultores familiares de um assentamento no Rio de Janeiro, no intuito de difundir técnicas para auxiliar na transição a uma agricultura agroecológica.
Google Acadêmico	<i>Hacia un modelo de desarrollo rural integral sustentable basado en la sociedad del conocimiento</i> (Salas-Razo & Juárez-Hernández,	Reorientar a política de desenvolvimento do México rumo a um modelo de desenvolvimento rural abrangente

	2018).	sustentável baseado na sociedade do conhecimento.
Portal de Periódicos da Capes	Relação entre os investimentos em TIC e a evolução patrimonial das cooperativas agropecuárias do oeste do Paraná (Bortoluzzi, Johann & Rojo, 2019).	Analisar a relação entre os investimentos em tecnologia da informação e comunicação e a evolução patrimonial das cooperativas agropecuárias do oeste do Paraná.
Google Acadêmico	<i>The Digitisation of Agriculture: a Survey of Research Activities on Smart Farming</i> (Bacco, Barsocchi, Ferro, Gotta & Ruggeri, 2019).	Fazer um levantamento das iniciativas de pesquisa e da literatura científica sobre o tema da <i>Smart Farming</i> [SF], observando as tecnologias e técnicas recentes que estão sendo usadas ou ativamente pressionadas para adoção.
Google Acadêmico	Internet e transferência de tecnologia: a Embrapa na opinião dos extensionistas rurais (Estevão & Sousa, 2020).	Analisar como o site da Embrapa Gado de Leite tem sido utilizado na rotina de transferência de tecnologia dos profissionais de extensão rural.
Google Acadêmico	Criação de Plataforma Agroecologia para agricultura familiar no Brasil (Castañeda Salazar, Feliciano de Oliveira, Batista Fernandes Rocha, & Biagi, 2020).	Demonstrar o uso das TICs a serviço do desenvolvimento rural sustentável em assentamentos de reforma agrária no Brasil.
Google Acadêmico	A problemática tecnológica e a agricultura familiar do Mercosul: uma análise a partir da REAF1 (Mengel & Diesel, 2020).	Caracterizar a discussão sobre técnicas e tecnologias para agricultura familiar na REAF/MERCOSUL, bem como compreender seus condicionantes e implicações.
Google Acadêmico	O uso e apropriação das tecnologias da informação e comunicação na agricultura familiar: um mapeamento sistemático da literatura (Silva Oliveira, Monteiro & Vidal de Andrade, 2021).	Subsidiar informações e verificar como se dá a inserção das tecnologias para contribuir com o desenvolvimento do agronegócio, além de identificar como o uso das TICs podem tornar algo rotineiro no trabalho dos agricultores familiares.
Scielo	-----	-----

Fonte: organização dos autores.

Os artigos analisados destacam a relevância das TICs para a agricultura a partir de diferentes aspectos que perpassam as relações entre o/a homem/mulher do campo; as tecnologias e a agricultura, desde a capacitação, o uso/apropriação das TICs até a exclusão digital associada ao modelo capitalista; partindo de estudos e experiências oriundas de projetos de extensão, de órgãos de pesquisa e de outros países.

Os estudos apontam a ausência de conectividade e infraestrutura adequada como principais desafios para implementação das TICs nas atividades de agricultores/as familiares (Felippi et al., 2017; Rosa, 2017; Carmo; et al., 2018; Mengel & Diesel, 2020; Silva Oliveira et al., 2021), mas também revelam a necessidade de capacitação digital

para apropriação da tecnologia, conforme destaca Bolfe et al. (2020).

#### IV. DISCUSSÃO

As Tecnologias da Informação e Comunicação [TICs] são um conjunto de artefatos físicos, que correspondem ao hardware, ou lógicos, ao software, que permitem captar, tratar, armazenar e disseminar informações, e ainda automatizar máquinas e processos. O desenvolvimento das TICs impactou tanto na produção de máquinas e equipamentos, possibilitando a inovação, quanto na construção de novas relações de trabalho e

formas de organização, o que representou avanços significativos para a humanidade (Rosa, 2017).

De acordo com Rosa (2017), as TICs são determinantes no aumento da eficiência e eficácia das corporações, em se tratando do incremento da capacidade produtiva ou de prestação de serviços na sociedade contemporânea. Mesmo reconhecendo que há fatores negativos, destaca sua importante contribuição na integração social e econômica, já que atua “nos processos e fluxos informacionais, otimizando a captura, tratamento, armazenamento, recuperação e disseminação da informação; no suporte à tomada de decisão e obtenção da vantagem competitiva” (p. 91). Apesar da expansão da oferta das tecnologias de informação e comunicação, ainda há uma enorme discrepância entre o acesso pelas populações urbanas e pelas comunidades do campo (Felippi et al., 2017).

Nesse sentido, observa-se que não é mais possível desassociar as TICs do meio rural, visto que elas tanto oportunizam o acesso à informação e ao conhecimento importantes para a gestão de atividades desenvolvidas nesse território, quanto possibilitam a formação dos sujeitos e sua inclusão na sociedade contemporânea. Entretanto, ressalta-se que o uso por agricultores/as familiares ainda é bastante limitado (Felippi et al., 2017).

Tal realidade aponta para a necessidade de capacitação do/a agricultor. Felippi et al. (2017) ressaltam que para além da infraestrutura adequada, é fundamental que as pessoas tenham acesso a uma qualificação específica.

A percepção de Castañeda Salazar et al. (2020) coaduna com a hipótese deste artigo de que o uso das TICs na capacitação tecnológica em agricultura sustentável pode contribuir para o desenvolvimento econômico e social dos territórios, ao afirmar que as TICs oportunizam a emancipação da comunidade rural, possibilitando seu uso para acessar o conhecimento, integrando os interesses da comunidade e as demandas da sociedade, “na busca da inclusão social e superação do modelo agrícola convencional” (Castañeda Salazar et al., 2020, p. 03). Os autores apontam as TICs como fator de facilitação nas relações comerciais e sociais, visto que promove o conhecimento da rede de agricultores, o encontro entre produtores e consumidores, facilitando a comercialização direta dos produtos.

De acordo com Silva Oliveira et al. (2021), “o setor da agricultura pode ter o uso ativo de TICs para a busca por alternativas que estimulem o progresso do ramo”, a exemplo do agronegócio que já dispõem de softwares que possibilitam um gerenciamento simples e competitivo. Os autores ressaltam que há uma disparidade entre o acesso de

pequenos agricultores em relação às grandes empresas, enquanto estas buscam soluções tecnológicas para alavancar seus negócios, aqueles não conseguem ter acesso a informações e inovações tecnológicas (Silva Oliveira et al., 2021), seja por falta de políticas públicas que possibilitem o acesso à infraestrutura adequada e à conectividade (Fornasier & Scaranti, 2017), seja pela ausência de capacitação dos/as agricultores/as para o uso/apropriação das TICs.

Um estudo qualitativo desenvolvido num território do Sul do Brasil, que visa investigar as práticas que surgem a partir da interação cotidiana de famílias da agricultura familiar com as TICs, revelou algumas limitações para a resistência ao uso das TICs pelos/as agricultores/as para o incremento de atividades produtivas, a saber: baixa escolaridade, pouca ou nenhuma capacitação formal para o uso e apropriação das TICs, acesso recente à nova mídia. Apontam como uma das possíveis causas a ausência de estímulos aos/as agricultores/as por parte das organizações que atuam nesse território (Felippi et al., 2017).

Os autores falam sobre uma nova ruralidade com o advento das TICs, no entanto, destacam a precariedade da inclusão digital no meio rural pela falta de investimentos em infraestrutura, entre outros desafios (Felippi et al., 2017). Nesse sentido, Zapparoli (2020) pontua,

Embora muito ainda precise ser feito no país em termos de infraestrutura de conexão e interoperabilidade — os maiores obstáculos para inclusão da agricultura brasileira na era do 4.0 —, a transformação digital no campo está em curso. No curto prazo, o ganho de eficiência repercute na saúde financeira das empresas. Olhando para o futuro, auxiliará o produtor a superar o desafio de ampliar a oferta de alimentos com preços acessíveis e de forma sustentável, sem ocupar áreas de floresta. “Em 2050 a população mundial deverá chegar a cerca de 9,8 bilhões de pessoas”, lembra Silvia Massruhá, da Embrapa. “O Brasil terá que aumentar em 40% sua produção de alimentos para suprir as necessidades que surgirão. O uso de novas tecnologias e a transformação digital serão fortes aliados para atingir essa meta (p. 20).

Salas-Razo & Juárez-Hernández (2018), ao reconhecerem a desigualdade nos países da América Latina e no Caribe, com destaque para o México, também corroboram a necessidade de mudanças na transferência de conhecimentos e tecnologia como uma das estratégias para o desenvolvimento sustentável. Os autores revelam um cenário de perda de rentabilidade agropecuária, o que traz

impactos negativos para o mercado de trabalho, e aos quais se somam diversas outras questões de caráter social, econômico que requerem um “novo modelo de desenvolvimento rural sustentável integral” (Salas-Razo & Juárez-Hernández, 2018, p. 16). Este modelo propõe a integração das tecnologias e conhecimentos produzidos pela atividade agrícola, bem como a incorporação de tecnologias ambientalmente sustentáveis.

Nesse sentido, Mengel & Diesel (2020) também ressaltam que a transformação social perpassa por uma atenção às técnicas e tecnologias utilizadas na agricultura, já que, segundo os autores, “a relação dos seres humanos com a natureza e entre si é mediada pelas técnicas utilizadas em um lugar, em dado período histórico, e porque estas condicionam o devir da sociedade” (p. 665).

Pensar a respeito das técnicas e tecnologias utilizadas em determinada atividade socioprodutiva é pensar a respeito da relação que as categorias envolvidas em tais atividades estabelecem entre si e com a natureza e a totalidade da sociedade. Da mesma forma, tratar da modificação de uma atividade ou da inserção de uma categoria social na mesma, implica em modificar as técnicas e tecnologias utilizadas por ela em suas relações socioprodutivas. Isto porque tal processo implica em modificar suas formas de trabalho, suas formas de organização e a transformação nos modos de pensar das pessoas, o que é considerado muito desafiador pois é necessário interpretar o mundo de novas maneiras, até então desconsideradas. (Mengel & Diesel, 2020, p. 667)

Em consonância com essa perspectiva, Newase, et al. (2017) reconhecem a importância das TICs na resolução de questões relacionadas ao desenvolvimento e problemas da sociedade, bem como na realização de tarefas bem-sucedidas em diversos segmentos, inclusive na agricultura, destacando sua contribuição para a melhoria do desenvolvimento econômico e social, a partir de uma pesquisa realizada na Índia, e seu papel no desenvolvimento rural ambientalmente sustentável. Os autores pontuam a necessidade de haver um empoderamento pelas comunidades rurais para que possam ter acesso às informações, selecioná-las e utilizá-las na busca de desenvolvimento, destacando as TICs como estratégia para impulsionar a produtividade, a inovação, o acesso à informação e a promoção da transparência.

Um dos estudos apresentados pelos autores apresentou três finalidades relacionadas à informação e comunicação para as comunidades rurais, são elas: permitir uma maior produtividade e eficiência em suas

atividades econômicas; aumentar sua capacidade de disseminação do conhecimento nativo; facilitar a coleta e análise de dados confiáveis da aldeia necessários ao planejamento do desenvolvimento (Newase, et al., 2017).

No tocante ao empoderamento, Rosa (2017) resalta que há uma negação do acesso às inovações tecnológicas e seus benefícios, em pleno século XXI, à grande parte da sociedade, inclusive o campesinato, decorrente da “inexistência de condições financeiras favoráveis, falta de capacitação para uso e ausência da infraestrutura técnica necessária” (Rosa, 2017, p. 89). Tal negação, segundo a autora, é decorrente do sistema capitalista de produção.

Ao lhe tirar a terra e levar-lhe à proletarização, expropriou-o e o explorou, agora está promovendo a exclusão digital deste mesmo camponês. Dessa forma, assim como cria uma massa de excluídos dos circuitos econômicos e sociais, o modelo de desenvolvimento capitalista gera também a exclusão digital (Rosa, 2017, p. 89).

O artigo proposto por Carmo et al. (2018) que teve como foco o processo formativo, traz uma experiência relevante sobre a capacitação em agroecologia e inclusão digital, destacando dificuldades dos participantes, principalmente, nos temas da área de informática, decorrentes de questões, como: ausência de conhecimento prévio em informática, faixa etária, carga horária da capacitação. Vale ressaltar que o artigo sugere a realização de acompanhamento dos participantes após as capacitações utilizando metodologias ativas de aprendizagem, a fim de oportunizar a efetiva adoção das técnicas aprendidas.

O artigo de Bacco et al. (2019) apresenta diversos projetos de pesquisa em tecnologia desenvolvidos na União Europeia que demonstram o potencial das TICs para a agricultura sustentável, entre elas estão: componentes robóticos não tripulados heterogêneos [terrestres e robôs aéreos]; sistemas baseados em nuvens, explorando estratégias baseadas em dados; plataformas de IoT [“Internet das coisas”] Acrescentam ainda que intervenções estratégicas foram financiadas para apoiar a adoção de tecnologias digitais, desenvolver novas soluções digitais e sustentar a avaliação crucial dos impactos socioeconômicos da digitalização.

Bacco et al. (2019) falam sobre a Smart Farming [SF] que se refere à aplicação das TICs na agricultura, de modo a utilizá-las, a exemplo de imagens de satélite, o uso de robôs agrícolas, nós sensores, Veículos Aéreos Não Tripulados [VANTs], para a coleta e análise de dados, objetivando tornar a agricultura mais eficiente, sustentável e de alta qualidade, considerando as necessidades dos agricultores.



Rosa (2017) traz uma perspectiva relevante ao reconhecer nas TICs as possibilidades de “articulação, resistência, cooperação, troca de informações, organização e desenvolvimento econômico, social e cultural” (Rosa, 2017, p. 94), alertando que a negação do acesso ao campesinato significa uma restrição à sua liberdade. A autora acrescenta ainda que a “exclusão digital inibe o intercâmbio de produtos, serviços, experiências e conhecimento, o que afeta negativamente as pessoas ao restringir a liberdade, autonomia, protagonismo e o acesso às oportunidades” (Rosa, 2017, p. 94).

As TICs consistem numa oportunidade para que o campesinato possa se articular, organizar, lutar, compartilhar conhecimentos, fortalecer a sua identidade, implementar novas técnicas e tecnologias, melhorar sua produtividade, bem como encontrar formas alternativas para desenvolver-se dentro do sistema capitalista, mas não fazendo parte dele e, contraditoriamente, sendo parte dele. Essas tecnologias têm potencial para auxiliar o campesinato com informações, por exemplo, sobre a previsão do tempo [chuva, frio, seca], os tipos e qualidade do solo, políticas de preços, aquisição, controle e venda de produtos. Apontar as épocas mais propícias para plantio ou colheita, uso e ocupação do solo, distribuição de sementes e fertilizantes conforme o tipo de solo, dentre outras (Rosa, 2017, p. 95).

Rosa (2017) destaca a necessidade de um conjunto de ações para a promoção da inclusão digital do campesinato que perpassam pela educação, infraestrutura física e de comunicação a fim de possibilitar a produção e gestão da unidade produtiva de modo sustentável, as quais coadunam com Bolfe et al. (2020).

Os artigos analisados apontam as implicações do uso das tecnologias da informação e comunicação para a agricultura, ressaltando os benefícios para a modernização de sistemas produtivos, bem como destacam as limitações, que vão desde o conhecimento para utilizar as TICs até a disponibilidade de infraestrutura adequada para acessá-las.

## V. CONCLUSÃO

Os estudos demonstram que as tecnologias da informação e comunicação têm sido cada vez mais aproveitados para o aperfeiçoamento das atividades produtivas da agricultura e apontam para a necessidade de apropriação pela população camponesa, visto que as TICs têm sido utilizadas como ferramentas estratégicas para alavancar a agricultura, a exemplo do uso para a mensuração de variações climáticas, manejo do solo e uso racional da água; bem como para a gestão do conhecimento, por meio da disseminação de saberes necessários à adoção de boas práticas de convivência com

a natureza e preservação do meio ambiente, ao tempo em que possibilita a geração de renda para as famílias.

Os estudos revelam que ainda há muito o que se explorar nessa relação entre as tecnologias de informação e comunicação e a agricultura sustentável. Apesar de apontarem os benefícios e as possibilidades que as TICs podem oferecer para a agricultura, ainda se observa carência de estudos que relacionem as TICs, a agricultura sustentável e a capacitação tecnológica, limitações que vão desde o conhecimento para utilizar as TICs até a disponibilidade de infraestrutura adequada para acessá-las.

O presente artigo se propôs a identificar as contribuições da capacitação tecnológica em agricultura sustentável viabilizadas com o uso das TICs e suas implicações para o desenvolvimento econômico e social dos territórios no contexto brasileiro, porém não pretendeu esgotar as discussões acerca das potencialidades e desafios decorrentes da inserção das TICs na agricultura sustentável, principalmente, no tocante à capacitação tecnológica como estratégia para o desenvolvimento econômico e social dos territórios.

Por fim, vale ressaltar a necessidade de estudos que evidenciem essa relação e possam impactar na implementação de políticas públicas que promovam a conectividade e acesso à infraestrutura; na apropriação das TICs pelas populações camponesas, reconhecendo seu potencial para contribuir com a capacidade produtiva e de geração de renda, e também como ferramenta para a disseminação de saberes e preservação da cultura local.

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# Relations and Interactions between Urban and Rural Spaces

## Relações e Interações Entre os Espaços Urbanos e Rurais

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Received: 31 Jul 2022,

Received in revised form: 21 Aug 2022,

Accepted: 25 Aug 2022,

Available online: 30 Aug 2022

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**Keywords**— *Urban spaces. Rural spaces. Relationships and interrelationships and complementarity. Countryside.*

**Palavras-chave**— *Espaços urbanos. Espaços rurais. Relações e inter-relações e complementaridade. Cidade-campo.*

**Abstract**— *This work promotes critical reflection on the constitution, structure and dynamics of relations, interrelations, interactions and socio-spatial and economic contradictions existing between urban and rural spaces, in different geographical spaces, on a regional scale, and present in the process of regional development. The central issue is the city-countryside and urban-rural themes in the regional development process. Productive restructuring and the new (inter) relations and contradictions between urban and rural: relations, contradictions and interdependencies. Relations between city and countryside, and between cities, and processes of cooperation, cohesion and territorial competition: rural and urban development. State and public policies in the articulation between rural and urban.*

**Resumo**— *Este trabalho promove a reflexão crítica sobre a constituição, a estrutura e a dinâmica das relações, inter-relações, interações e contradições socioespaciais e econômicas existentes entre espaços urbanos e rurais, em distintos espaços geográficos, na escala regional, e, presentes no processo de desenvolvimento regional. A questão central é a temática cidade-campo e urbano-rural no processo de desenvolvimento regional. A reestruturação produtiva e as novas (inter) relações e contradições entre o urbano e o rural: relações, contradições e interdependências. As relações entre cidade e campo, e entre cidades, e processos de cooperação, coesão e competição territorial: desenvolvimento rural e urbano. Estado e políticas públicas na articulação entre o rural e o urbano.*

### I. INTRODUÇÃO

Santos (2004) e Silveira (2003) afirmam que, provavelmente, em torno de 20 anos, as cidades terão ocupado completamente a fronteira agrícola nessas áreas e o processo se reverterá de forma mais intensiva e também percolativa. Principalmente, as cidades de porte médio que estão ligadas a formas modernas de produção e consumo estimuladas pela renda da agricultura moderna e um parque industrial associado ao setor primário. Se a cidade é a materialização das condições gerais de reprodução do capital, a cidade do agronegócio é aquela cujas funções de atendimento às demandas do

agronegócio globalizado são hegemônicas sobre as demais funções. Abramovay (2007) enfatiza que haverá urbano, desde que haja uma extensão de serviços públicos a certo aglomerado populacional.

O Brasil é um exemplo de país onde é definido como urbana, as sedes distritais com algumas centenas de casas. O mesmo reforça a ideia de que nem toda aglomeração urbana provida de um mínimo de serviços pode ser adequadamente chamada de cidade.

Na perspectiva de Sposito (2006), a unidade espacial urbana cedeu lugar ao binômio urbano/rural no decorrer do longo processo de urbanização, o que resultou

na incapacidade de distinguir onde acaba a cidade e começa o campo. Para a autora, as formas confundem-se porque as relações se intensificam e os limites entre os dois tornaram imprecisos, o que favorece o pensamento de uma nova unidade territorial contendo, contraditoriamente, os dois espaços que são resultado e condição das formas de produção.

Estas transformações acentuaram, em dado momento, a possibilidade de diferenciação entre o campo e a cidade, especialmente em razão dos avanços técnicos provocados, que significaram a ampliação da centralização econômica e social da cidade, tornando seu modo de vida e organização singulares em relação ao restante do espaço. Entretanto, o advento da Revolução Industrial, intensificou as relações entre o urbano e o rural, e, “introduziu uma confusão total” (BEAUJEU-GUARNIER, 1997).

O aprofundamento das mudanças decorrentes do processo de industrialização e da constituição do meio técnico-científico-informacional proporcionou uma reconfiguração no modo de organização socioespacial da sociedade, promovendo alterações na composição das densidades espaciais, na dinâmica de interligações e nas significações funcionais da cidade e do campo, o debate a respeito da questão da interpretação sobre o que é cidade e campo e sobre o que é urbano e rural adquiriu importância no debate acadêmico, instigando muitos pesquisadores a aprofundarem-se na temática como Sposito (2006) e Rosa & Ferreira (2006).

Este debate foi revigorado pela observância de alguns fatos novos que marcam a reorganização da sociedade, tais como: Atividades não tradicionais que passaram a desenvolver-se no campo, configurando uma “resignificação” do rural, desde a utilização de novos produtos agropecuários, decorrentes do processo de industrialização da agricultura, após a “Revolução Verde”, e a questão do assalariamento dos trabalhadores do campo. Atividades caracterizadas por não serem tipicamente agropecuárias, como aquelas vinculadas à prestação de serviços, atividades de entretenimento ou mesmo moradia. A falta de critérios mais precisos para a definição do que é cidade e por oposição o que é campo, acabam revelando um processo de urbanização questionada (ETGES; SILVEIRA; TALASKA, 2018).

Na antiguidade os limites campo-cidade podiam ser considerados nítidos, na atualidade tal afirmativos não é mais verdadeira. Isso decorre, sobretudo, por uma série de transformações socioespaciais que ocorreram principalmente após a Revolução Industrial (SPOSITO, 2006).

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## II. RELAÇÕES RURAL-URBANO: RETROSPECTIVA HISTÓRICA

Ferrão (2000) ressalta que, historicamente, o mundo rural destaca-se por se organizar em torno de uma tetralogia de aspectos bem conhecida:

- uma função principal: a produção de alimentos;
- uma atividade econômica dominante: a agricultura;
- um grupo social de referência: a família camponesa, com modos de vida, valores e comportamentos próprios;
- um tipo de paisagem que reflete a conquista de equilíbrios entre as características naturais e o tipo de atividades humanas desenvolvidas.

Este mundo rural secular opõe-se claramente ao

mundo urbano, marcado por funções, atividades, grupos sociais e paisagens não só distintos, mas, também, em grande medida construídos "contra" o mundo rural. Esta oposição tende a ser encarada como "natural" e, por isso, recorrentemente associada a relações de natureza simbiótica: campo e cidade são complementares e mantêm um relacionamento estável num contexto aparente, marcado pelo equilíbrio e pela harmonia de conjunto (FERRÃO, 2000).

### **2.1 Mundo rural arcaico e mundo urbano-industrial moderno: complementaridade e contrariedades**

De acordo com Ferrão (2000), a Revolução Industrial iniciada no século XVIII veio alterar a situação, com o surgimento emergente de uma nova sociedade urbano-industrial que acarretou duas consequências principais para as áreas rurais.

Por um lado, inicia-se um acentuado processo de perda de centralidade econômica, social e simbólica por parte do mundo rural. Por outro lado, este tende a ser globalmente identificado com realidades arcaicas, enquanto as aglomerações urbano-industriais são vistas como o palco, por excelência, do progresso. A relação rural-urbano não pode deixar de refletir esta alteração profunda, forjando-se novas complementaridades e modificando-se sua natureza (MATHIEU, 1998).

Cavaco e Carminda (1999) afirmam que as relações de complementaridade rural-urbano, ao mesmo tempo em que a sua natureza tradicional simbiótica vem dando lugar a interdependência, mesmo sendo reconhecidas como assimétricas ou divergentes perde importância relativa, face à emergência de aglomerações urbano-industriais mais "autônomas" e com maior capacidade de polarizar, do ponto de vista funcional, as áreas envolventes.

### **2.2 Mudam-se os tempos, mudam-se as relações: a nova dicotomia pós-rural/urbano**

A industrialização da agricultura, particularmente visível a partir do final da 2ª Guerra Mundial, veio introduzir uma nova inflexão importante, ao fraturar o mundo rural em duas realidades bem distintas: o *mundo rural moderno* e o *mundo rural tradicional*. Pela primeira vez na história da humanidade, a oposição rural-urbano começa a não ser vista como a mais decisiva, na medida em que a modernidade deixa de constituir um exclusivo das áreas urbanas (CAVACO; CARMINDA, 1999).

Começa, assim, a ganhar consistência uma nova dicotomia pós-rural/urbano, que valoriza antes a oposição existente entre um mundo moderno (que pode ser urbano-industrial ou rural) e um mundo arcaico (predominantemente rural). É verdade que continua a

persistir a ideia de que o mundo rural se encontra num processo estrutural de marginalização econômica, social e simbólica. Mas a forte mercantilização da produção agrícola em massa vem deslocar a fronteira das grandes oposições, chamando a atenção para o fato de nem todas as áreas rurais estarem condenadas aos processos de agonia do "velho" mundo tradicional (FERRÃO, 2000).

Neste novo contexto, conforme Ferrão (2000), a relação rural-urbano bifurca-se, dando origem a uma partição das áreas rurais em função da sua proximidade (física, mas também funcional e socioeconômica) aos principais centros urbanos. A diferenciação entre áreas rurais "centrais", "periféricas" e "marginais" ou ainda a designação de "áreas rurais profundas" evidenciam, com clareza, esta nova situação.

Entre os centros urbanos e as áreas rurais "centrais" ou "periféricas" prossegue a tendência anterior de diversificação de relações de complementaridade desenvolvidas num quadro fortemente assimétrico. Pelo contrário, entre o mundo urbano e as áreas rurais "marginais" ou "profundas" as relações de complementaridade ativa vão-se dissipando, já que estas últimas, alvo de uma sangria continuada de pessoas e recursos e com condições de acessibilidade particularmente desfavoráveis, pouco interesse desperta nos cidadãos. No entanto, a partir dos anos 80 assiste-se à invenção social de uma nova realidade: o mundo rural não agrícola. Esta perspectiva introduz elementos novos no modo de encarar os mundos rurais e urbanos, em si e na forma como se relacionam (FERRÃO, 2000).

## **III. RELAÇÕES E INTER-RELAÇÕES ENTRE O ESPAÇO RURAL E ESPAÇO URBANO**

Jacinto, Mendes e Perekouski (2012), consideram que o desenvolvimento econômico regional está no centro dos assuntos urbanos, locais, rurais e regionais. Isso se traduz por ações que visam encontrar, para uma determinada zona, um equilíbrio entre o fortalecimento de sua capacidade concorrencial e a melhoria da qualidade de vida de seus habitantes.

O processo de industrialização da agricultura tem eliminado gradativamente a separação entre a cidade e o campo, entre o rural e o urbano, unificando-o dialeticamente. Isto quer dizer que campo e cidade, cidade e campo formam uma unidade contraditória. Uma unidade onde a diferença entre os setores da atividade econômica (agricultura, pecuária e outros, em um; indústria, o comércio, etc., em outro) vai sendo soldada de um lado pela presença, na cidade, do trabalhador assalariado (boia-fria) do campo. De outro lado, pode-se constatar que a industrialização dos produtos agrícolas pode ser feita no

campo com os trabalhadores das cidades. Tudo indica que o desenvolvimento do capitalismo está consolidando a união “contraditória” da agricultura e da indústria, do campo e da cidade, que ele mesmo separou no início de sua expansão (JACINTO, MENDES; PEREHOUSKEI, 2012).

Atingir esse objetivo exige a criação de novas formas de parcerias, quer sejam públicas, privadas, nacionais, regionais ou locais. Estímulos a projetos, iniciativa rural, ação urbana, tudo isso decorre da mesma ideia, segundo a qual as contribuições locais permitem operar mudanças significativas na paisagem socioeconômica territorial (FELIPI, 2016).

Santos (2004) propõe que a clássica divisão rural e urbano no Brasil, seja substituída pela divisão em dois grandes subtipos: “os espaços agrícolas e os espaços urbanos”, as regiões agrícolas e não rurais contém cidades; as regiões urbanas contém atividades rurais, assim teríamos áreas agrícolas contendo cidades adaptadas às suas demandas e áreas rurais adaptadas às demandas urbanas. Assim, avançando sobre os processos que regem a expansão da urbanização e das novas funções exercidas pelas cidades, lócus da gestão da agricultura científica e do agronegócio globalizado, Santos (2000) e Elias (2009a) denominam tais espacialidades como cidades do agronegócio.

#### **IV. RELAÇÕES E CONTRADIÇÕES ENTRE O URBANO E O RURAL**

Conforme Talaska, Silveira e Etges (2014), a definição do urbano e do rural a partir dos critérios anteriormente mencionados, de forma descontextualizada, sem analisar a historicidade presente nos fatos e processos, parece estático demais. Essa afirmação está relacionada com a necessidade de se entender a dinâmica da sociedade em sua totalidade, na qual a simples distinção e oposição urbano-rural não são suficientes.

A partir das perspectivas mencionadas de forma generalizada, o entendimento da existência de uma oposição entre urbano e rural, a abordagem da “diferenciação social”, possibilita, enquanto procedimento analítico, considerar os processos de “relação entre cidade e campo” (SPOSITO, 2006).

E dessa forma, revelar os sentidos e papéis desses espaços e conseqüentemente a unicidade e complementaridade compreendida por esse par dialético. Assim, para a definição do urbano e do rural, é importante a compreensão dos movimentos e forças que os articulam e os produzem, o que exige não apenas a apreensão dos fatos, mas uma teoria, no âmbito da qual os conceitos de

urbano e rural constituem-se em ferramentas fundamentais para se compreender cidade e campo (SPOSITO, 2006).

Clarificando essa afirmativa Beaujeu-Garnier (1997) indica que a cidade, enquanto “concentração de homens, de necessidades, de possibilidades de toda a espécie, com uma capacidade de organização e transmissão, é ao mesmo tempo sujeito e objeto”. É objeto por se constituir materialmente “o quadro urbano”, e é sujeito por “exercer influência nos seus habitantes”, mantendo ligações complexas com espaços que ultrapassam o seu quadro urbano.

Mesmo considerando que a cidade é marcada pelo predomínio de relações secundárias e de negociações e o campo pelas relações primárias, Wirth (1987) afirma que os modos de vida produzidos nesses espaços, se interpenetram. Para esse autor, o urbano e rural não devem ser interpretados como opostos ou como espaços e modos de vida separados e sem contato.

O modo de vida produzido na cidade, o urbano, é influenciado, em certa medida, pelo modo de vida produzido no campo, o rural, e do mesmo modo, o “urbanismo” é espraiado para além das fronteiras da cidade, denotando a ideia de cultura urbana. Nas palavras de Wirth (1987): “o urbanismo” não está confinado a tais localidades, mas manifesta-se em graus variáveis onde quer que cheguem as influências das cidades. De maneira geral, essas possibilidades de abordagens teóricas trazem perspectivas urbanas, por meio das quais, se pode buscar a compreensão das transformações histórico-espaciais da sociedade.

Reiterando algumas considerações, pode-se ressaltar que a quantificação e também a qualificação do urbano e do rural não se resume à estipulação de critérios ou da simples ponderação de atributos. Essas abordagens teóricas indicam a apreensão de que se pode conceber cidade-campo e urbano-rural como categorias diferenciadas. As primeiras, campo e cidade, entendidas enquanto materialidade, meio, condição e produto da sociedade, espaços construídos/modificados que manifestam em seus conteúdos os processos contraditórios de desenvolvimento histórico da sociedade. E as segundas, o urbano e o rural, compreendidas enquanto relações sociais, ou seja, formas abstratas, também condição e produto do desenvolvimento histórico da sociedade, mas que extrapolam os limites morfológicos da cidade e, no sentido inverso, os limites do campo (TALASKA; SILVEIRA; ETGES, 2014)

#### **V. INTERDEPENDÊNCIA ECONÔMICA E SOCIAL ENTRE CAMPO E A CIDADE: O RURAL E O URBANO**

Conforme Talaska, Silveira e Etges (2014), a definição do urbano e da rural “forma descontextualizada, sem analisar a historicidade presente nos fatos e processos, parece estático demais”. Essa afirmação está relacionada com a necessidade de se entender a dinâmica da sociedade em sua totalidade, na qual a simples distinção e oposição urbano-rural não são suficientes.

Nesse sentido, se as perspectivas mencionadas anteriormente trazem, de forma generalizada, o entendimento da existência de uma oposição entre urbano e rural, a abordagem da “diferenciação social”, possibilita, enquanto procedimento analítico, considerar os processos de “relação entre cidade e campo”. E dessa forma, revelar os sentidos e papéis desses espaços e consequentemente a unicidade e complementaridade compreendida por esse par dialético (BERNADELLI, 2006).

Assim, para além dos critérios e atributos para a definição do urbano e do rural, é importante a compreensão dos movimentos e forças que os articulam e os produzem, o que exige não apenas a apreensão dos fatos, mas uma teoria, no âmbito da qual os conceitos de urbano e rural constituem-se em ferramentas fundamentais para se compreender cidade e campo.

Explicitando essa afirmativa Beaujeu-Garnier (1997) indica que a cidade, enquanto “concentração de homens, de necessidades, de possibilidades de toda a espécie [...], com uma capacidade de organização e transmissão, é ao mesmo tempo sujeito e objeto”. É objeto por se constituir materialmente [“o quadro urbano”], e é sujeito por “exercer influência nos seus habitantes”, mantendo ligações complexas com espaços que ultrapassam o seu quadro urbano. Assim, o papel da cidade engloba a “noção de difusão de um bem ou de um rendimento e a do limiar da sua população” indicando a tendência do urbano se alargar para além dos seus limites e consequentemente permitindo a separação dos conceitos de cidade e urbano, mesmo ambos possuindo conexões profundas.

Mesmo considerando que a cidade é marcada pelo domínio de relações secundárias e de negociações e o campo pelas relações primárias, Wirth (1987) afirma que os modos de vida produzidos nesses espaços se interpenetram. Para esse autor, o urbano e rural não devem ser interpretados como opostos ou como espaços e modos de vida separados e sem contato. O modo de vida produzido na cidade, o urbano, é influenciado, em certa medida, pelo modo de vida produzido no campo, o rural, e do mesmo modo, o urbanismo é espreado para além das fronteiras da cidade, denotando a ideia de cultura urbana. Nas palavras do autor: “o urbanismo não está confinado a tais localidades, mas manifesta-se em graus variáveis onde

quer que cheguem as influências das cidades”.

Para Lefebvre (2001), a relação cidade-campo torna a cidade um centro de decisão e aparentemente de associação e, desse modo, “a cidade em expansão ataca o campo, corrói-o, dissolve-o”.

Simultaneamente, a condição de vida urbana penetra na condição de vida do campo, transformando características e elementos tidos como tradicionais, num processo marcado, às vezes, por resistências. Essas formas abstratas, surgidas e derivadas da cidade ou do campo, mantêm constante embate entre si no tempo-espaço e acabam modificando pouco a pouco a configuração e o padrão de organização da sociedade, revelando, por exemplo, alterações nos “modos de vida” e, inclusive, possibilitando a constituição de uma nova condição de vida da sociedade (TALASKA; SILVEIRA; ETGES, 2014).

Assim, a compreensão da essência da cidade e do campo, suas relações, analogias e contradições, passa pela consideração da intrínseca relação sociedade-natureza, onde através de um processo dialético, materializado pelo trabalho, pelas relações sociais, pelos “sistemas técnicos e sistemas de ações, a sociedade se organiza espacialmente e reproduz seu espaço, num processo indissociável com a natureza. Acredita-se, portanto, que a compreensão do urbano e do rural, enquanto relações derivadas da cidade e do campo, requer a consideração da dialética, onde a organização da sociedade no tempo-espaço se desenvolve através de movimentos, de mudanças, de processo de transformações, considerando o desenvolvimento das forças produtivas e a estruturação econômica e social. É a partir do olhar histórico e dialético sobre a cidade, o campo e suas relações que se percebe que nenhuma das suas configurações são definitivas. Tudo tem uma forma anterior e uma forma posterior. Tudo está em movimento. Houve e há processos de mudança, de transformação, onde novos elementos, novas funções, novas ruralidades e novas urbanidades são verificados.

Dessa forma, o espaço geográfico não só se transforma e se configura em campo ou cidade, mas mantém traços que não são simplesmente puros de um ou de outro. Assim, no interior das relações urbanas ou rurais existem forças que se embatem, pois mantém características de polos opostos. Estas forças tendem para a afirmação e para a negação de características urbanas e rurais (JACINTO, 2013).

Logo, o entendimento e a compreensão do urbano e do rural passam pela lógica da afirmação, negação e negação da negação. As relações tipicamente urbanas ou rurais apresentam contradições, enquanto um agrupamento de relações é negado por não possuir



característica que o outro possui, o outro agrupamento de relações que possui tal característica é valorizado, portanto afirmado. Exemplo: o campo é afirmado por ter a capacidade de gerar alimentos para serem comercializados e consumidos na cidade ou por proporcionar usos dificilmente possíveis de serem realizados nas cidades; entretanto, é negado por carecer de serviços urbanos, típicos da cidade. Assim, um espaço é afirmado pelo que possui, mas é negado pelo que não possui, num processo contraditório de presença e ausência. A afirmação de um espaço se dá pela negação do outro espaço. Nota-se, nenhuma deixa de existir por isso, pelo contrário (SILVEIRA, FELIPPI, 2018).

Endlich (2006) afirma que as diferenças entre os espaços rurais e urbanos se apresentam de forma a complementar-se, mas não se tornando homogêneos. Do ponto de vista da dialética, a cidade, por exemplo, é ao mesmo tempo o urbano e é o seu contrário, o rural. A cidade não existe sem o rural e o campo não existe sem o urbano. Embora, haja oposição e diferenças entre a cidade e o campo, ambos só existem a partir de seu contrário. Isso equivale a dizer que uma afirmação não é absoluta, pois a afirmação contém uma parte da negação, exemplo: o campo, produtor de alimentos para comercializar na cidade, contém em si a necessidade dos serviços e características urbanas para existir, é a afirmação que contém parte da negação. Logo, por a cidade e o campo e suas relações, o urbano e o rural, conterem afirmações e negações conflitantes, eles se transformam, se modificam num terceiro termo que é a negação da negação, asíntese.

De acordo com Talaska, Silveira e Etges (2014), o movimento de afirmação-negação ajuda na compreensão das modificações que ocorrem nesses espaços, nas suas relações e na permanência das suas características próprias. Há, pois, movimento de territorialização de atividades urbanas sobre o campo e conseqüentemente de desterritorialização de atividades

rurais, mas há, também, a transformação do rural e do urbano num sentido que, enquanto síntese dessas contradições, geram uma nova realidade.

Conforme Damiani (2008), não existe o desaparecimento da cidade e do campo como unidades espaciais distintas, mas, a constituição de áreas de transição e contato entre esses espaços que se caracterizam pelo compartilhamento, no mesmo território, ou em micro parcelas territoriais justapostas e sobrepostas, de usos do solo, de práticas socioespaciais e de interesses políticos e econômicos associados ao mundo rural e ao urbano.

Assim, essa proposição consegue conter contraditoriamente o urbano e o rural “superpostos,

amalgamados e intrinsecamente relacionados. Essa superposição, além de superar a oposição entre o campo e a cidade, engloba todo o ritmo de mudanças recentes que marcam a organização da sociedade, resultados da lógica da produção territorial da cidade no modo de produção capitalista.

A noção do *continuum* implica considerar a existência de uma graduação entre o urbano e o rural, de modo que se pode identificar diferentes níveis escalares de relações urbanas ou rurais, os quais seriam níveis de transição entre os extremos urbano e rural.

## VI. CONSIDERAÇÕES FINAIS

O objetivo desta contribuição, num primeiro momento, foi tecer considerações teóricas acerca das categorias do Rural e do Urbano e suas relações entre si. O estudo da relação entre campo e cidade e, rural e urbano necessita de uma visão dialética e abrangente, que incorpore as potencialidades e os atores sociais presentes, tanto no campo, quanto na cidade.

Outro ponto a ser considerado verifica-se na realidade urbana e na realidade rural, que não são estanques e, ultimamente, têm passado por rápidas e intensas transformações, as quais ressoam de forma direta na reorganização do espaço, na redefinição de relações e na constituição de novas territorialidades. Por isso, acredita-se ser um equívoco, pensar a extinção dos espaços rurais em função do avanço do processo de urbanização e, conseqüentemente, de haver um *continuum* rural urbano, visto que, campo e cidade são espaços que se diferenciam frente ao fortalecimento de suas peculiaridades.

É fato que a revolução técnico-científica comprometeu as relações entre o rural e o urbano. A preocupação maior nesse início de século é compreender as modificações que os atores sociais imprimem a essas categorias que se mesclam dialeticamente num *continuum* rural-urbano.

A análise da relação campo e cidade e, rural e urbano tem avançado, onde se acredita ser essencial entender o rural para além do campo e o urbano para além da cidade, pois campo e cidade são partes integrantes do todo, mesmo que às vezes, o campo não seja tão rural e a cidade nem tão urbana, eles não se opõem, excluindo-se mutuamente, ao contrário, se complementam, justamente pelas diferenças. Em suma, desaparece todo o sentido em tratar o rural exclusivamente como o oposto do urbano, em proclamar seu desaparecimento, ou em resumi-lo a apenas uma de suas dimensões.

A tentativa de utilização de diferentes critérios e

atributos para esclarecer a questão e elucidar a diferenciação entre o que é cidade/urbano e o que é campo/rural não atendem a compreensão da problemática em sua plenitude, visto sua complexidade.

Considera-se pertinente, manter estudos quanto às abordagens teórico-metodológicas para a interpretação da questão, pela potencialidade de qualificação das categorias analíticas cidade/campo e urbano/rural, que parece ser o grande problema em questão; e, conseqüentemente, pelo fato da possibilidade de compreensão da dinâmica das relações e contradições que compõem a sociedade no tempo-espaço.

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# Global Companies and Their Territorialization Strategies: The Royal Agrifirm Group Case in Brazil

## Empresas Globais e suas Estratégias de Territorialização: O Caso *Royal Agrifirm Group* no Brasil

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Received: 30 Jul 2022,

Received in revised form: 18 Aug 2022,

Accepted: 25 Aug 2022,

Available online: 31 Aug 2022

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**Keywords**— *transnational companies,  
territorialization, strategies, fixed and flows,  
royal agrifirm group.*

**Palavras-chave**— *empresas transnacionais,  
territorialização, estratégias, fixos e fluxos,  
royal agrifirm group.*

**Abstract**— *This article studies transnational companies and their territorialization strategies. The case study addressed refers to the Royal Agrifirm Group cooperative. We sought to analyze how the territorialization strategies of global companies, aiming at greater competitiveness and opportunities for expansion in new markets, have repercussions on the territory in which they are installed. To understand such contexts, semi-structured interviews were carried out with qualified informants; data collected from secondary sources; bibliographic and documentary. The systematization and interpretation of qualitative data took place through content analysis, with the MAXQDA software (2022). The results obtained showed that the company has a strong culture, with well-defined norms and that it applies its strategies by developing its processes in a space of continuous and vertical flows. Its territorialization strategies include specific and orderly planning, based on the planning and control of goals and results to be achieved, as a way of making investments made in the territory viable.*

**Resumo**— *Este artigo estuda as empresas transnacionais e suas estratégias de territorialização. O estudo de caso abordado refere-se a cooperativa Royal Agrifirm Group. Buscou-se, analisar como as estratégias de territorialização das empresas globais, visando maior competitividade e oportunidades de expansão em novos mercados, repercutem no território em que se instalam. Para compreender tais contextos, foram realizadas entrevistas semiestruturadas, com informantes qualificados; dados coletados de fontes secundárias; bibliográficas e documentais. A sistematização e interpretação dos dados qualitativos deu-se por meio da análise de conteúdo, com o software MAXQDA (2022). Os resultados obtidos mostraram que a empresa tem uma cultura forte, com normas bem definidas e que aplica suas estratégias desenvolvendo seus processos em um espaço de fluxos contínuos e verticalizados. Suas estratégias de territorialização contemplam um planejamento específico e ordenado, pautado no planejamento e no controle de metas e resultados a serem cumpridos, como forma de viabilizar os investimentos realizados no território.*

## I. INTRODUÇÃO

As discussões em torno da globalização, enquanto processo político, econômico, social e cultural, acentuam-se a partir da década de 1980, levando pesquisadores de várias áreas a debruçar-se sobre o estudo do tema, fortemente marcado pelo avanço tecnológico e dos meios de comunicação.

Com a globalização, surgem empresas que atuam globalmente, as chamadas empresas globais. Estas funcionam a partir de fragmentações, ou seja, começam a se expandir na produção e na circulação de mercadorias, adentrando em mercados de outros territórios que, segundo suas estratégias, seriam promissores (Santos, 2000).

E, dentro dessas dinâmicas territoriais contemporâneas, Porter (1992) aponta para as mudanças de mercado em decorrência da globalização, afirmando que ocorre uma maior competitividade no contexto contemporâneo, fazendo com que as organizações estejam em constante aprendizado para a criação de novas estratégias competitivas.

Assim, propõe-se o estudo da empresa global Royal Agrifirm Group, uma cooperativa fundada em 1890 na Holanda, por iniciativa de agricultores e produtores rurais, cuja formalização, por meio de estatuto próprio, ocorreu no ano de 1892 (AGRIFIRM, 2020).

Mediante essas considerações, se apresenta o seguinte problema de pesquisa: Como as estratégias de territorialização de empresas globais, visando maior competitividade e oportunidades de expansão em novos mercados, repercutem no território?

Objetiva-se, portanto, analisar como as estratégias de territorialização de empresas globais, visando maior competitividade e oportunidades de expansão em novos mercados, repercutem no território. Objetiva-se também caracterizar a formação do Royal Agrifirm Group como empresa global no segmento de nutrição animal; analisar as estratégias de territorialização dessa empresa no Brasil; e analisar o processo de incorporação da Nutrifarma pelo Royal Agrifirm Group, e a consequente repercussão no território de Teutônia/RS.

Os dados apresentados neste artigo, foram coletados em fontes secundárias, bem como bibliográficas e documentais, além de entrevistas semiestruturadas, realizadas com os agentes envolvidos no processo. Foram realizadas entrevistas semiestruturadas com informantes qualificados que tiveram relevante participação no processo da aquisição da Empresa Nutrifarma S/A, empresa brasileira, pelo Royal Agrifirm Group, empresa transnacional, como: uma ex. liderança e duas lideranças atuais, uma ex. funcionária e um funcionário atual, e um

representante da liderança pública municipal da cidade de Teutônia/RS.

A sistematização e interpretação dos dados qualitativos foi realizada por meio da análise de conteúdo, com a utilização do software MAXQDA (2022).

Além desta introdução, esse artigo traz a seção de fundamentação teórica, de metodologia, de análise dos resultados, e, ao final, as discussões, juntamente com as considerações finais.

### Fundamentação Teórica

#### A racionalidade da ordem global

Santos (2000) ressalta que a nova relação entre regiões tem como conteúdo novo a racionalidade, outorgada pelas ações e pelos objetos. A racionalidade não se dá igualmente em toda parte, há espaços marcados pela ciência, pela tecnologia, pela informação, por essa mencionada carga de racionalidade; e há os outros espaços. Há os espaços do mandar e os espaços do obedecer. Todavia, essa racionalidade sistêmica, não se dá de maneira total e homogênea, pois permanecem zonas onde ela é menor e, mesmo, inexistente e onde cabem outras formas de expressão que têm sua própria lógica.

Assim, o sistema técnico científico informacional atual se caracteriza por ser racional, artificial e universal, sendo estas suas principais características, além de atuar por toda superfície terrestre. De tal maneira, Santos (2006), ressalta que quanto mais artificial um espaço for, mais racional ele se torna.

O conhecimento do território se torna indispensável no processo da globalização da economia e da fragmentação dos espaços/territórios. Mas, segundo Costa et al. (2012), para definir um território é necessário considerar a natureza e a ação humana no mesmo, o trabalho e a política, onde os fixos e os fluxos devem ser abordados, já que influenciam na composição deste.

Santos (1994) define fixos como os objetos materiais, ou seja, aquilo que é concreto, material e que passou por um processo de transformação e adquiriu uma função. Os elementos fixos, fixados em cada lugar, permitem ações que modificam o próprio lugar, permitindo fluxos novos ou renovados que recriam as condições ambientais e as condições sociais, e redefinem cada lugar. Alguns exemplos de fixos são casas, portos, armazéns, fábricas, entre outros.

Para Santos (1994), as redes realizam modificações na relação entre fixos e fluxos, visto que, ao alterarem o conteúdo técnico e organizacional dos objetos

em seu espaço, empreendem a hegemonia das verticalidades, em oposição às horizontalidades.

Segundo Silva (2013), para que uma empresa de caráter transnacional se instale em uma localidade, são realizadas mudanças visando a proteção da mesma nos campos jurídicos, político e fiscal para que ela possa se efetivar e assim garantir que não sofra perdas econômicas advindas de eventuais conflitos com as comunidades locais atingidas pela instalação da empresa em seu território.

#### Estratégias internacionais das empresas globais

Uma estratégia internacional é aquela por meio da qual a empresa vende seus produtos ou serviços fora da esfera de seu mercado local. Um dos principais motivos para a implementação de uma estratégia internacional (em oposição à estratégia focada no mercado local) é o potencial que os mercados internacionais têm de gerar novas oportunidades (HITT; IRELAND; HOSKISSON, 2008).

Ao eleger um novo território, as empresas globais optam por um ou por dois tipos básicos de estratégias internacionais. Sendo elas:

- **Estratégia Internacional no Nível de Negócios:**

A primeira dimensão do modelo de Porter estão os fatores de produção; a segunda dimensão condições de demanda; na terceira dimensão há as indústrias relacionadas e de apoio.

- **Estratégia Internacional no Nível Corporativo:**

As três estratégias desta categoria são as mais utilizadas nos territórios onde as empresas globais atuam. Sendo elas: A estratégia multilocal, se caracteriza por ter decisões estratégicas e operacionais descentralizadas em termos da unidade central. A estratégia global, como o próprio nome sugere, estabelece critérios de padronização por intermédio dos mercados territoriais, pois a estratégia competitiva é estabelecida pela unidade central. A estratégia transnacional procura atender as necessidades tanto de sua unidade central, quanto de seu mercado local, uma equação complicada, mas não impossível de ser praticada (HITT; IRELAND; HOSKISSON, 2008).

Em se tratando de estratégia internacional em nível de negócios, cabe salientar que o país de origem da empresa global é geralmente a fonte mais importante da vantagem competitiva, pelo menos num primeiro momento, sendo uma base forte para as movimentações, pois fornece os recursos e as capacitações que darão a sustentação necessária para que esta busque a melhor estratégia nos mercados globalizados. No entanto, à medida que uma empresa consegue desenvolver suas próprias ações de crescimento para múltiplas localidades

internacionais, o país de origem passa a ser um mero coadjuvante em termos de vantagem competitiva para suas afiliadas (HITT; IRELAND; HOSKISSON, 2008).

O Enfoque Estratégico da Royal Agrifirm Group no Brasil, com base nos conceitos abordados, e nas entrevistas realizadas, centraliza-se na Estratégia Multilocal, tendo em vista que opera em vários países no mundo.

#### O Royal Agrifirm Group como empresa global no segmento de nutrição animal

Segundo os dados obtidos do Royal Agrifirm Group, a empresa conta com mais de 3.000 funcionários em nível mundial, e em torno de 300 colaboradores no Brasil. Estes colaboradores estão distribuídos no escritório de Curitiba/PR, e nas três unidades industriais: situadas nas cidades de Taió/SC, Maripá/PR e Uberlândia/MG. As unidades industriais produzem uma linha completa de suplementos vitamínicos e minerais, núcleos, rações especiais, substitutos lácteos e aditivos (Agrifirm, 2022).

No site do Royal Agrifirm Group, a empresa destaca seu objetivo de criar valor para seus clientes e colaboradores de maneira sustentável por meio de sua Responsabilidade Social Corporativa (CSR). Para a empresa, uma agricultura eficiente e sustentável é um pré-requisito para a produção de alimentos suficientes e saudáveis.

A fundação do grupo ocorreu no ano de 1870, sendo que somente vinte e dois anos após, em 1892 ocorreu a formalização de seu estatuto e sua fundação oficial na Holanda. Em 1892, agricultores holandeses iniciaram uma cooperativa (*Landbouwwerening Ekamp-Meerland*). O objetivo da cooperativa era: compra conjunta de insumos agrícolas e promoção de vendas de produtos agrícolas. Em 1909, a cooperativa (*Coöperatieve Landbouwersbank en Handelsvereniging te Meppel*) tinha uma fábrica de ração, silos de grãos e cargas de fertilizantes. Além disso, havia uma empresa bancária e uma estação de inseminação artificial. No começo a cooperativa não tinha dinheiro para dar início às suas atividades, o dinheiro para a terra e o prédio foram adquiridos via empréstimo bancário, onde os agricultores e produtores assumiram o risco.

Em 1932 a cooperativa contava com 7.200 membros e milhares de agricultores ligados por associações membros, tornando-se conhecida como a primeira cooperativa na Holanda a possuir um Conselho de Membros.

Em 2010 a cooperativa realizou sua primeira fusão com a Cehave e Agrifirm, formando assim a

AgriFirm Group. No ano seguinte, fez a sua primeira aquisição, a empresa Strahmann na Alemanha.

Em 2012, a cooperativa conquistou o título de Royal. Este fato marcante e de grande honraria, é assim denominado: Predicado Real, ocorreu no ano de 2012, quando a empresa recebeu a Designação “Royal” da Casa Real Holandesa. Esta honraria é concedida para empresas que se destacam em seu setor de atuação por mais de 100

anos, mantendo estabilidade financeira e zelando por sua reputação. Desta forma a empresa passou a ser chamada de Royal Agrifirm.

E assim, a empresa foi se desenvolvendo com aquisições, vendas, *Join Ventures*, etc. conforme sua estratégia, o que fica bem demonstrado na Figura 1, Linha do Tempo.



Fig.1 – Linha do tempo da empresa Royal Agrifirm Group (2019)

Fonte: Royal Agrifirm Group, 2019.

Uma estratégia que normalmente é utilizada por empresas de grande porte como transnacionais, por exemplo, é a transferência de sua cultura organizacional para novas unidades incorporadas à sua estrutura, pois a cultura se forma pela atuação dos grupos pode chamar-se de “personalidade da organização”. Os grupos relacionam-se, desenvolvendo formas de agir que vão sendo incorporadas. A partir do momento em que o grupo passa a agir, a cultura está enraizada, ou seja, os comportamentos surgem naturalmente no grupo e são respeitados em razão de serem entendidos como a maneira correta de interpretar e agir sobre uma determinada situação até que um novo comportamento venha a ser valorizado pelo grupo em detrimento do outro (MARCHIORI, 2009).

Cabe destacar que no caso em questão, houve uma miscigenação de culturas, pois a Nutrifarma e seus funcionários já tinham uma cultura definida, baseados num estilo de liderança familiar. E, com a entrada da Agrifirm, precisaram se readaptar em vários aspectos, pois o grupo holandês possui uma cultura forte e baseada em estratégias de endomarketing.

Outras estratégias apontadas, a fim de mostrar a empresa como socialmente responsável, por exemplo, se

referem aos Pilares da *Corporate Social Responsibility* (CSR), e aos Pilares Operacionais. Estes pilares apoiam e reforçam a visão da empresa, como “uma cadeia alimentar responsável para as gerações futuras”.

Assim, empresas transnacionais adotam estas estratégias de responsabilidade sócio ambiental, revertendo vantagens competitivas e agregando valor a sua imagem no mercado, e consequentemente conseguindo a preferência dos consumidores, pois há uma preocupação por consumir de empresas que são socialmente responsáveis.

A Agrifirm sustenta os seguintes pilares da CSR:

- Matérias primas sustentáveis;
- Agricultura circular e eficiente em termos de recursos;
- Solo saudável, plantas e animais;
- Cadeias socialmente responsáveis.

Segundo a empresa, estes pilares fazem parte da cultura, e ao desenvolver cada ponto entre seus colaboradores, estes o assimilam e trabalham com os clientes. Esta filosofia que é trabalhada estrategicamente, faz com que se diferenciem frente à concorrência,

mostrando um discurso ético e sustentável (AGRIFIRM, 2019).

As estratégias de territorialização do Royal Agrifirm Group no Sul do Brasil

As empresas transnacionais incrementam seu processo de territorialização através de estratégias, alianças, parcerias e articulações políticas. Desta forma, neste capítulo será apresentado o processo de incorporação da Empresa Nutrifarma, no Brasil pelo Royal Agrifirm Group, e sua repercussão no território.

Caracterização da empresa Nutrifarma no Município de Teutônia, região Sul do Brasil

A Nutrifarma foi fundada no dia 02 de julho de 1999 pelos senhores Alfonso Corral Allegue (Espanhol) e Rubên Fernando Eluchans (Argentino). Havia também mais um terceiro sócio, também espanhol, que não participava ativamente da empresa (era apenas um sócio investidor). Assim, a empresa era brasileira, porém de capital multinacional, devido a nacionalidade de seus sócios.

Após alguns anos de trabalho na Argentina, Sr. Alfonso descobriu o grande potencial que existia no Brasil e, a partir disto nasceu o interesse de atuar também no país. Nascia, assim, a Nutrifarma, a qual instalou sua primeira unidade fabril em Taió/SC. As atividades produtivas em Taió, iniciaram em dezembro de 2000, com o foco voltado para produção de alimentos (rações) para consumo animal.

As demais unidades fabris foram inauguradas em 2011, sendo: Teutônia/RS e Maripá/PR, as duas filiais. A unidade fabril de Teutônia/RS, foi inaugurada em maio de 2011, e, acabou tornando-se também a sede administrativa, por ter a liderança da empresa concentrada no município. A unidade possuía em torno de trinta funcionários, entre fábrica e escritório.

O município de Teutônia/RS possui uma população estimada de 34.275 habitantes, de acordo com dados do IBGE (2001). Sua área é de 179 km<sup>2</sup> representando 0.0666% do Estado, 0.0318% da Região e 0.0021% de todo o território brasileiro. Seu Índice de Desenvolvimento Humano (IDH) é de 0,747 segundo o Atlas de Desenvolvimento Humano/PNUD (2010). Pertence à microrregião: Lajeado-Estrela, localizada no Vale do Taquari e à mesorregião: Centro Oriental Rio-Grandense.

Teutônia limita-se com os municípios de Imigrante, Westfália, Estrela, Colinas, Fazenda Vilanova, Paverama, Poço das Antas, Barão, Boa Vista do Sul e

Maratá. Em termos de economia, Teutônia apresenta um PIB per capita (2019) de R\$ 46.107,65, conforme demonstrado na Figura 12. É a terceira economia entre os trinta e nove municípios filiados à Associação dos Municípios do Vale do Taquari (AMVAT), de acordo com o índice de retorno do Imposto Sobre Circulação de Mercadorias e Serviços (ICMS) (IBGE, 2019).

Para a Nutrifarma, o município de Teutônia, por estar localizado a uma distância de apenas 85,52 Km da capital Porto Alegre e do aeroporto, tornou-se uma localização estratégica em relação às demais unidades, pela facilidade de deslocamento da liderança e também para receber os sócios, quando estes vinham à empresa.

Uma das estratégias da empresa para crescimento no mercado foi a produção de produtos com a marca do cliente, ou seja, terceirização de marcas. Com isso, a empresa conseguiu atingir as maiores cooperativas da região Sul, além de outras revendas e consumidores finais de grande porte.

## II. METODOLOGIA

A fim de tornar o processo contextualizado, foi realizado um estudo de caso, com dados coletados de fontes secundárias, bem como bibliográficas e documentais, além de entrevistas semiestruturadas. As entrevistas semiestruturadas são utilizadas frequentemente e conseguem bom resultados (FLICK, 2009). [1]

As entrevistas semiestruturadas, foram realizadas com informantes qualificados que tiveram relevante participação no processo de aquisição da empresa Nutrifarma (empresa brasileira), pelo Royal Agrifirm Group (empresa transnacional).

Os entrevistados foram selecionados pela disponibilidade e pelos seguintes critérios:

- Ter participado do processo de incorporação Nutrifarma pela Agrifirm;
- Ter conhecimento dos processos internos da Empresa Royal Agrifirm Group;
- Ter a percepção dos eventos ocorridos no município de Teutônia/RS, onde estava instalada uma das plantas fabris da Nutrifarma, incorporada pela Agrifirm.

As entrevistas semiestruturadas foram planejadas para responder ao problema e aos objetivos desta tese. Desta forma, o roteiro das entrevistas contemplou perguntas abertas que possibilitaram um diálogo entre a pesquisadora e os entrevistados, que permitiu captar os sentimentos, opiniões e as experiências de cada um no

processo de territorialização da Royal Agrifirm Group no Brasil.

Através das entrevistas e dos demais dados secundários coletados, se buscou o entendimento necessário para analisar o tema proposto neste artigo.

Em virtude do momento pandêmico mundial em decorrência da COVID-19, e que se alastrou em todo Brasil no início do ano de 2020, a maioria das entrevistas foi realizada através de aplicativos de videoconferências online, como: Google Meet ou Microsoft Teams, ficando a critério do entrevistado a escolha do recurso. Apenas uma entrevista foi realizada de forma presencial, com a liderança municipal de Teutônia/RS, por solicitação da mesma. Todas as entrevistas foram gravadas, com o devido esclarecimento do teor da pesquisa e o consentimento de cada entrevistado, sendo que cada um assinou um Termo de Livre Consentimento. As entrevistas tiveram duração média de 1 hora e 30 minutos.

A sistematização e interpretação dos dados qualitativos foi realizada por meio da análise de conteúdo, com a utilização do software MAXQDA (2022). A análise de conteúdo teve como foco os seguintes aspectos:

- Formação histórica do Royal Agrifirm Group como empresa global no segmento de nutrição animal;
- Estratégias de territorialização da empresa Royal Agrifirm Group no Brasil;
- E o processo de incorporação da empresa Nutrifarma pelo Royal Agrifirm Group, e sua consequente repercussão no território de Teutônia/RS.

A análise através do software MAXQDA (2022), teve como propósito examinar e interpretar as locuções dos entrevistados. Ao realizar a análise e interpretação das informações qualitativas das entrevistas, detectou-se as palavras mais expressivas e significativas de cada entrevistado, resultando numa nuvem de palavras para cada um deles e, posteriormente, numa nuvem de palavras geral para identificar pontos comuns e eventuais discordâncias e/ou contradições.

A estratégia metodológica utilizada ancorou-se na racionalidade do espaço, expressa nos fixos e fluxos que moldam os territórios no contexto da economia globalizada, que orientam a ação de grandes empresas transnacionais, como a empresa Royal Agrifirm Group, quando estabelecem suas estratégias comerciais e sua cultura organizacional em novos territórios. Santos (1994), em sua teoria sobre os fixos e fluxos, nos esclarece como acontece esta movimentação e seus agentes.

### III. ANÁLISE DOS RESULTADOS

A pesquisa iniciou com o levantamento dos dados da empresa através das informações obtidas em fontes secundárias ou documentais, pois através destas, foi possível realizar a verificação a respeito do processo histórico de formação do *Royal Agrifirm Group* e assim contemplar o primeiro objetivo específico: caracterizar a formação histórica do *Royal Agrifirm Group* como empresa global no segmento de nutrição animal.

O segundo objetivo específico: analisar as estratégias de territorialização da empresa *Royal Agrifirm Group* no Brasil, foi auferido por meio de documentos e entrevistas semiestruturadas.

O terceiro objetivo específico: analisar o processo de incorporação da empresa Nutrifarma pelo *Royal Agrifirm Group*, e a consequente repercussão no território de Teutônia/RS, foi alcançado mediante as respostas das entrevistas semiestruturadas.

Na estruturação e verificação dos dados qualitativos por meio do software MAXQDA, analisou-se a nuvem de palavras formada por todos os entrevistados, onde na Figura 2, pode-se observar o destaque para os quatro seguintes termos: "**Empresa, Gente, Pessoas e Mercado**". E, se analisarmos estas quatro palavras, elas se tornam chave para qualquer empreendimento, pois uma **empresa** é feita de **gente** ou **pessoas** na cultura organizacional, para que esta possa atingir as metas estabelecidas e se inserir no **mercado**, gerando assim resultados. Neste sentido, pode-se observar o quanto fortalecer a cultura da empresa, se torna estratégico para as empresas, independente de seu tamanho.

A cultura organizacional oficial tende a refletir as soluções que o grupo de dirigentes da organização e os membros que detêm maior poder perceberam e instruíram como as melhores, de acordo com os seus interesses e objetivos específicos. Neste sentido, a cultura organizacional oficial tem uma **função ideológica**: explicar e provar a validade das regras, das estruturas, dos valores e dos modos de funcionamento predominantes no sistema. Justifica-se porque as coisas devem ser assim, funcionar dessa forma e não de outra, de acordo com a visão dos grupos que detêm o poder. A cultura organizacional oficial oferece uma visão de mundo e explicações que devem ser razoáveis, claras e lógicas a fim de serem aceitas pelos outros membros da organização, para que estes aceitem o modo de funcionamento do sistema e não o contestem, encontrando sentido em seu trabalho cotidiano, algo no qual possam



acreditar, no qual possam fundamentar as suas ações e justifica-las para si próprios. Assim, diz-se que a cultura oficial, em sua função ideológica, mascara as relações de poder – ao fornecer uma explicação da realidade que leva os membros da organização a aceitar certa estrutura e colaborar para preservá-la. Em geral, a estrutura a ser preservada, no entanto, beneficia mais a alguns grupos de indivíduos e menos a

outros ao formular e difundir a cultura organizacional, sua visão de mundo. O grupo de dirigentes, na realidade, estaria lutando pela preservação de suas posições de controle, prestígio e de poder no sistema (MOTTA; VASCONCELOS, 2006).

Desta forma, difundir a cultura organizacional se torna estratégico para as empresas, pois há uma função ideológica.



Fig.2: As palavras mais relevantes para os entrevistados que fazem ou já fizeram parte do Royal Agrifirm Group

Fonte: Elaborada pelas autoras no Software MAXQDA, 2022.

Em relação ao processo de incorporação da empresa Nutrifarma pelo *Royal Agrifirm Group*, pode-se observar nos depoimentos dos entrevistados, que o processo de mudança da cultura Nutrifarma para a cultura Agrifirm deu-se em dois momentos distintos.

Num primeiro momento, as mudanças foram leves e muito sutis. Percebeu-se que a empresa quis entender melhor os processos antes de realizar as mudanças necessárias. Quando o entrevistado 2, comenta: “entender os pontos fortes da Nutrifarma”, fica entendida a intenção da Agrifirm, de num primeiro momento, compreender os processos, para depois realizar as mudanças necessárias. Neste intento, a empresa decidiu deixar toda a antiga direção no comando da empresa, por um período específico.

Depois deste período estabelecido pela Agrifirm, e com as informações necessárias, as mudanças começaram a ocorrer abruptamente, sendo a saída dos antigos dirigentes o início deste processo, e a saída da Presidente da Nutrifarma um fato marcante de um fim de ciclo.

Para entender as repercussões no território de Teutônia/RS, a partir do fechamento da unidade fabril local da Nutrifarma/Agrifirm, foram compilados os dados de todos os setores disponíveis no CAGED (2018), com as movimentações sobre as admissões e desligamentos do ano de 2018, para traçar um paralelo com o ano de 2019, que foi o ano em que houveram as demissões da empresa Agrifirm, devido ao fechamento da unidade fabril do município de Teutônia/RS.

Observou-se, no entanto, que não houveram diferenças significativas no número de trabalhadores

admitidos e desligados nos anos de 2018 e 2019, o que nos leva a entender que o fechamento da unidade fabril da Nutrifarma/Agrifirm não causou repercussões negativas à nível de emprego no município de Teutônia/RS.

Segundo os dados do CAGED (2018), o número de admissões foi de 50,08%, e o número de demissões foi de 49,92%, ou seja, houve mais contratações do que demissões, apesar de ser um percentual, que representa 0,16%, ainda assim as contratações foram superiores neste ano de 2018. Porém, ao analisar os mesmos dados do CAGED (2019), o percentual de admissões foi de 50,14% ao passo que as demissões geradas foram de 49,86%. Neste sentido, pode-se observar que as admissões continuam sendo maiores do que as demissões, assim como no ano anterior.

Em termos de PIB (Produto Interno Bruto) per capita, no ano de 2018, apurou-se o montante de R\$ 43.786,97 versus o PIB per capita do ano de 2019 com montante de R\$ 46.107,65. Com isso, há um crescimento de 5,3% do PIB per capita de 2018 em relação ao ano de 2019 (IBGE, 2021).

Corroborando com isto, o entrevistado 6, quando questionado sobre a percepção da comunidade, produtores rurais, sindicatos e associações de classe de Teutônia/RS, sobre o fechamento desta unidade fabril da Nutrifarma/Agrifirm, sobre como este evento foi recebido pela população em geral, que relatou a “importância das pessoas perceberem que a estrutura está sendo reaproveitada por uma outra empresa, ou seja, para as pessoas da comunidade, o mais importante é a estrutura estar sendo aproveitada, e gerando riquezas para o município.”

Neste sentido, pelas informações do PIB per capita (2018 - 2019), dados do CAGED (2018 - 2019), e também pela percepção das lideranças locais e comunidade em geral, o impacto do fechamento da empresa Nutrifarma/Agrifirm no território de Teutônia/RS, não apresentou impactos significativos em termos de desemprego ou perdas na receita do município, e com isso levantam-se os elementos necessários para aferir o terceiro objetivo.

#### IV. DISCUSSÕES<sup>[1]</sup>

O Royal Agrifirm Group em sua estratégia de expansão, tinha o Brasil em seu planejamento estratégico, e aliado aos negócios que vinha realizando com a empresa Nutrifarma, que com uma boa reputação no mercado e um negócio estruturado no Brasil, mostrou-se um empreendimento viável, após as devidas análises.

Uma empresa transnacional, quando escolhe um território para se estabelecer, está previamente segura dos riscos inerentes ao negócio, pois faz avaliações, e procura entender a conjuntura econômica do país. Mesmo assim, existem variáveis sobre as quais não há como ter domínio, como o risco de uma pandemia mundial, por exemplo, como esta que se vive, e que em 11 de março de 2020, foi declarada pela Organização Mundial da Saúde (OMS), como a pandemia do COVID-19 (WORLD HEALTH ORGANIZATION, 2020).

Em 9 de fevereiro de 2020 já havia sido declarada no Brasil Emergência em Saúde Pública de Importância Nacional, o que levou várias empresas a migrarem para o trabalho on-line, trazendo consequências para a vida dos trabalhadores, modificando algumas concepções de negócios e formatos de trabalho (MINISTÉRIO DA SAÚDE GABINETE DO MINISTRO, 2020).

Neste intuito, algumas empresas que não estavam inseridas no universo on-line ou até mesmo preparadas para entrar no e-commerce, sites, redes sociais, enfim, precisaram tornar o negócio online e se adaptar rapidamente. Outras que não se adaptaram, ou ainda, não inovaram neste sentido, acabaram encerrando suas atividades.

Assim, fica congruente a fala do geógrafo Milton Santos sobre as verticalidades, pois independente do momento e/ou situação em que se encontra o mercado, as empresas transnacionais cientes de seu papel e em consonância com as suas políticas, desenvolvem seus processos em um espaço de fluxos contínuos e verticalizados, através da construção de seus interesses, pois há metas e resultados a serem cumpridos e um número a ser entregue a fim de viabilizar os investimentos realizados no território.

Analisando todos esses contextos e traçando um paralelo com a caracterização e a formação histórica do Royal Agrifirm Group como empresa global no segmento de nutrição animal, percebe-se o impacto da sua cultura organizacional transnacional característicos das verticalidades que fazem parte de suas políticas. Porém, há de se ressaltar que uma organização transnacional com praticamente 130 anos versada num modelo de gestão cooperativista, tem muito a agregar em termos tecnológicos e de inovação em seu nicho de mercado, pois tem um estilo de cultura em sua origem alicerçada no cooperativismo, segurança de seus colaboradores, e na sustentabilidade, como é ressaltado em seus pilares. Além disso, por ter uma dinâmica comercial fora da Europa, a empresa mantém muitos princípios do cooperativismo na sua ação verticalizada. Portanto, o primeiro objetivo: caracterizar a formação histórica do Royal Agrifirm Group

como empresa global no segmento de nutrição animal, foi contemplado nas análises realizadas através das entrevistas semiestruturadas e também com os dados secundários levantados.

O segundo objetivo: analisar as estratégias de territorialização da empresa Royal Agrifirm Group no Brasil, foi plenamente atendido com a apresentação das entrevistas semiestruturadas, com observações e análises através das nuvens de palavras, que foram realizadas com o software MAXQDA, à luz do referencial teórico, pois foram coletados dados da empresa e também muitas informações dos entrevistados, que enriqueceram a pesquisa com suas contribuições. E também, com os dados do agronegócio brasileiro que foi importante e decisivo, como estratégia para a escolha do Brasil como um player de negócios.

Importante observar como estas empresas transnacionais traçam suas estratégias, e como podemos estabelecer paralelos com as teorias de autores consagrados como o Milton Santos, por exemplo, quando ele discorre sobre horizontalidades e verticalidades do território. E nisso, podemos discernir e refletir se nestas horizontalidades e verticalidades há algum foco no desenvolvimento regional do território, ou somente um espaço econômico. São questões que nos fazem refletir sobre como os territórios estão sendo ocupados, e para que finalidade esses fluxos se inserem no espaço geográfico.

O terceiro objetivo: analisar o processo de incorporação da empresa Nutrifarma pelo Royal Agrifirm Group, e a conseqüente repercussão no território de Teutônia/RS, foram realizadas análises a partir de dados do CAGED e do PIB per capita do município de Teutônia/RS, dos anos de 2018 e 2019, para estabelecer relações da possível repercussão no município pelo fechamento da unidade fabril, bem como recortes dos entrevistados, e com isso logrou-se êxito neste quesito.

O problema da pesquisa: como as estratégias de territorialização de empresas globais, visando maior competitividade e oportunidades de expansão em novos mercados, repercutem no território?; foram analisadas com referenciais teóricos e autores que têm muito a contribuir neste sentido, como: Santos, Porter, Marchiori, Hitt, entre outros escritores renomados.

## V. CONSIDERAÇÕES FINAIS

Sabe-se que não há fronteiras em um mundo globalizado, e a cada momento, empresas transnacionais estão buscando novos espaços para cumprir suas estratégias e interligar suas verticalidades. Novos

territórios são abertos e ações implementadas, pois se lograr êxito, ótimo, caso contrário, busca-se outro player comercial, e assim segue-se o fluxo.

Faz-se necessária uma reflexão acerca de soluções efetivas ao planejamento, sustentabilidade e agregação de renda aos territórios, considerando os seus mais variados aspectos, levando em conta suas potencialidades e desafios. É latente que se desenvolva um olhar participativo nos níveis local e regional para que as empresas transnacionais, possam ser mais efetivas aos se instalarem nos territórios, e assim sejam atuantes em projetos de âmbito sustentáveis, sociais, e culturais, afim de estarem comprometidas com o desenvolvimento regional.

Aponta-se como limitações do estudo, a dificuldade de conseguir estar presencialmente para a realização das entrevistas. Esta limitação deu-se por dois fatores: a distância e a pandemia. A maioria dos entrevistados da empresa Royal Agrifirm Group estava sediado fora do Rio Grande do Sul e do Brasil, tornando-se um limitante a distância geográfica. E a pandemia, acabou não permitindo qualquer interação entre entrevistadora e os demais entrevistados. Sabe-se que presencialmente há várias situações que podem ser observadas e instigadas durante a entrevista.

Como sugestões para pesquisas futuras, recomenda-se que sejam avaliadas outras situações e repercussões no território estudado, assim como analisar com profundidade as estratégias de sustentabilidade adotadas pela empresa transnacional, pois o tema é amplo, possui relevância a nível mundial, e não se esgota com este estudo.

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## Evaluation of the interference of paracetamol on blood glucose measurement: A randomized laboratory trial

## Avaliação da Interferência do Paracetamol na Dosagem Glicêmica: Um Ensaio Laboratorial Randomizado

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Received: 26 Jul 2022,

Received in revised form: 17 Aug 2022,

Accepted: 22 Aug 2022,

Available online: 31 Aug 2022

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**Keywords** — Glycemic Dosage, Interference, Acetaminophen, Paracetamol.

**Palavras-chave** — Dosagem Glicêmica, Interferência, Acetaminofeno, Paracetamol.

**Abstract**— Data from the International Diabetes Federation (IDF) indicate that 8.8% of the world's population suffers from diabetes. Glycemic dosage is one of the most important laboratory parameters for the diagnosis and monitoring of the disease. That is why it is of paramount importance to guarantee doctors and the patient a reliable, safe and error-free report. It is known that the majority of the population uses medications randomly and without a prescription. Many drugs can interfere with the analytical methods of various laboratory tests. The objective of this study was to evaluate the in vitro interference of the drug paracetamol in glycemic dosage by the glucose oxidase method, which the literature reports is the most used method in glycemic dosages and which is susceptible to interference by paracetamol. Glycemic measurement of a control sample was performed with commercial serum of known value, at a concentration of 100 mg/dl, and commercial serum samples submitted to different concentrations of paracetamol, ranging from 10 µg/ml to 5 mg/ml. A significant decrease ( $p < 0.0001$ ) in blood glucose was observed in the samples with the presence of paracetamol at concentrations of 200 µg/ml and 5mg/ml. The present study demonstrated a negative correlation between increasing concentrations of acetaminophen and glycemic dosage.

**Resumo**— Dados da International Diabetes Federation apontam que 8,8% da população mundial sofrem de diabetes. A dosagem glicêmica é um dos mais importantes parâmetros laboratoriais para o diagnóstico e monitoramento da doença. Por isso é de suma importância garantir aos médicos e ao paciente um laudo confiável, seguro e livre de erros. Sabe-se que a população em sua maioria faz uso de medicamentos de forma

*aleatória e sem prescrição médica. Muitos medicamentos podem interferir nos métodos analíticos de vários exames laboratoriais. O objetivo deste trabalho foi avaliar a interferência in vitro do medicamento paracetamol na dosagem glicêmica pelo método de glicose oxidase, o qual a literatura relata ser o método mais utilizados nas dosagens glicêmicas e o qual é passível de interferência pelo paracetamol. Ensaio laboratorial, randomizado, comparativo. Foi realizada a dosagem glicêmica de uma amostra controle com soro comercial de valor conhecido, na concentração de 100 mg/dl, e amostras de soro comercial submetidas a diferentes concentrações de paracetamol, variando de 10 µg/ml a 5 mg/ml. As diferenças entre os valores obtidos da amostra controle e amostras com concentrações distintas de paracetamol, foram verificadas pela análise de variância (ANOVA), seguido pelo pós-teste de Tukey. Observou-se uma diminuição significativa ( $p < 0,0001$ ) da glicemia nas amostras com a presença de paracetamol nas concentrações de 200 µg/ml e 5mg/ml. O presente estudo demonstrou haver uma correlação negativa entre concentrações crescentes de paracetamol e dosagem glicêmica. Portanto, este artigo contribuiu com evidências sobre a influência potencial do paracetamol na dosagem da glicemia pelo método de glicose-oxidase.*

## I. INTRODUÇÃO

Dados da Federação Internacional de Diabetes (IDF) apontam que aproximadamente 463 milhões de adultos com idade entre 20 e 79 anos sofrem com diabetes em todo o mundo, e estima-se um aumento de 55% de novos casos até 2045. A taxa de mortalidade é alta, chegando a 4,2 milhões somente em 2019 (2,3 milhões de mulheres e 1,9 milhões de homens), sendo responsável por 11% das mortes globais (IDF, 2019). Segundo a Sociedade Brasileira de Diabetes (2019), no Brasil há mais de 13 milhões de pessoas acometidas pelo diabetes, o que representa 6,9% da população. O diabetes é uma doença global e o Brasil ocupa o 4º lugar no ranking dos países com o maior número de casos, atrás de China, Índia e Estados Unidos (PINHEIRO e GOMES, 2018).

O Diabetes Mellitus (DM) é um distúrbio metabólico, causado por defeitos na ação da insulina ou na secreção da mesma, levando a um quadro de hiperglicemia crônica. Sua etiologia envolve fatores biológicos e/ou ambientais. Essa doença pode evoluir para complicações agudas (hipoglicemia, cetoacidose) e crônicas, microvasculares (nefropatia e neuropatia) e macrovasculares (doença arterial coronariana, arterial periférica e cerebrovascular) (CONITEC, 2019). Há três tipos de diabetes mellitus: a do tipo 1, a qual é definida pela deficiência total na secreção de insulina, em virtude da destruição das células beta pancreáticas, a do tipo 2, causada por uma resistência do organismo a ação da insulina ou pela sua produção insuficiente e a diabetes gestacional, que se caracteriza pela presença de glicose elevada no sangue durante a gravidez (SBD,2019).

Existem vários testes laboratoriais que são realizados para que o paciente consiga obter um diagnóstico correto da doença, sendo a dosagem glicêmica o teste mais utilizado. Esse exame é capaz de detectar a quantidade de glicose presente no sangue a partir de um tempo de jejum (8-12 horas), e para o diagnóstico preciso ele é realizado duas vezes com intervalo de curto prazo, uma a duas semanas. A dosagem geralmente é feita no soro ou plasma fluoretado, usando o método enzimático (SBD, 2015).

A avaliação correta dos laudos dos exames, bem como a correlação de informações passadas do paciente sobre seus sinais e sintomas é de grande importância para um diagnóstico válido e correto. Erros na interpretação dos laudos podem colocar a vida dos pacientes em risco, visto que os tratamentos das diversas doenças são individuais e específicos (DANI *et al.*, 2011).

Para que não ocorra erros nos resultados é muito importante a anamnese do paciente, ou seja, que o laboratório tenha um cuidado maior na fase pré-analítica, sendo essa considerada a fase onde ocorrem mais erros, devido à grande evolução e automatização das fases analíticas e pós-analíticas. Além de ser a fase em que ocorre mais erros, é também a mais difícil de ser controlada, pois algumas etapas não dependem somente do laboratório, mas também do paciente, como o seu preparo/jejum (SBPC/ML, 2018).

Os medicamentos são um dos principais interferentes, pois nem sempre seu uso é relatado durante a anamnese. Sua ação pode causar interferências tanto *in*

*vivo* quanto *in vitro*, gerando resultados falsamente aumentados ou diminuídos (BEZERRA e MALTA, 2015).

Segundo a Organização Mundial de Saúde (OMS), estima-se que metade dos medicamentos são inadequadamente prescritos e/ou vendidos, e que a maioria dos pacientes os usam de forma errônea, o que pode causar danos severos à saúde, como o óbito. O Sistema Nacional de Informações Tóxico-Farmacológicas relata, que no Brasil a maior causa de intoxicação é devido a ingestão indevida destes medicamentos (Ministério da Saúde, 2019).

Um dos medicamentos mais consumidos pela população mundial, são os anti-inflamatórios e analgésicos, os quais são capazes de sanar as dores momentaneamente. Dentre os diversos fármacos que se encaixam nessa classe, temos o paracetamol, sendo este encontrado facilmente, possuindo baixo custo, e não sendo necessário prescrição médica para sua compra (SILVA, SOUZA e FERREIRA, 2019).

Em razão do grande número de diabéticos e crescente automedicação, este trabalho tem como objetivo avaliar *in vitro* a possível interferência do paracetamol nas dosagens glicêmicas.

## 1.1 PROBLEMÁTICA

O paracetamol interfere nas dosagens glicêmicas?

## 1.2 JUSTIFICATIVA

Os estudos demonstram um crescente aumento no número de pessoas portadoras de diabetes mellitus no mundo, e concomitantemente um aumento no número de mortes em decorrência da mesma. Isso decorre dos novos modelos de vida da sociedade, além de pouco conhecimento da população sobre a doença.

Todavia o diagnóstico correto se torna muito importante para que o tratamento seja preciso e eficaz. Portanto os exames laboratoriais podem apresentar falsos resultados devido principalmente a erros na fase pré-analítica.

A automedicação cresce em níveis exponenciais no mundo todo, principalmente pelo fácil acesso, baixo custo e por não precisarem de receitas médicas para serem adquiridos.

Segundo dados de uma pesquisa realizada em 2019 pelo Conselho Federal de Farmácia, 77% dos brasileiros tem o hábito de se automedicar. A facilidade de acesso ao medicamento foi um dos principais fatores apontados pela pesquisa. Entre os medicamentos mais consumidos, os analgésicos e antitérmicos são os mais utilizados (50%) (CRFSP, 2019).

Um dos analgésicos mais comercializados é o paracetamol. Dentre os motivos estão o baixo custo, pode ser adquirido sem prescrição médica, tem um efeito rápido e satisfatório na analgesia e controle da temperatura corporal.

Contudo alguns medicamentos podem causar alterações tanto *in vivo* quanto *in vitro*, levando a erros principalmente nas dosagens bioquímicas.

Partindo desta perspectiva, o trabalho visa avaliar se o medicamento paracetamol interfere na reação da dosagem sérica de glicose, levando a possíveis erros nos resultados laboratoriais, interferindo no diagnóstico e controle do diabetes.

## 1.3 OBJETIVOS

### 1.3.1 Objetivo Geral

Avaliar a interferência *in vitro* do medicamento paracetamol em dosagens glicêmicas realizadas pelo método de glicose-oxidase.

### 1.3.2 Objetivo Específico

- Realizar a dosagem bioquímica de glicose em amostras de soro previamente incubadas com diferentes doses de paracetamol;
- Avaliar se houve alterações nos resultados das dosagens glicêmicas.

## II. FUNDAMENTAÇÃO TEÓRICA

### 2.1 Glicose

A glicose é considerada um combustível metabólico importantíssimo para as células mamíferas. Em condições fisiológicas normais, as células são dependentes de vários nutrientes que em sua maioria são transmitidos através da corrente sanguínea (SHAO e TIAN, 2015).

Isolada pela primeira vez em 1747 por Andreas Sigismund Marggraf, a glicose apresenta fórmula molecular  $C_2H_{12}O_6$ . É um monossacarídeo, pertencente à família dos carboidratos. Apresenta-se como uma molécula polar com uma baixa massa molecular, sendo considerada uma das principais fontes de energia dos organismos (SILVA; FILHO e FREITAS, 2018).

Os glicídios provenientes da alimentação são as principais fontes de glicose do organismo. Eles são digeridos enzimaticamente a unidades mais simples, os monossacarídeos (maioritariamente glicose, galactose e frutose), antes da sua absorção no intestino delgado ao nível dos enterócitos das vilosidades intestinais (ARAÚJO e MARTEL, 2009).

O intestino é capaz de absorver toda glicose que é ingerida, sendo essa absorção realizada através dos

eritrócitos maduros que revestem o intestino delgado. A glicose é transportada pela membrana através dos cotransportadores de glicose de sódio (SGLT1) (SALA *et al.*, 2018). O gradiente de concentração sódio também ajuda no transporte, pois a glicose é absorvida pela diferença de concentração do transportador, que possui uma membrana externa com dois sítios de ligação, um para cada elemento (MIRANDA, 2018).

A camada lipídica da membrana plasmática é impermeável a glicose devido a sua propriedade hidrofílica; portanto, a absorção de glicose pela célula é mediada através de uma variedade de transportadores de glicose (SHAO e TIAN, 2015). Para que o transporte ocorra, a glicose conta com a ajuda de alguns transportadores facilitadores de glicose, os chamados GLUTs, que estão presentes nas superfícies das membranas celulares. Estes transportadores são responsáveis por conduzirem a glicose do meio extracelular para o meio intracelular (VENANCIO, 2018).

Em humanos, a glicose é armazenada na forma de glicogênio no fígado ou como triglicerídeos no tecido adiposo. Por essa reserva não ser suficiente para o organismo, ocorre processos de síntese de glicose principalmente pelas células hepáticas. Essa produção é realizada através do processo chamado de gliconeogênese onde temos a síntese de glicose a partir de precursores que não sejam carboidratos como o lactato, piruvato, glicerol e aminoácidos (SILVA; FILHO e FREITAS, 2018).

O controle hormonal da glicose no sangue ocorre pelo processo da homeostase, mediado principalmente pela insulina e glucagon. Esses hormônios têm ação em grande parte dos tecidos, em especial no fígado, pâncreas, músculo esquelético e tecido adiposo (MIRANDA, 2018). A insulina é responsável por aumentar a concentração intracelular de glicose, além de alterar a atividade das enzimas que regulam o metabolismo, estimulando o armazenamento de combustível. Já o glucagon é responsável por aumentar concentração plasmática de glicose, sendo capaz de liberar os combustíveis armazenados e converter o lactato, aminoácidos e glicerol em glicose (GUYTON e HALL, 2011).

O organismo humano, para que realize seus processos metabólicos adequadamente, necessita de no mínimo 200 g de glicose por dia. Se a concentração sanguínea estiver abaixo de 40 mg/dl podem ocorrer episódios de coma, convulsões e até mesmo morte, por outro lado, se exceder o valor de 180 mg/dl, caracterizando

a hiperglicemia, podem ocorrer complicações imediatas ou a longo prazo (ARAÚJO e MARTEL, 2009).

## 2.2 Diabetes Mellitus (DM)

O diabetes foi descrito a mais de 3.500 anos por Celsos, onde ‘Diabetes’ significa sifão e ‘Mellitus’ vem do grego meles, que significa ‘mel’. Considerado mundialmente como um problema de saúde pública, que apesar de ter sido descoberto a muitas décadas, seu caráter avassalador se torna presente até os dias atuais (BARBOSA e CAMBOIM, 2016). Pertencente ao grupo de doenças metabólicas, é caracterizado por uma hiperglicemia, de caráter multifatorial que envolve desordens metabólica nos carboidratos, lipídeos e proteínas, resultando em defeitos na secreção da insulina, na ação da insulina ou em ambas (ADA, 2014).

A sua prevalência está associada a diversos fatores, como: a rápida urbanização, transição epidemiológica, mudança nutricional, prevalência do sedentarismo, excesso de peso, crescimento e envelhecimento populacional, além da maior sobrevivência dos portadores de diabetes (SBD, 2019).

Os principais sintomas do diabetes, considerados clássicos, são: poliúria, polidipsia, polifagia, e perda involuntária de peso; além de outros que levam a suspeitas, como: fadiga, fraqueza, letargia, infecções de repetição, dentre outros. Portanto muitas vezes o diabetes não apresenta sinais nem sintomas, tornando o portador assintomático o que leva a um diagnóstico tardio, apenas quando aparece as complicações crônicas (neuropatia, nefropatia, retinopatia, doença cerebrovascular, doença coronariana e doença arterial periférica) (ALMEIDA, 2018).

O diagnóstico tardio e as complicações são as maiores causas de mortalidade na maioria dos países, sendo a doença cardiovascular a mais causal. O diabetes é responsável por 10,7% das mortes mundiais, sendo maior do que a soma dos óbitos causados por doenças infecciosas. Na tabela 1 são apresentadas as taxas de mortalidade por diabetes no Brasil no ano de 2017. Está separada por faixa etária e macrorregião geográfica e se pode observar a crescente importância do diabetes como causa de morte com o progredir da idade, aumentando de forma exponencial da faixa etária de 0 a 29 anos para a de 60 anos ou mais, ou seja, com o aumento da expectativa de vida da população brasileira, o diabetes certamente passará a ter maior contribuição para a mortalidade no país (SBD, 2019).

*Tabela 1- Taxa de mortalidade por diabetes (a cada 100 mil habitantes), por macrorregião geográfica brasileira, segundo a faixa etária, no ano de 2017.*



Faixa etária (anos)	Norte	Nordeste	Sudeste	Sul	Centro-Oeste	Total
0 a 29	0,6	0,7	0,7	0,5	1,7	1,1
30 a 39	2,6	3,3	2,8	2,5	2,8	2,8
40 a 49	10,2	12,4	8,4	8,4	14,8	9,7
50 a 59	46,4	41,7	28,3	30,0	31,9	33,3
60 e mais	255,6	263,4	150,9	181,7	188,0	90,1
<b>Total</b>	<b>26,3</b>	<b>37,5</b>	<b>27,3</b>	<b>32,8</b>	<b>26,1</b>	<b>30,7</b>

Fonte: SBD, 2019.

O diabetes mellitus é classificado em diabetes mellitus tipo 1 (DM1), diabetes mellitus tipo 2 (DM2), diabetes mellitus gestacional e outros tipos específicos. O DM1 é causado por uma doença autoimune, onde o sistema imunológico humano ataca as células beta pancreáticas, destruindo-as. Essas células são responsáveis pela produção de insulina, e devido a sua destruição, o organismo fica inapto a essa função (ADA, 2014). As causas desse processo não são totalmente compreendidas, mas a combinação de susceptibilidade genética e infecções virais são prováveis explicações para o caso. Pode se desenvolver em qualquer idade, embora seja mais comum seu aparecimento em crianças e jovens (FONSECA e RACHED, 2019). O DM1 corresponde a apenas 5 a 10% de todos os casos de DM (SBD, 2019).

Os sintomas mais comuns do DM1 são a polidipsia, poliúria e a perda de peso. Portanto os portadores do DM1 precisam da administração de insulina diariamente para manter seus níveis de glicose desejável, pois sem ela é impossível sobreviver. A aplicação desse medicamento juntamente com práticas de atividade física e alimentação saudável, eleva extraordinariamente a taxa de vida dos portadores, porém principalmente em países e família de baixa renda esse tratamento se torna complicado, devido às limitações de acesso ao autocuidado, podendo levar a mortes prematuras (ARAUJO, 2017).

DM2 é responsável em média por 90% dos casos de diabetes (SBD, 2019). É definido pela incapacidade do organismo de responder a insulina, caracterizando a resistência à insulina (ADA, 2014). O hormônio, portanto, se torna ineficaz e acaba ficando acumulado no organismo, com o tempo a inadequada produção da insulina pode desencadear falhas nas células beta pancreáticas. É mais comumente diagnosticado em pacientes com idades mais avançadas, porém devido ao aumento da obesidade, falta de atividade física e nutrição inadequada, os números de portadores jovens e crianças estão cada vez mais altos (BERTONHI e DIAS, 2018).

Trata-se de doença poligênica, com forte herança familiar, ainda não completamente esclarecida, cuja ocorrência tem contribuição significativa de fatores ambientais. Hábitos dietéticos e inatividade física, que contribuem para a obesidade, diagnóstico prévio de pré-diabetes ou diabetes mellitus gestacional, destacam-se como os principais fatores de risco (SBD, 2019).

Os sintomas do DM2 são semelhantes com a do tipo 1, sendo mais brandos e em muitos casos são assintomáticos. Outros sintomas menos comuns são fraqueza e fadiga. Com menor frequência, indivíduos com DM2 apresentam sintomas clássicos de hiperglicemia (poliúria, polidipsia, polifagia e emagrecimento inexplicado). O tratamento inclui um estilo de vida saudável (alimentação e atividade física), interrupção do tabagismo e manutenção de um peso corporal saudável. Se a mudança no estilo de vida não for suficiente, se faz necessários os tratamentos medicamentosos (MACIEL *et al.*, 2018).

O diagnóstico do diabetes mellitus é realizado através de exames laboratoriais, como a glicemia casual, glicemia em jejum, teste de oral tolerância a glicose (TOTG) e hemoglobina glicada. A glicemia em jejum é considerada padrão ouro para confirmação do diagnóstico, já os outros exames são recomendados para monitoramento e estratificação do controle metabólico, no caso da hemoglobina glicada (ALMEIDA, 2018).

Os valores de normalidade para os respectivos exames, bem como os critérios diagnósticos para pré-diabetes e DM mais aceitos e adotados pela Sociedade Brasileira de Diabetes (SBD), encontram-se descritos na tabela 2.

Tabela 2- Critérios laboratoriais para diagnóstico de normoglicemia, pré-diabetes e DM, adotados pela SBD.

	Glicose em jejum (mg/dL)	Glicose 2 horas após sobrecarga com 75 g de glicose (mg/dL)	Glicose ao acaso (mg/dL)	HbA1c (%)	Observações
<b>Normoglicemia</b>	< 100	< 140	–	< 5,7	OMS emprega valor de

					corte de 110 mg/ dL para normalidade da glicose em jejum.
<b>Pré-diabetes ou risco aumentado para DM</b>	$\geq 100$ e $< 126$	$\geq 140$ e $< 200$	-	$\geq 5,7$ e $< 6,5$	Qualquer dos parâmetros positivos confirma diagnóstico de pré-diabetes.
<b>Diabetes estabelecido</b>	$\geq 126$	$\geq 200$	$\geq 200$ com sintomas evidentes de hiperglicemia	$\geq 6,5$	Qualquer dos parâmetros positivos confirma diagnóstico de DM.

Fonte: Adaptado de SBD, 2019.

A prevenção é de extrema importância e se torna efetiva quando a atenção a saúde é realizada de forma eficaz. A prevenção pode ser primária, onde ocorre uma busca constante para evitar que mais indivíduos desenvolva a doença, ela não tem base racional e pode ser aplicada a toda população. Na secundária, a prevenção é direcionada para complicações agudas e crônicas; e a prevenção terciária, onde há uma reabilitação das incapacidades produzidas pelas suas complicações. Por isso é muito importante que se evite excesso de peso corporal e obesidade, tenham uma alimentação saudável, exercite a prática de atividade física para que tais eventos não aconteçam (TONETTO *et al.*, 2019).

### 2.3 Dosagem Glicêmica

A manutenção da glicemia minimiza de maneira significativa as complicações do DM. Desta forma, metodologias que analisam a frequência e a magnitude da hiperglicemia são de suma importância no rastreamento e acompanhamento do DM (SBD, 2015).

O diabetes mellitus exigem constante monitoração dos níveis de glicemia a fim de se evitarem complicações, permitindo adequações na dieta e na terapia dos pacientes (OLIVEIRA *et al.*, 2015).

O diagnóstico laboratorial do DM pode ser realizado por meio de glicemia de jejum, glicemia 2 horas após o TOTG e hemoglobina glicada (HbA1c). A glicemia tem sido utilizada por muitas décadas como critério de definição para DM (SBD, 2019).

Os métodos de dosagem mais utilizados na prática laboratorial são os enzimáticos, onde várias enzimas, com especificidade máxima para a glicose, têm sido empregadas nos reagentes atuais. A glicose oxidase é a mais usada, mas enzimas como a hexoquinase e a glicose desidrogenase também podem ser utilizadas. Os métodos enzimáticos são exatos, precisos, baratos e podem ser facilmente automatizados (GROSS *et al.*, 2002).

A Glicose é oxidada enzimaticamente pela Glicose Oxidase (GOD) como mostra a figura 1:

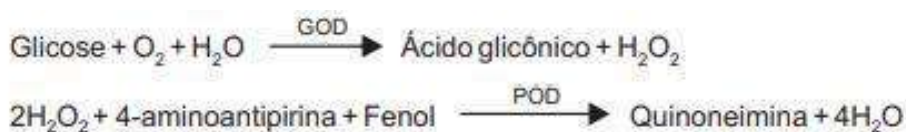


Fig.1- Reação de oxirredução para determinação da concentração de glicose sérica.

Fonte: Gold Analisa, 2018

O princípio da reação pelo método glicose-oxidase é a oxidação da glicose presente na amostra sob a ação catalisadora da enzima glicose-oxidase presente no reagente, convertendo a glicose em ácido glicônico e peróxido de hidrogênio. Através de uma reação oxidativa de acoplamento catalisada pela peroxidase (POD), o peróxido de hidrogênio formado reage com 4-aminoantipirina e fenol formando um complexo de cor

vermelha (quinoneimina), cuja absorbância medida em 505 nm, é diretamente proporcional à concentração de glicose na amostra (Gold Analisa, 2018).

A segunda etapa desta reação, onde ocorre a transferência de peróxido de hidrogênio para um aceitador de oxigênio cromogênico, resultando na formação de cor, não é específica. A presença de qualquer composto

reduzidor, como urato, ascorbato, glutatona, etc., na amostra, interfere negativamente na medição da glicose (JURETIC *et al.*, 2002).

#### 2.4 Interferentes analíticos

Os exames laboratoriais têm como principal objetivo fornecer informações necessárias para o auxílio do diagnóstico. Dados obtidos por meio de anamnese devem sempre ser levados em consideração para que os resultados produzidos sejam precisos (RAMOS *et al.*, 2020).

A fase pré-analítica compreende a etapa entre a solicitação e a realização do exame no laboratório. Essa fase é responsável por mais de dois terços dos erros laboratoriais (LIPPI *et al.*, 2013). Segundo Hollensead *et al.* (2004) os erros na fase pré-analítica podem representar 84,5% do total de erros em um laboratório clínico. Esses erros podem ser determinantes para um diagnóstico falso-positivo e/ou falso-negativo. Diversos são os fatores para sua ocorrência, desde omissão do paciente ou do profissional até por falta de conhecimento (COSTA e MORELI, 2012).

Os erros ocasionados na fase pré-analítica ocorrem por diversos fatores como idade, sexo, prática de atividade física, medicamentos, ritmos biológicos, gravidez, uso de bebidas alcoólicas e doenças intercorrente, além dos erros do laboratorista como coleta inadequada, troca de amostras, armazenamento inadequado, dentre vários outros (XAVIER, 2013).

Os medicamentos administrados em doses terapêuticas, bem como os seus metabólitos, podem potencialmente, junto com reagentes ou analitos, interferir e alterar resultados de exames laboratoriais (RAMOS *et al.*, 2020). A falta de conhecimento sobre a interação entre teste de laboratório e drogas, é um erro comum na interpretação dos resultados, o que acaba levando a diagnósticos errôneos, testes de diagnósticos extras, terapias ou até mesmo acompanhamento desnecessários. Essa interação entre fármaco e teste laboratorial são classificadas em duas categorias, sendo elas as interações fisiológicas e as analíticas (BALVEREN *et al.*, 2019).

As interações fisiológicas estão diretamente relacionadas aos processos *in vivo*, quando o medicamento causa alterações a nível corporal. Podem ocorrer por indução ou inibição enzimática, competição metabólica e ação farmacológica, quando o fármaco ou seus produtos de biotransformação são responsáveis pela modificação de um componente biológico, por meio de um mecanismo fisiológico, farmacológico ou toxicológico. As interações analíticas são processos *in vitro*, quando alguma propriedade física ou química da droga interfere na reação do teste onde os fármacos têm a capacidade de alterar os

processos analíticos, com impactos clínicos negativamente relevantes, pois os resultados podem não demonstrar a real situação que o paciente se encontra (RAMOS *et al.*, 2020; BALVEREN *et al.*, 2019).

Segundo Costa e Moreli (2012) a glicose é o principal analito mensurado com erros em sua dosagem, principalmente na fase pré-analítica.

Tang *et al.* (2000) estudou a interferência de 30 drogas nas leituras de medidor de glicose. Interferência significativa foi observada com o uso de acetaminofeno, ácido ascórbico, dopamina e manitol. Os medidores baseados em glicose-oxidase foram afetados com mais frequência, possivelmente por causa do método de detecção de redução de peróxido utilizado por esses medidores. O paracetamol e o ácido ascórbico consomem peróxido, o que resulta em glicose sanguínea mais baixa.

#### 2.5 Acetaminofeno

Sintetizado em 1852 o paracetamol, também chamado de acetaminofeno ou N-acetil-p-aminofenol, é o analgésico e antipirético mais popular. Apesar da popularidade desse medicamento, o mecanismo pelo qual o paracetamol atinge seus efeitos sobre a febre e a dor ainda é questionável. Presume-se que o paracetamol provavelmente age através da via ciclogênese (COX). Este é o caminho através do qual os anti-inflamatórios não esteroides (AINEs) agem. Os AINEs inibem a produção de prostaglandinas (produtos químicos pró-inflamatórios) através da inibição das ciclogêneses. No entanto, o paracetamol não tem atividade anti-inflamatória significativa nem inibe a produção dos tromboxanos e procoagulantes. Embora possa haver algum efeito nas enzimas COX, este efeito é diferente do visto com os AINEs (ANDERSON, 2008).

Ele tem a capacidade de inibir a síntese das prostaglandinas, causando efeitos analgésicos. Essa inibição ocorre devido a diminuição de prostaglandina E2 (PGE2) no sistema nervoso central a partir da cicloxigenase, além de impedir a formação dos impulsos quimiorreceptores sensíveis a bradicinina, os quais são responsáveis pelos impulsos nociceptivos. Também tem ação contra os mecanismos de ação do óxido nítrico espinal, atuando como um antagonista do receptor N-metil-D-aspartato (NMDA) e no neurotransmissor P da medula espinal (modulador da dor) (JACQZ-AIGRAIN e ANDERSON, 2006).

Em temperatura ambiente se apresenta como um sólido de cristais, totalmente inodoro, porém com um sabor levemente amargo. Em água fria esse fármaco apresenta-se pouco solúvel, sendo bem solúvel em água quente ou álcool. Quando em solução aquosa saturada apresenta um pH em torno de 6,0 (REMIÃO, 2020).

Essa medicação é uma das mais vendidas em todo o mundo, tendo a possibilidade de aquisição sem prescrição médica. Sua popularização pode ser atribuída ao fato de ser bem tolerada, não apresentar muitos dos efeitos colaterais dos salicilatos (como os sangramentos digestivos, por exemplo) (CASTRO, 2014).

Existe a disponibilidade do fármaco em variadas composições, apresentações e concentrações. Pode ser

Tabela 3- Medicamentos que contém o Paracetamol em sua composição.

MEDICAMENTOS		
Buscoduo	Fluviral	Sonridor
Torsilax	Multigrip	Doril Enxaqueca
Cefalium	Vick Pyrena	Neolefrin
Tylenol	Tylox	Cyfenol
Cibalena A	Cimegripe	

Fonte: Própria, 2021.

No Brasil existe comprimidos de duas concentrações, sendo eles 500 e 750 mg. A dose terapêutica recomendada para uso em crianças é de 10 mg/Kg sendo administradas no intervalo de 4/4 horas ou de 6/6 horas, atentando-se que a dose diária não pode ser maior que 75 mg/Kg. Para adultos, é administrado nos mesmos intervalos de tempo, porém, as doses diárias podem chegar até 4 g por dia (MUHLBAUER, 2016).

Em doses terapêuticas adequadas, estudos indicam que o paracetamol se apresenta como um fármaco seguro para uso, portanto em super dosagens pode causar danos hepatotóxicos. Essa toxicidade ocorre principalmente pelo fato de que sua metabolização ocorre no fígado, através de duas vias, uma que é responsável por 90% do seu metabolismo, onde acarreta uma formação de metabolitos conjugados não tóxicos, sendo excretados por via renal. A outra via chamada de bioativação, é capaz de realizar a metabolização pela via oxidativa com a ajuda de enzimas do citocromo p450, gerando o metabolito tóxico N-acetil-p-benzoquinone (NAPQI), que é eliminado junto com glutathione (GSH) por conjugação (PEREIRA, 2018).

O paracetamol, administrado oralmente, é rapidamente e quase completamente absorvido no trato gastrointestinal, principalmente no intestino delgado. A absorção ocorre por transporte passivo, sendo que sua biodisponibilidade relativa varia de 85% a 98%. Em indivíduos adultos as concentrações plasmáticas máximas ocorrem dentro de uma hora após a ingestão, variando de 7,7 a 17,6 mcg/mL para uma dose única de 1000 mg. As concentrações plasmáticas máximas no estado de equilíbrio após administração de doses de 1000 mg a cada

comercializado e comprado de forma isolada ou em concomitância a outros fármacos, como nos compostos para alívio da sintomatologia gripal, bem como nos relaxantes musculares, antiespasmódicos ou associado a outros analgésicos, como mostra a tabela 3 (SCHUH, 2007).

6 horas variam de 7,9 a 27,0 mcg/mL (PARACETAMOL, 2015).

Em dosagens habituais, o tempo de meia vida é de 2 horas em adultos normais, já em recém-nascidos e adultos portadores de cirrose esse tempo é aumentado, e em crianças o tempo é diminuído. Sua depuração na urina é em média 13,5 l/h, sendo que durante o primeiro dia podemos recuperar cerca de 90 a 100% do medicamento nessa amostra (BERTOLINI *et al.*, 2006).

Em exames laboratoriais, o paracetamol pode interferir de maneira significativa nos valores normais, como é o caso do teste de glicemia em fitas reagentes, onde ele pode diminuir os valores em até 20%. Caso o medicamento não for suspenso por no mínimo 3 dias, os testes de função pancreática realizados com bentiromida, são considerados inválidos devido tal interferência. É capaz de interferir também na determinação do ácido úrico sérico e do ácido-5-hidróxi-indolacético aumentando e positivando resultados, quando utilizados o método de tungstato e o reagente nitrozonafol respectivamente (PARACETAMOL, 2015).

### III. METODOLOGIA

O presente trabalho realizou uma análise *in vitro* para avaliação da interferência do paracetamol na dosagem sérica de glicose. O método utilizado foi a glicose oxidase, o qual a literatura descreve sofrer interferência na presença do medicamento paracetamol. Porém existem poucas pesquisas que constatem isso. A técnica empregada foi desenvolvida no laboratório escola da Universidade

Estadual de Minas Gerais – Unidade Passos, com autorização da coordenação do mesmo (apêndice A).

Para o procedimento utilizou-se uma amostra comercial de concentração conhecida, apresentando o valor de 100 mg/dL. A quantificação da glicose foi realizada por um aparelho semiautomático da marca Celler, utilizando o princípio da espectrofotometria. Para o teste utilizou-se o Kit Glicose-PP (glicose monoreagente) do laboratório Gold Analisa Diagnóstica, o qual foi validado utilizando amostra comercial de soro controle.

### 3.1 Protocolo experimental para estudo *in vitro*

Foi dissolvido um comprimido de paracetamol de 500 mg em 50 mL de água destilada, homogeneizado e aquecido em banho-maria à 37°C. Dessa solução foram realizadas diluições, a fim de formar novas soluções com concentrações determinadas, distintas e crescentes de paracetamol.

Em cada diluição foi adicionado soro controle comercial, com concentração de glicose conhecida, na mesma proporção do volume da diluição, obtendo-se soluções finais com as seguintes concentrações: 10 µg/ml, 50 µg/ml, 200 µg/ml e 5 mg/ml.

Foram preparadas amostras controles, as quais possuem apenas reagente e a amostra controle comercial com valor conhecido de glicose, sem a presença do paracetamol.

Foram realizados três experimentos independentes e de cada experimento os testes foram realizados em quintuplicata.

A determinação da glicemia foi realizada nas amostras contendo o fármaco nas diversas concentrações e

amostras controle (amostra sem o fármaco), sendo a leitura feita de forma randomizada. As determinações dos analitos bioquímicos foram realizadas segundo as instruções do fabricante Gold Analisa Diagnóstica.

### 3.2 Análise estatística

Os gráficos expressando média  $\pm$  erro padrão da média (EPM) e todas as análises estatísticas foram feitas através do programa GraphPad Prism versão 5.0 (GraphPad Software, Inc. 2007). As diferenças entre os valores obtidos da amostra controle e amostras com concentrações distintas de paracetamol, foram verificadas pela análise de variância (ANOVA), seguido pelo pós-teste de Tukey. Foi considerado um nível de significância de  $p < 0,05$ .

## IV. RESULTADOS

Para analisar a interferência do paracetamol, foram feitas dosagens glicêmicas de amostras de soro controle comercial e amostras contendo concentrações finais 10 µg/ml, 50 µg/ml, 200 µg/ml e 5 mg/ml deste fármaco. A verificação em diferentes concentrações teve por finalidade pesquisar qual o grau de interferência do paracetamol nas dosagens da glicemia.

A figura 2 mostra a média aritmética dos valores da glicemia encontrados após as dosagens com diferentes concentrações de paracetamol nas amostras, onde o controle corresponde à amostra de soro sem a adição de paracetamol, utilizado como valor de referência para a análise estatística.

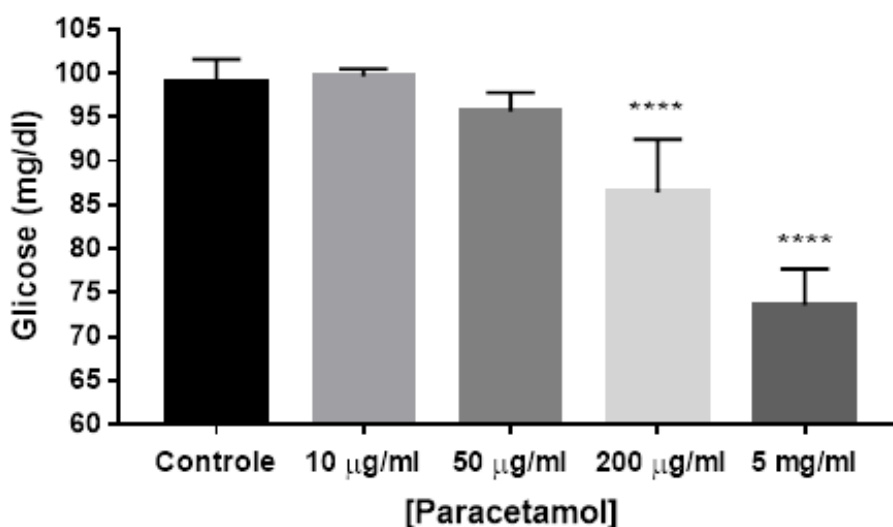


Fig.2-. Interferência do paracetamol em dosagem glicêmica em amostra controle e amostras com concentrações distintas de paracetamol.

Fonte: Própria, 2021.

Dosagens bioquímicas em amostras contendo glicose (100 mg/dl) e paracetamol nas concentrações de 10 µg/ml – 5 mg/ml. As amostras controles continham apenas glicose na concentração de 100 mg/dl. Diferença significativa em relação ao grupo controle \*\*\*\*P< 0.0001.

O paracetamol interferiu, de maneira dose-dependente, na dosagem da glicose das amostras com concentrações previamente definidas de 100 mg/dl. Os maiores índices de interferência estão nas amostras com maior concentração de paracetamol. A presença do paracetamol, nas concentrações de 200 µg/ml ou 5 mg/ml, resultou na redução estatisticamente significativa dos valores de glicose nas amostras, em comparação com o grupo controle sem o paracetamol (figura 2).

## V. DISCUSSÃO

O paracetamol está entre os analgésicos mais utilizados atualmente, pois apresenta eficiência terapêutica, não interage com a maioria dos medicamentos e tem livre acesso sem necessidade de prescrição médica. Seu uso está direcionado como analgésico e antipirético (BRAYNER *et al.*,2018).

Uma fonte comum de erro de diagnóstico é a falta de conhecimento da presença de interações de testes de laboratório de drogas (DLTIs). A má interpretação dos resultados dos testes pode levar a um diagnóstico errôneo, exames extras desnecessários, terapia ou acompanhamento.

Segundo Tang *et al.* (2000), em reações pelo método de glicose-oxidase, agentes redutores como o acetaminofeno e o ácido ascórbico podem consumir o peróxido de hidrogênio e diminuir sua reação com o corante, resultando em leituras menores.

O presente estudo confirma essa influência negativa, onde os dados evidenciam uma clara interferência do paracetamol, inversamente proporcional à glicemia da amostra controle. O que significa que, quanto maior a concentração de paracetamol na amostra, menor o resultado para a dosagem glicêmica.

Analisando-os separadamente, observa-se níveis de glicose mais baixos nas concentrações de paracetamol de 200 µg/ml e 5 mg/ml, gerando resultados significativos (p<0,0001). No entanto, sabe-se que os níveis basais de paracetamol não chegam a esse valor exceto em situações de megadoses.

É possível observar que a interferência, apesar de existir, provavelmente terá pouca influência na prática

laboratorial, visto que a concentração sérica de paracetamol após a ingestão de 4g/dia alcança o valor de 108 µg/ml, distante dos 200 µg/ml que geraram um resultado significativo. Ressalvo em casos de megadoses.

## VI. CONCLUSÃO

Em suma, os resultados desse trabalho demonstraram que o paracetamol interferiu, de forma proporcional a sua concentração, no ensaio laboratorial para a determinação da glicemia pelo método de glicose-oxidase. Assim, é muito importante que os profissionais da saúde, principalmente os analistas, biomédicos e bioquímicos, tenham conhecimento do potencial de influência dos fármacos nos resultados de exames laboratoriais. As orientações em relação ao preparo do paciente para a coleta do exame, quanto uma anamnese completa, é fundamental para minimizar possíveis interferências e erros nos resultados laboratoriais e emissão de laudos errôneos, prejudicando o diagnóstico e/ou tratamento do paciente.

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## Environmental Policy of Solid Urban waste and the Socio-Environmental impacts in Baturité, Ceará, Brazil

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Received: 20 Jul 2022,

Received in revised form: 05 Aug 2022,

Accepted: 10 Aug 2022,

Available online: 31 Aug 2022

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**Keywords—** Urban Solid Waste. Environmental Policy. Garbage Dump. Baturité-CE.

**Abstract—** *The research had as its primary objective to understand, from the socio-environmental perspective, the limits, and possibilities of the dynamics of solid urban waste treatment in the municipality. Methodologically, this research study is an exploratory case study, of a basic nature with a qualitative approach. For data collection the techniques of direct observation and non-directive interview were applied to collectors/ dwellers of the municipal dump of Baturité-CE. As for the analysis techniques, content analysis and socio-historical contextual narrative discourse were used. As conclusive results, the study found that the collectors / residents live in a situation of socio-economic and environmental vulnerability, without having a collective organization to support them, including the absence of municipal government in relation to support these professional collectors of urban solid waste in general and in the locus of the research, specifically.*

## I. INTRODUCTION

Currently consumerism has become a constant practice in capitalist society. The way of life based on the growing propensity to consume, mostly superfluous, due to its symbolic meaning to achieve a need for pleasure, are often induced by a mass communication: media system means that has characteristics of reaching at the same time many receivers, starting from a single sender disseminating information to the high degree of consumption.

Following this reasoning, we observe that the increase in population leads to a large mass of people consuming in high quantities, products with no durability potential accommodated in long life containers. The "leftovers" from this unbridled consumption accumulate without consumers being concerned about their destination, causing an excessive generation of Urban Solid Waste - USW's. In the municipalities, this problem is crystal clear, since. "Waste generation is directly proportional to the total income of the municipality, i.e., the larger the city and the higher the income, the more waste will be produced by them" [1].

However, we can affirm that, whether in large or small cities, the increase in the generation of SUW's, as well as the absence of specific places, separated from the population centers, that present prerequisites for the disposal of these residues, avoiding and/or reducing the great contamination of soils, water resources, and air, has become a problem of great administrative repercussion.

In the municipality of Baturité the presence of open-air garbage is constant. To the people, the garbage dump is a place that many of us would never pass by, not

even close, because it is a place where we can't go anywhere else - smelly and horrendous. There are miserable people, poor wretches, underprivileged people, and other adjectives that people use when referring to those who deal with garbage. These stereotypes are based on prejudice and have perpetuated errors of judgment for many years, which only contribute to ineffective communication and personal relationships.

Based on this premise, many municipalities in Brazil, such as Baturité, in the state of Ceará, present situations of negative socio-environmental impacts, associated with anthropological actions related to USW's, for not having adequate management and management for their waste. Therefore, it is essential to alert both the municipal government and the population of this municipality to reflect on our attitudes towards the natural environment and the "garbage" that is produced.

The problems arising from the lack of proper attention to the USW's, are easily attributed to the demographic growth, the lack of awareness and environmental education of the population as well as visitors to the Maciço de Baturité; to the detriment of the conservation of the natural environment, have made these factors aggravating this problem.

It is necessary to show society the garbage scenario, where those people are inserted, the subhuman working conditions, housing, health, in the sense of public power support, and their perspectives for improvement of this environment. What do these waste pickers think about their working conditions? Why don't they look for another way to survive without depending on the absurd scenario

that those ramps are?

Since this is a theme related to our reality, the impacts that these dumps cause are the result of an absent and poorly managed public policy, resulting in a vulnerable situation for the collectors' way of life in that region.

In turn, both the government and the population, in general, need to assume their responsibilities regarding the minimization of this problem, from the public instance, yes, with programs of Environmental Education - EE consequent and concrete actions of management and proper waste management. Thus, such research was characterized in the search to understand and deepen the study on RSUs, sought the investigation beyond the consultations of documents from the competent bodies in the three spheres: Federal, State and Municipal - ABNT 10004/2004 Brazilian Standard; PNRS; PERS; PNEA; PDR<sub>Maciço</sub>; PPA<sub>Maciço</sub>; Organic Law, PA the City of Baturité-Ceará.

## II. THEORETICAL AND METHODOLOGICAL PROCEDURES

At the current juncture, Baturité has not yet realized what public policy dictates. And the elaboration of the PRRS of the Massif has not been properly accomplished. It should be noted that Baturité receives SUW's from neighboring municipalities, deposited in the open-air dump.

The environmental actions officially proposed by the municipality - see Municipal Organic Law; Law 160/2001; Law 1.221/2003; Law 1.615/2013, and PDR, 2004 - are not known by the population, therefore, without the necessary resonance in society. In fact, the proposals of the municipal government in "practice" still do not mean "public policy," since the "public" is not aware of them.

Thus, it is expected that the public authorities - schools - civil associations, and society in general, invest in environmental practices that can concretely minimize the impacts resulting from the lack of socio-environmental awareness of the population, as stipulated in law 1.221/2003.

The Ágape Institute counts on partnerships with small companies and the active participation of young people from schools and the community in general, besides building a bridge with Unilab. The educational action of the institution focuses on the development of social work in the environmental area through lectures, courses and workshops involving the theme, technical guidance for the realization of EE, especially in the APA Baturité; activities that, primarily, would be the responsibility of the public authorities.

There is also in the municipality the AACEMB - Associação dos Agentes de Endemias do Maciço de Baturité, which is a private association, founded in 2012, which develops, for example, the sustainable project of recycling materials, turning them into art. The project works with reusing tires, turning them into trash cans or plant pots; pet bottles that become vases... among others. All the products are displayed in public spaces, in the city squares, to be sold as income for the project's logistics, and to count on several partners: merchants and people from the community.

These examples demonstrate the need to rethink what has been done so far and what needs to be changed for the transformations necessary to maintain and improve the natural environment to happen in practice.

According to [2] the waste collectors are "people condemned to live at the margins of the capitalist accumulation system", being seen as non-citizens, unnecessary to the system: they do not produce, do not consume, and are still "stigmatized by the fact that the marginality and precariousness" of their living conditions are interpreted as an individual will not to work, and not as an imposition of the increasingly selective and exclusionary productive system.

Thus, these professionals are marked by precariousness, prejudice, and devaluation.

For [3] they are "careless-looking" people who, literally, live inside the garbage.

These are provocative views, for exposing in a public way, poverty. Misery. Socially deprived subjects, placed at the margin. Since ancient times they have been surviving on the leftovers of those who consume and discard what they consider useless, being called garbage (solid waste), in contemporary times. These stereotypes are based on prejudices that, for many years, have perpetuated errors of judgment that only contribute to ineffective communication and social-political relations.

In this context, they find themselves in the garbage dump, where they perform their labor as an act of resistance to the exclusion and insecurity caused by the "transformations of the globalized but unfair world", forcing them to live in a situation of extreme vulnerability. They are people who have been unemployed for a long time, come from the agricultural and cattle raising sectors, former prisoners, and/or come from places of extreme poverty, and are on the verge of indigence. As a rule, they have little or no schooling, or no professional training.

[3], further states that:

The collectors of the Dump recognize that their working

conditions are precarious, considering the lack of personal protective equipment, the lack of a suitable place to work, such as covered sheds, which makes it difficult to work in the afternoon, due to sun exposure. At night, there is no lighting, and, in periods of rain, they end up working inside humidity.

For [4] the work performed by the collectors is considered precarious, due to inadequate conditions, with a high degree of danger and unhealthiness, without social recognition, with risks that are often irreversible to health, and with a total absence of labor guarantees.

[5] affirms that the Industrial Revolution, in the XVIII century, allowed the development of several industries, giving rise to new material artifacts and increasing the generation of several types of waste,

[...] with emphasis on industrial or synthetic products; products bought, used, and discarded; demanding increasing amounts of raw materials, subtracted from nature; many of them non-renewable; and the large increase in their chemical compositions, which are now very diverse, making their natural degradation and reabsorption difficult. Many of them have a short time of use, as is the case of batteries, electro-electronic products, and the most varied packaging, notably, polymeric packaging, such as plastic and plastic-cellulose.

This confirms that since the Industrial Revolution human actions in relation to consumption have been unrestrained, increasing, uncontrollably, the production of waste with final disposal in an inadequate way where everything ends up in the dump.

For the author, all human activities - anthropic - produce residues that induce enormous difficulties at the time of their treatment and final disposal. Therefore, there is a major problem at hand: municipal governments depend on the resources involved, as high investments are required, to remunerate people; training and qualification,

as well as for the purchase of equipment and the cost of the RS's management system.

However, it is the municipality that generates the waste that must take responsibility for the production and final disposal of the garbage. The photographic records and the interviews with the garbage collectors show that the municipality must fulfill its role according to what is stated in the legislation, involving the whole society to do its part in a shared manner.

[6] explains that such a process enables a uniform and harmonious development among all stakeholders, to achieve the proposed objectives, appropriate to the needs and characteristics of each community. For this to occur, it is necessary dedication to think about the planning model and establish strategies to execute and program controls in the action that will be developed.

Another fact, facing the socio-environmental issue, is the continuous burning of garbage, preventing the reuse of these materials, because their sale as waste is compromised. The materials cited by the collectors as good and considered as profitable are plastic bottles, rubber, iron, and other materials such as - "the melissa", aluminum and dry plastic.

After a rough, urgent, competitive selection with their "peers"; the collectors in their "homes" make a "finer" selection of what really has value and will to provide them with a livelihood. It is necessary to emphasize that all this work is also developed among various materials of inflammable compositions, with constant burning of garbage, making it very difficult to handle the selection of materials that make it possible to generate income. Some waste pickers don't know or don't want to understand these processes that can harm their health. They are subjected to intense heat, both from exposure to the sun and the heat that is expelled from the ground because of the burning and decomposition of the garbage.

During the interviews at the dump, we witnessed waste pickers collecting waste "for recycling" in the center of the dump without any working conditions and without any safety. This happens because the waste arrives mixed and they must get there "on the ramp" - as they say - practically diving into the garbage, to pick up everything that seems to fit them. And, after a tiring day, they think about what might come the next day, so that they can start again another process of waste separation. The pickers are not concerned about whether they are sharing the scenery with the garbage, their concern lies in their ability to collect as much garbage as can be stacked.

We observe many discarded tires, which becomes a serious environmental problem. Even though they are

classified as inert, they are undesirable residues from the environmental point of view. When discarded in rivers and lakes, they can contribute to silting and flooding. When they are burned, they produce extremely toxic emissions, due to the presence of substances that contain dioxins and furans.

When disposed of inappropriately, for example, in landfills, they allow water to accumulate inside and can contribute to the proliferation of mosquitoes that transmit dengue and cholera. The glass rejects are quite visible on the ramp, and that their decomposition takes a long time to deteriorate. It is known that the composition of glass is resistant enough to understand that it is not reabsorbed by nature. The lifetime of this material is 4,000 years to disintegrate by erosion and/or action of chemical agents [7].

In the methodological scope, this work aims to address, qualitatively, a case study. It is characterized by understanding from the socio-environmental perspective, the limits, and possibilities of the dynamics of treatment of solid urban waste in the city of Baturité- Ceará. To delineate the way of life of the collectors/landfill dwellers, and to observe how the issue of environmental education of the municipality of Baturité- Ceará is today.

The methodological strategies employed for the development of this research follow the scientific method proper to the empirical-formal sciences. The method is understood as scientific the strategic paths used to investigate a research object in a systematic way through theory, methodology and peculiar technical procedures, adopted and accepted by the academic-scientific community [8]; [9].

As for the objectives, this study is of exploratory nature, because, in addition to exploring a concrete and verified reality, exploring specific facts, enabling the familiarization of the theme from the specific and scientifically studied contents. Exploratory research seeks to provide "greater familiarity with the problem, with a view to making it more explicit" [10]; [8].

It is worth mentioning that the field diary was very useful for noting details and curiosities during the research. A field diary is a complex instrument that allows the detailing of information, observations and reflections suggested during the research or moment observed [11].

Regarding the technical procedure adopted, the case study, we inform that the case chosen, among many others, were the socio-environmental impacts from solid urban waste from the dump of the city of Baturité, State of Ceará. According to [12] this procedure corresponds to an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when

the boundaries between the phenomenon and the context are not clearly defined.

Thus, the case study was structured with the use of individual interviews, guided by a semi-structured script and direct observation, as techniques for collecting data and information. According to [13], in the individual interview, the interviewer structures a script that will serve as a guide so that he can get the answer that reflects the position of the interviewee and that helps him to answer the investigated problem.

Therefore, we investigated the destination of the garbage generated and collected in the municipality, to find out where and how this waste is disposed of by the competent body. A survey of the environmental agencies and their attributions was also carried out.

These techniques were important because the data analysis and treatment were supported in a qualitative way and presented through discursive language. About the treatment, the techniques of content analysis were applied, in which it was carried out comparative reading of the quotes from the research subjects and contextualized sociohistorical discourse analysis. The results obtained with the interview were evaluated in parallel to the notes made in the field diary instrument during the investigative process.

The field research was carried out at the dump of Baturité located near the margins of the CE-021 that connects the CE-060 to the other municipalities of the Massif. It is approximately 3 km away from the municipal center.

### III. RESULTS AND DISCUSSION

The results observed during the visits to the dump were transcribed and analyzed according to the mentioned approach and correlated to the characterization of the socio- environmental impacts caused by the garbage in the interviewees' daily lives, as well as in the surrounding environment.

Especially, with the waste pickers, we analyzed the occupational risks, their perspectives for improvement, among others, focusing on the discourse of those subjects.

The first impact that distressed us was the sequence of several trash chutes and a lot of smoke all the time, making it impossible to be present at the site.

The collectors are forced to live with this pollution, with health risks: respiratory, lung, and, mainly, eye problems due to the gases that are eliminated by burning the garbage.

When we entered the dump, there were scavengers in the middle of the ramps collecting waste, i.e., their livelihood, all without PPE. We took photographs with the permission of the waste pickers, and we registered clippings of the place that caught our attention to assess the social and environmental context of those involved in the activity of waste collection. In addition, we conducted interviews that took place at various stages and during visits to the research site.

Initially, the research sought to know the profile of the collectors and through it, we obtained information from the subjects from their free speech. Thus, it was delineated from: sex, age, place of birth, education, marital status, place of residence, type and conditions of housing, how long they have been performing this professional activity, type of recyclable material, the most profitable and individual income, where they collect this material, receive any benefit, have ever acquired any disease, suffered any kind of verbal or physical violence, ever suffered prejudice, have children and if they are involved in the collection activities, if they are associated with any cooperative, if they have support from public authorities or the community.

For the socioeconomic characterization, the first point detected is that 70% of the interviewees were male and 30% were female (Figure 1-A). All inhabiting shacks in recyclables, especially flammable ones, in the dump itself. Regarding the age of the waste pickers interviewed, we observed that a percentage of 40% of the waste pickers are between 28 and 38 years old (Figure 1-B).

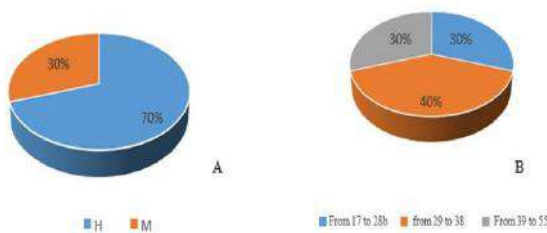


Fig. 1: A - n° of interviewees per gender. B - age range of the waste pickers at the dump.

Source: Elaborated from the interviews with the catadores

As for the pickers' place of birth, it was found that 74% are children of Baturité, and most were residents of the Candeia district - a rural area of the municipality - while 26% were from Quixadá (Figure 2-A). Regarding the collectors' schooling, it was found that 70% can neither read nor write, while 20% only know the name, but cannot read, and 10% have incomplete elementary school

education (Figure 2-B).

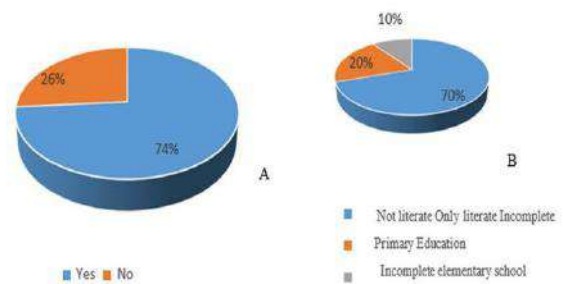


Fig. 2: A - Place of birth. B - Education of the collectors.

Source: Elaborated from the interviews with the catadores

As far as the place where the interviewees live is concerned, they sleep at their own workplace, that is, at the garbage dump - in a shack built out of tin foil collected on site (Figure 3).



Fig. 3: Home of the garbage collectors.

Source: Personal archive.

According to the reports, there are two residents who live in Candeia and return to their homes on weekends or on days that are pre-established by them. According to them, "the house there" is made of mud, and they all justify staying directly in the shack "because nobody invades and takes the space". They don't have bathrooms for their special needs, no running water - they buy water - and no energy. Inside their houses the temperature is very hot, because the walls are made of tin, the partitions are made of cloth and most of them sleep on the floor on a mattress.

Figure 4 demonstrates how long they have been practicing the collection activity at the dump. With 80% stating that they work with waste picking/inhabit the site in a range of ten to seventeen years; the remaining 20% claim to have been in the waste picking activity for five to nine years and reported that they "accompanied their mother" -

who has been there the longest, since childhood. The pickers who have lived the longest, say that they have been picking up trash since the first dumpsite that appeared in the municipality and that when they rented another piece of land, they came in search of their livelihood. "At first it was difficult because it was far from home," but with sometime later they began to make their shacks to store the recycled materials and then "it was staying" until it became a fixed dwelling.

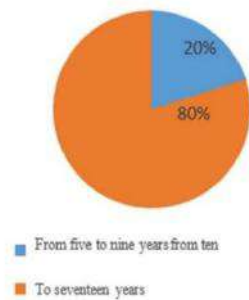


Fig. 4: Length of time working as a garbage collector.

Source: Elaborated from the interviews with the catadores.

As for the materials collected for sale, most "prefer" aluminum, melissa (characterized by various types of rubber, e.g., slippers), thick plastic (characterized by packaging, mainly of hygiene and cleaning products, e.g., shampoo bottles), PET (characterized by soda and oil packaging), iron and copper scrap, and glass. There is a predilection for aluminum because of the price paid, but this "little has come locally", therefore, the collection depends on what is available now, only the cardboard is not collected because of the organic mixture that ends up damaging it for recycling or burning.

Since everyone works, individually - "here the couple is uno!" - some claim to get, monthly, "half of a minimum wage." Others even "exceed this", earning about R\$ 500.00 per month. The value obtained from the sale of the materials is insufficient to support their families. The waste pickers have no fixed buyer, they sell their material according to the arrival of different buyers and for "unfair prices".

It was noticed that the average income they claim to take from the dump, depends on the pace and what "garbage" arrives, the more garbage, the higher the income. A few believe that it is enough, because they have assistance from the family scholarship, but most do not receive any benefit. Waste collection is done at their own workplace, at the garbage dump. And they do the separation-recycling in the shack where they live.

When asked about health problems due to their frequent contact with garbage, they said that "no serious illnesses", but most said they suffer from headaches, fevers, stomach aches, coughs, and flu, which are constant, "due to exposure to the sun". Only one resident said he had an operation for an ulcer.

When asked if they have suffered verbal or physical violence because of their conditions, the majority said yes. The total of the interviewees claim that they suffer both verbal and physical violence, because of the "disputes", for example, about the dumpsters of the

garbage. Currently, they have had to organize themselves so as not to have more fights, separated by cities, about the origin of the garbage. For this, some of the interviewees reported that there was an agreement among them, in the municipal forum, to divide the collection days for each picker/ resident.

As for suffering prejudice, 90% of the interviewees consider that when they say they "work at the dump," many "people" suggest another job, but at the same time, they answer "I think it's better to be at the dump than somewhere else. The other 10%, say that yes, they have suffered when they say that they work at the "ramp" now of some purchase in certain stores, in the "credit issue" (Figure 5). When asked if they had children and if they are involved in the collection activities, most said that they do not involve children in the collection, but sometimes some from the neighborhoods show up to "make mischief".

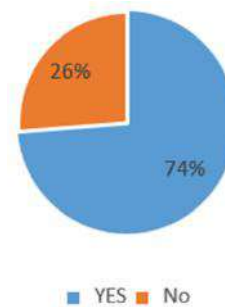


Fig. 5: Prejudice suffered for simply being known as a waste picker

Source: Elaborated from the interviews with the catadores

The interviewees affirmed that there is no cooperative. Some believe that individual work becomes more profitable; if they had a "cooperative, it wouldn't work because some can rely on each other's work" and prefer to go it alone. When asked how important the selective collection in a cooperative was, most answered that it would be "a delay of life".

The prospects of these collectors are minimal because they claim that at the dump "nothing ever changes", they always say that they are used to this situation. About the support offered by the public authorities or the community to the class of collectors, they say that they are forgotten, that there is a lack of support and that they have never received visits from doctors, health agents, and much less from Social Action.

It is worth noting that the process of urban occupation and the use of rudimentary techniques by agriculture have contributed to the degradation of natural resources. This is contributing to the reduction of the planting areas, resulting in a decrease in the productivity of the agricultural sector, which is one of the pillars of the region's economy, occupying a large part of the active labor force [14]; [15].

Baturité, through the municipal law No. 1.615/2013, which provides for the Multi-Year Plan - PPA of the municipality for the period 2014-2017, with strategic basis focused on the improvement and quality of life of the population, provided for 2017 the end of the open dump. And guided: Improve the conditions of infrastructure, urban planning, basic sanitation, essential services, providing residents with the appropriate habitability and displacements and urban development in a rational and balanced manner. The plan intended to promote the practice of environmental protection and preservation [16].

The municipal law nº 1.160/2001 - Environmental Policy of the Municipality of Baturité - propounds, for the exercise of its constitutional competence and in the terms of the Organic Law, that it will be responsible for the creation of means, instruments, and mechanisms that ensure effectiveness in the implementation and control of policies, programs, and projects related to the environment (Article 3º):

XI - To ensure the environmental sanitation in Baturité, in a broad way, covering the aspects of water supply, sanitary sewage, collection, treatment and final disposal of solid residues, drainage, sanitary education, incineration of hospital residues, among others; XIII - To ensure permanently the environmental education as an instrument of awareness, citizenship formation in all levels and age groups.

In this way, it proposes to guarantee to the citizens a better quality of life for the exercise of citizenship in general, establishing its principles, objectives, and instruments, emphasizing the responsibilities of the government. This law also deals with the management and destination of solid and semi-solid waste, which must follow a technical approach with differentiated collection and integrated treatment.

For this collection to be properly separated, an integrated waste transportation system is required. The public authority is responsible for a technical study, prepared by the competent municipal agency and approved by the Municipal Council of Environment and Urban Development (Article 43º, §3º). In this way, the municipality must seek appropriate technologies that are less costly to implement and operate; maintenance; in minimizing health risks; and to the wellbeing of the community and environmental quality.

On the other hand, the traffic of garbage collection vehicles should be avoided, especially the loads composed of by-products or hazardous materials through permanent preservation areas, as well as the transit of trucks through densely populated areas (Article 43º, § 4º). Regarding reuse, the pruning's, and remains of trees, whenever possible, will be transformed into charcoal for certain companies such as: bakeries, potteries, and ceramics (Article 43º, § 3º).

According to the referred law, the Executive Branch shall maintain a system of selective collection of garbage, with separation of waste at its origin, into two distinct classes - inorganic waste and organic waste - aiming at its recycling (Article 44º). Under these perspectives, the competent body will maintain the collection of dry residues and they will be independently transported for recycling purposes, and the wet residues will be collected and forwarded for final disposal.

Consequently, the municipality may be committing an infraction by omission with what is proposed in PERS in its articles 51 to 53, by not having a survey of possible contamination of the water table in the locations of its dumps [17].

Thus, the agencies responsible for enforcement, together with civil society, should act effectively to seek ways to manage the RSU's of Baturité, with responsibilities and efficiency suitable for environmental protection.

To comply with this legislation, the Baturité City Hall, aiming to encourage shared responsibility with the population, seeks a partnership with the Education and Sports Secretariat, understanding that formal education can



contribute to attitudes that aim to improve society's quality of life.

Consequently, he sanctioned a new law No. 1.221/2003, which provides for environmental education in schools of the Municipal Education Network. Thus, EE gains prominence in the school network, bringing a proposal to stimulate students to defend and preserve the environment for present and future generations, emphasizing the curriculum composition (Article 1°).

The Municipal Department of Education and Sports is responsible for the adequacy of programmatic content and interdisciplinarity of the school curriculum, in accordance with the law No. 9.795, 1999 (Article, 4°). Thus, the programmatic content relating to EE has an instructional and educational character, without, however, failing students (Article, 3°). This demonstrates a timid concern of the government with learning and deepening the concepts of Environmental Education, enabling sensitization of students to change their attitudes and behaviors habits and performance of sustainable actions in society. Moreover, the law does not present indications for a continuous or even punctual practice, such as the organization of environmental fairs and social projects in schools involving the community.

Among the strategic areas, the "Area-Program 5" - Regional Human Support Infrastructure, focusing on the intervention "Sanitary Sewage with the elaboration of the Massif Regional Plan of Sanitary Sewage/PRES MACIÇO and recovery and expansion of the sanitary sewage systems (networks and simplified systems) of the Massif" stands out as relevant because it deals with SR's. Still on the intervention of the regional development plan, it discusses the elaboration of the Regional Plan of RS's of the Massif/PRRS MACIÇO and implementation of the regionalized system of collection and destination of garbage in the Massif [18].

Starting from the intervention on the SR's of the PDR, the city of Baturité, would participate, with other municipalities in the region, in a public consortium based on the Federal Law No. 11.107/2005 for the creation of a regional landfill [19]. This consortium was formed in 2007, through AMSA aiming at the management and administration; associated public services, for the construction, maintenance, and management of the regional sanitary landfill, located at the headquarters of the municipality of Baturité.

#### IV. CONCLUSION

After the investigative process undertaken in this research including: the field visits, the contact with the

catadores/waste pickers, the informal relationship during the visits, and the analysis of the documents, it was possible to have a comprehensive view of the management situation of the USW in Baturité and of the situation of those subjects inserted in the dump.

It was also observed that the waste pickers are in a situation of social vulnerability. They live in a state of extreme need. They live in the most unhealthy and dangerous conditions possible. They live in the same place where they work, without any sanitary conditions. They live and coexist with garbage. Their "survival" is determined, solely and exclusively, by the materials that they collect from that environment and that can be recycled and sold; even if the "market value" is not at all adequate, as is their income. However, we can see that this is one way, if not the only way, found to deal with the capitalist and consumerist society. For this is how the waste pickers find a way to insert themselves into it, a way to establish themselves socially and in the labor market, even if in a cruel way.

The study also allowed us to conclude that, among the difficulties encountered by the collectors of the garbage dump, the lack of water and energy in that environment, and the lack of attention to health by the public authorities and the subjects themselves, due to the problems that arise from the presence of the garbage, with its various vectors, stand out.

Still on the financial aspect, besides leading them to a lack of income for an adequate support for the family, they face great difficulties for not having a fixed buyer, being at the mercy of a buyer who "dictates the rules of the market".

It is worth pointing out that the insecurity of living in a shed on their own site is not the only one of this situation. Much worse is not being able to leave for a long time, lest they be invaded by others.

It is obvious that the lack of organization of the subjects and the absence of the municipal public power in minimally organizing and valuing them, leads the collectors/residents to face several social and environmental problems for living together with the garbage, showing that men and women in full productive life, degrade themselves, together with the garbage they survive on.

It is also necessary to say that this proposal is only the "initial step" of a journey that, starting by getting it right, should be continued with more in-depth studies on the environmental issue involving both the municipality of Baturité and the other municipalities of the Maciço de Baturité Region, State of Ceará in Brazil.

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## Innovative cocktails: Physical-chemical profile during storage

## Coquetéis inovadores: Perfil físico-químico durante o armazenamento

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Received: 14 Jul 2022,

Received in revised form: 03 Aug 2022,

Accepted: 09 Aug 2022,

Available online: 31 Aug 2022

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**Keywords**— grain alcohol, physicochemical analysis, mixed alcoholic beverages, cachaça, shelf life.

**Palavras-chave**— álcool de cereais, análises físico-químicas, bebidas alcoólicas mistas, cachaça, vida de prateleira.

**Abstract**— For the improvement and inclusion of new food technologies in the market, several evaluations must be carried out carefully in a new product, from its formulation, physical-chemical and microbiological tests to acceptance by the final consumer. This study aimed to evaluate the formulation of bottled alcoholic beverages in relation to physical-chemical aspects and stability during storage at two temperatures, for a period of up to 150 days, analyzing the physical-chemical parameters. Mixed alcoholic beverages, caipirinha, margherita and dulce de leche flavors, were evaluated regarding mandatory parameters of identity and quality standards of the legislation, quantification of chemical elements (Mg, K, Mn, Fe, Cu, Pb, As, Cd and Sn). For the stability study, the Accelerated Shelf-Life Test (TAVP) was performed, the samples were stored at temperatures of 30 and 40 °C in a BOD-type oven, in the absence of light and evaluated at regular intervals of time in relation to the parameters physical-chemical properties and color, in order to verify if there was a significant difference between the standard sample (beginning of storage) in relation to each elapsed temperature and time. With the exception of the caipirinha, which did not reach the minimum limit of 1g/100 mL of lemon juice, but this parameter can be easily corrected. The drinks remained stable throughout the storage time, the physico-chemical parameters analyzed of the three samples did not show changes in behavior at temperatures of 30 and 40 °C, when compared to each other, despite having presented a significant difference by the Tukey test and the non-

*parametric Kruskal Wallis test at a significance level of 5%. It was noticeable in the visual analysis of color and the comparisons of color parameters (L, Chroma and HUE) that there was a color variation over the storage time, however, this did not influence the shelf life, which was estimated to be greater than 150 days. Thus, it can be concluded that the drinks were stable and commercially acceptable.*

**Resumo**— *Para o aprimoramento e inclusão de novas tecnologias de alimentos no mercado, diversas avaliações devem ser realizadas criteriosamente em um novo produto, desde sua formulação, testes físico-químicos e microbiológicos até a aceitação pelo consumidor final. Este trabalho teve como objetivo avaliar a formulação de bebidas alcoólicas engarrafadas em relação aos aspectos físico-químicos e estabilidade durante o armazenamento em duas temperaturas, por um período de até 150 dias, analisando os parâmetros físico-químicos. As bebidas alcoólicas mistas nos sabores caipirinha, margherita e doce de leite foram avaliadas quanto aos parâmetros obrigatórios de identidade e padrões de qualidade da legislação, quantificação de elementos químicos (Mg, K, Mn, Fe, Cu, Pb, As, Cd e Sn). Para o estudo de estabilidade, realizado o Accelerated Shelf-Life Test (TAVP), as amostras foram armazenadas nas temperaturas de 30 e 40 °C em estufa tipo BOD, na ausência de luz e avaliadas em intervalos regulares de tempo em relação aos parâmetros propriedades físico-químicas e cor, a fim de verificar se houve diferença significativa entre a amostra padrão (início do armazenamento) em relação a cada temperatura e tempo decorridos. Com exceção da caipirinha, que não atingiu o limite mínimo de 1g/100 mL de suco de limão, mas esse parâmetro pode ser facilmente corrigido. As bebidas permaneceram estáveis durante todo o tempo de armazenamento, os parâmetros físico-químicos analisados das três amostras não apresentaram alterações de comportamento nas temperaturas de 30 e 40 °C, quando comparadas entre si, apesar de terem apresentado diferença significativa pelo teste de Tukey e pelo teste não paramétrico de Kruskal Wallis ao nível de significância de 5%. Foi perceptível na análise visual de cor e nas comparações dos parâmetros de cor (L, Cromo e HUE) que houve uma variação ao longo do tempo de armazenamento, porém, isso não influenciou na vida útil, que foi estimada em superior a 150 dias. Assim, pode-se concluir que as bebidas foram estáveis e comercialmente aceitáveis.*

## I. INTRODUCTION

Alcoholic beverages have been manufactured for hundreds of years and feature in some passages in human history. Although they have been produced by hand for centuries, in Brazil, today they are obtained through industrial processes (Gonzaga & Moreira, 2008). Cachaça or sugar cane spirit, a genuinely Brazilian drink, the main ingredient of caipirinha, a famous Brazilian drink (FONSÊCA, 2020), is the second most consumed drink in the Brazilian market and the third most consumed distillate in the world. The national production of cachaça is 1.5 billion liters/year and has remained constant in recent years, it stands out as one of the most produced and consumed beverages in Brazil, with about 1.5 billion liters

per year. (VIANA, 2016). It is estimated that there are 40,000 cachaça producers in Brazil, generating 6,000 direct jobs, with an annual income of US\$2 billion (Nacanha, 2021), with more than 5,000 registered brands and about 30,000 producers across the country (MIRANDA, 2007).

According to Filho (2003), for a good quality alcoholic beverage, appropriate quality control procedures must be adopted from the beginning of the process, starting with the choice of raw material, passing through the processing, fermentation, distillation and careful storage of the final product. obtained. The identity and quality standards of an alcoholic beverage can be

evaluated considering the physical-chemical, microbiological and sensorial aspects.

Mixed alcoholic beverages or alcoholic cocktails or alcoholic cocktails are drinks existing in the national territory and supervised by the Ministry of Agriculture, Livestock and Supply (MAPA), through the provisions of Decree N° 35 (BRASIL, 2010a), RDC 05(BRASIL, 2013), RDC 45 (ANVISA, 2010), (RDC n° 2, de 15 de janeiro de 2007 and (IN 13, 2005).

According to current Brazilian legislation, a drink made up of fruit, pulp or plant extract is a drink obtained by mixing juices, pulps or plant extracts, together or separately, with a product of animal origin, with a predominance in its composition of a product of vegetable origin, with or without sugars (BRASIL, 2009).

The legislation allows a wide combination of its ingredients, varying between maximum and minimum concentrations, causing less or greater acceptance of consumers between drinks with the same denomination, however, from different producing industries. There are few formulations on the market; these drinks are usually made at home for immediate consumption, by people who enjoy it, at parties by bartenders or made by mixologists. Ready-to-eat commercialized formulations can optimize the entire production chain process in terms of reducing waste generated, preparation time, long lines (when produced by bartenders at parties), increased standardization, among other aspects.

For the development of food products, a series of quality assessments are necessary, including physical-chemical, sensory and microbiological analyses, which can intervene in the different stages of the product's life cycle (Giménez et al., 2012); (Schneider et al., 2018). Products can undergo changes during storage, such as microbiological deterioration, lipolytic oxidation reactions and nutrient degradation, causing the non-acceptance of the product by the consumer (Schneider et al., 2018).

In this context, the objective of the present work is to evaluate three formulations of mixed alcoholic beverages, which will be placed in the market by the company Asscorp Alimentos LTDA, regarding the physicochemical characteristics in relation to the identity and quality standards (IN N° 13, de 2005) (Decree No. 6,871 of June 4, 2009).

## II. MATERIALS AND METHODS

### 2.1 Materials

Three mixed alcoholic beverages were analyzed in this work: caipirinha, margherita and dulce de milk cocktail. The proposed formulation of margherita has as

ingredients demineralized water, cereal distillate, sugar, lemon juice, orange juice, antioxidant and stabilizer. The dulce de leche cocktail in its formulation has demineralized water, cereal distillate, skimmed milk jam, sugar, antioxidant and stabilizer. For the caipirinha, the base was used, which is cachaça, sugar, lemon juice, natural lemon aroma (essential oil), antioxidant and stabilizer. The samples were made at the company Asscorp Alimentos LTDA and kindly provided to carry out the project, Asscorp is located in the city of Salinas, Minas Gerais-Brazil), a partner company in the project.

## III. METHODOLOGIES

### 3.1 Study Design

In the first batch, 72 samples of the three beverages were manufactured and packaged in glass bottles with a volume of 750 mL, being 24 mixed alcoholic drinks of caipirinha, 24 of dulce de milk and 24 of margherita. These 72 samples were transferred to the physical-chemical analysis laboratory of the IFNMG-Campus Salinas and placed in an oven for storage at 30 or 40 °C, in the absence of light, until the physical-chemical analysis was carried out, where monthly, for 6 months until the final period of 150 days, 2 samples of each of the 3 flavors, at the two storage temperatures, were removed from the ovens intended for physical-chemical analysis.

Initially, the batch samples (time zero) of the three drinks were subjected to mandatory analyzes by the Ministry of Agriculture to verify that the drinks meet the identity and quality standards according to (Brasil, 2019). For the sample of caipirinha, the parameters of alcohol content, in %, in v/v, at 20 °C, lemon juice, expressed in %, with 5% acidity titratable in citric acid, in g/100 g, sugar in sucrose expressed in g/L, coefficient of congeners (expressed in mg/100mL of anhydrous alcohol), aldehydes, total esters, higher alcohols (expressed as the sum of n-propyl alcohol, isobutyl alcohol and isoamyl alcohol), and furfural (furfural + 5-hydroxymethylfurfural), analysis for organic contaminants: methyl alcohol (methanol) in mg/100 mL of anhydrous alcohol, ethyl carbamate, in µg/L, acrolein (2-propenal), in mg/100 mL of anhydrous alcohol, n-butyl alcohol (1-butanol), in mg/100 ml of anhydrous alcohol, sec-butyl alcohol (2-butanol), in mg/100 ml of anhydrous alcohol and inorganic contaminants: Cu, Pb, As, Cd, and Mr. Mixed alcoholic beverages in the flavors of margherita and dulce de leche were also submitted to mandatory parameters to verify compliance with current norms of: real alcohol content, in %, in v/v, at 20 °C, organic contaminants: methyl alcohol and inorganic contaminants: Cu and Pb. In addition to these parameters, the three

samples of the (standard) production batch were submitted to the parameters of total acidity, pH, total soluble solids (°Brix), total sugars, ascorbic acid, metal analysis: Mg, k, Mn, Fe.

For the evaluation of shelf life, every 30 days the samples stored at 30 and 40 °C up to a total period of 150 days were subjected to analysis of actual alcohol content, pH, total titratable acidity (TA), ascorbic acid, total sugars, total soluble solids (TSS), dry extract and instrumental color analysis.

### 3.2 Analysis for Mixed Drink (Cocktail) and Caipirinha

#### 3.2.1 Alcoholic Degree

The determination of alcohol content was done through the refractometric method, this method was adapted from (AOAC, 2005). Refractometry is a physical method, where the refractive index of a solution varies regularly with the concentration of the solute, thus, the amount of ethanol in the solution was estimated through its refractive index (AOAC, method 950.04). The method used to determine the alcohol content involved a previous step of sample distillation, which was used a digital wine distiller model SUPER DEE, followed by the determination of ethanol by refractometry, the device used to read the alcohol content of the samples was from the brand e-LABShop, model RHW-80 with measurement from 0 to 80% v/v, with automatic temperature compensation (ATC) between 10 and 30 °C and accuracy of 1% ±. The refractometer was calibrated using distilled water, verifying that there was 0% alcohol in the reading, after which the samples were read directly, placing 2 drops in the prism, closing immediately so that there was no loss of components.

#### 3.2.2 Total acidity

Total acidity is based on the neutralization reaction of acids with a standardized solution of alkali, up to the point of equivalence with the use of an indicator or potentiometer, up to pH = 8.2. For analysis, 25 mL of the sample was transferred to an Erlenmeyer flask containing 200 mL of distilled water, adding 2 to 3 drops of phenolphthalein. Then the sample was titrated with 0.1 N sodium hydroxide solution until pink. The total acidity result was expressed in grams of acetic acid per 100 mL of sample (g/100 mL). For caipirinha, the total acidity was expressed in grams of citric acid per 100 mL of sample (g/100 mL), (BRASIL, 2005b).

#### 3.2.3 Inorganic contaminants

Inorganic contaminants were analyzed by plasma source mass spectrometry (ICP-MS) according to the determinations of (Adapted from Lawrence et al., (2006),

the concentrations of the metals Mg, K, Mn, Fe, Cu, As, Cd, Sn and Pb, despite the fact that most of these contaminants are not part of the parameters of the legislation, there is a certain interest in their quantification, since the composition of beverages, especially cocktails, is very variable, allowing the characterization of different formulations. . With the aid of a plasma source mass spectrometer (ICP-MS), located at the Universidade Federal dos Vales do Jequitinhonha e Mucuri (UFVJM), the contaminants were analyzed under the following operating conditions: Nebulizer gas flows: 0.95 L/min; Auxiliary Gas Flow: 1.2 L/min; Plasma Gas flow: 15 L/min; Lens Voltage: 7.25V; ICP RF power: 1300 W; CeO/Ce = 0.011; Ba ++/Ba + = 0.016. To determine the concentrations of metals in the samples, the quantitative method was used, applying a multi-element calibration method containing: a standard at a concentration of 10 mg ml<sup>-1</sup> for the nine metals (Matrix: 5% HNO<sub>3</sub>, Perkin Elmer), a standard of 10 mg ml<sup>-1</sup> of Hg Matrix: 5% HNO<sub>3</sub>, Perkin Elmer) and a standard of 10 mg ml<sup>-1</sup> of rare metals (Matrix 5% HNO<sub>3</sub>. The metals analyzed were: Mg, k, Mn, Fe, Cu, As, Cd, Sn and Pb. The samples were prepared by diluting 250 µL by 40 times in 2% nitric acid (v/v), then taken for quantification.

#### 3.2.4 Inorganic contaminants

Inorganic contaminants were analyzed by plasma source mass spectrometry (ICP-MS) according to the determinations of (Adapted from LAWRENCE et al. 2006), the concentrations of the metals Mg, K, Mn, Fe, Cu, As, Cd, Sn and Pb, despite the fact that most of these contaminants are not part of the parameters of the legislation, there is a certain interest in their quantification, since the composition of beverages, especially cocktails, is very variable, allowing the characterization of different formulations.

With the aid of a plasma source mass spectrometer (ICP-MS), located at the Universidade Federal dos Vales do Jequitinhonha e Mucuri (UFVJM), the contaminants were analyzed under the following operating conditions: Nebulizer gas flows: 0.95 L/min; Auxiliary Gas Flow: 1.2 L/min; Plasma Gas flow: 15 L/min; Lens Voltage: 7.25V; ICP RF power: 1300 W; CeO/Ce = 0.011; Ba ++/Ba + = 0.016.

To determine the concentrations of metals in the samples, the quantitative method was used, applying a multi-element calibration method containing: a standard at a concentration of 10 mg ml<sup>-1</sup> for the nine metals (Matrix: 5% HNO<sub>3</sub>, Perkin Elmer), a standard of 10 mg ml<sup>-1</sup> of Hg Matrix: 5% HNO<sub>3</sub>, Perkin Elmer) and a standard of 10 mg ml<sup>-1</sup> of rare metals (Matrix 5% HNO<sub>3</sub>. The metals analyzed were: Mg, k, Mn, Fe, Cu, As, Cd, Sn and Pb. The

samples were prepared by diluting 250  $\mu\text{L}$  by 40 times in 2% nitric acid (v/v), then taken for quantification.

### 3.2.5 Methyl alcohol

The analysis of methanol in alcoholic beverages was performed using the spectrophotometric method, where methanol is oxidized by potassium permanganate to formaldehyde, which reacts with the chromotropic acid salt to give a spectrophotometrically measured purple color. The calculations were performed and expressed in mL of methyl alcohol per 100 mL of anhydrous alcohol, according to the formula (BRASIL, 1986).

### 3.2.6 pH

The pH was analyzed by the potentiometric method, according to (BRASIL, 2005b). A pH meter was used for the analysis, the temperature of which was between 20 and 25  $^{\circ}\text{C}$  and as close as possible to 20  $^{\circ}\text{C}$ . The electrode was immersed in the beaker containing the homogenized sample and the reading was performed at 20  $^{\circ}\text{C} \pm 2^{\circ}\text{C}$ . The result was expressed as a pH value with two decimal places.

### 3.2.7 Total soluble solids ( $^{\circ}\text{Brix}$ )

The analysis of total soluble solids was performed by refractometric reading of the degrees  $^{\circ}\text{Brix}$  of the sample at 20 $^{\circ}\text{C}$  (BRASIL, 2005b). To perform this analysis, we used an Abbe refractometer with a  $^{\circ}\text{Brix}$  degree scale with divisions of at least 0.2.

### 3.2.8 Total Sugars

For the analysis of total sugars, the titrimetric method (Eynon Lane method) was used. The non-reducing sugars were submitted to previous hydrolysis in an acid medium, dissociating the disaccharides into their monosaccharides, which react with the cupric ions of the Felling solution, reducing them to cuprous ions, under the action of heat in an alkaline medium. When reacting with cupric ions, the sugars undergo oxidation, while Cu(II) is reduced to Cu(I), forming a red precipitate of cuprous oxide, according to the methodology of (IAL, 2008).

### 3.2.9 Ascorbic acid

The determination of ascorbic acid was performed by the titrimetric method with potassium iodate. The method has its principle in the oxidation of ascorbic acid by titration with potassium iodate in a medium acidified with sulfuric acid in the presence of potassium iodide and starch solution, the analysis was determined according to the (IAL, 2008).

### 3.2.10 Color analysis

The color test was carried out in the physical-chemical analysis laboratory of the Federal Institute of Science and Technology of the North of Minas – Campus

Salinas. After the sensory test, the beverage samples were stored at a temperature around 5  $^{\circ}\text{C}$  in order to avoid changes in their color.

Color analysis was performed according to RAVINDRANATH et al., 2018, with some adaptations. A Samsung Galaxy A31 smartphone was used with a resolution of 2400x1080 pixel, 48-megapixel camera that allows a resolution of 8000x6000 pixels, in this device the colorimeter application (Lab tools version 1.6.6.4) was installed, available in the application store. for Android OS smartphones (PLAY STORE, 2022).

The values of  $L^*$ ,  $a^*e b^*$ ,  $C^*$  and  $h$  given by the smartphone were measured and the color space adopted for the interpretation of the results was the CIELAB. In the CIELAB color system,  $L^*$  represents luminosity, where values range from 0 (black) to 100 (white). Also,  $-a^*$  (green),  $a^*$  (red),  $-b^*$  (blue), and  $b^*$  (yellow) are the color coordinates. The parameters  $C^*$  and  $h$  are derived from the previously mentioned colorimetric coordinates, where  $C^*$  is the chromaticity or color saturation (“brightness”) and  $h$  indicates the color tone, whose measurement is given in degrees.

The center of the CIELAB color space is achromatic and the color saturation increases as the values move away from the origin (Rossini et al., 2012). From each sample, 4 replicates were collected, with 6 samples referring to each storage time for a period of 150 days divided into 5 times plus the standard sample. A light box was created to standardize the light intensity directed towards the sample at the time of data collection, this light falls on the four sides of the box generating about 2100 lux measured in a SMART SENSOR brand luxmeter model: AS803, the device has a measurement range 0-200,000 Lux, resolution of 1 lux, sampling rate of 1.5 times/s and measurement repeatability of about 2%. In order to avoid interference from the surface where the 15 cm diameter Petri dish was placed, a mirror was placed under the sample, with the intention of obtaining a color without external interference.

For the actual color analysis, the sample was homogenized and 40 mL was measured in each Petri dish, positioning it in the center of the rectangular box that has an area for the smartphone made for this purpose. The collection shots were performed at about 20 cm from the sample in all readings, after which the data were exported in an Excel spreadsheet to the computer to receive the treatments.

## 3.3 Reviews for Caipirinha

For the determination of congener coefficient parameters (expressed in mg/100ml of anhydrous alcohol), aldehydes, in acetaldehyde, in mg/100 ml of anhydrous

alcohol, total esters in ethyl acetate, ethyl lactate, higher alcohols (expressed by sum of n-propyl alcohol, isobutyl alcohol and isoamyl alcohol), (furfural + 5-hydroxymethylfurfural); acrolein (2-propenal), in mg/100 ml of anhydrous alcohol; n-butyl alcohol (1-butanol), in mg/100 ml of anhydrous alcohol; sec-butyl alcohol (2-butanol), in mg/100 ml of anhydrous alcohol and ethyl carbamate, in  $\mu\text{g/l}$ , parameters charged by Decree 6,871/2009, art. 68, § 5, IN MAPA 35/2010, arts. 8 and 17 to 21, IN MAPA 13/2005 and Resolution RDC 42/2013, the caipirinha pattern sample was sent to the Laboratory Amazile Biagioni Maia Ltda (LABM) in Belo Horizonte (MG), according to the description of the analytical methods of the analysis of the sample caipirinha ref. LABM 1569/2. The results of the analyses, Annex A, were sent by the company, carried out in duplicate and do not have standard deviation.

The coefficient of congeners (expressed in mg/100ml of anhydrous alcohol), aldehydes, total esters, ethyl lactate, higher alcohols (n-propyl alcohol, isobutyl alcohol and isoamyl alcohol), (furfural + 5-hydroxymethylfurfural); acrolein; n-butyl alcohol, sec-butyl alcohol were analyzed by gas chromatography with flame ionization detector (GC-FID). For the analysis, a GCROM Generation 8000 chromatograph equipped with a flame ionization detector (CG-FID) is used. The chromatography column used is DB-WAXETR from AGILENT. The oven temperature setting is 3 minutes at 35 °C (3.0 min), 35-80 °C (5.0 °C/min), 80 °C (3 min), 80-160 °C (6 .1°C/min). The inlet and detector temperatures are 140 °C and 180 °C, respectively. The injection volume is 2  $\mu\text{L}$  in split mode (1:1) and the carrier gas is nitrogen (6.0 mL/min).

Ethyl carbamate was quantified by gas chromatography coupled to a mass spectrometer. An AGILENT GC 4350A gas chromatograph was used, equipped with a 7036A mass detector and a G4513A automatic injector, operating in electronic impact mode at

70eV, with monitoring of the selective ion m/z 62. The HP- AGILENT's FFAP. The carrier gas helium at a flow of 1.5mL/min; Temperature programming starts at 90°C (2min) high (14 minutes - 10.7°C/min) up to 240°C (10 min). The inlet temperature is 230 °C and the detector temperature is also 230 °C. The injection volume was 2  $\mu\text{L}$  (direct injection of the sample distillate), the results are shown in Annex B.

#### IV. STATISTICAL ANALYSIS

Physicochemical analyzes were performed in triplicate. The results obtained were submitted to the Restudio statistical program and the Shapiro-Wilk normality tests were applied, the descriptive statistics in the Tukey test and the non-parametric data, the Kruskal Wallis test, both at a 5% significance level. The color analysis data were submitted to the Shapiro Wilk normality test, the ANOVA was performed by Kruskal Willis where the data were identified as non-parametric and the analysis of variance by the Tukey test, both at a 5% significance level in the program Minitab version 19.1, LLC All rights reserved.

#### V. RESULTS AND DISCUSSIONS

##### 1.1 Evaluation of the formulation of bottled beverages in relation to physical-chemical aspects

Physicochemical analyzes were carried out on the drinks after their manufacture, the caipirinha being called C-T0, the margherita M-T0 and the dulce de leche DL-T0, the results are organized in Tables 1, 2 and 3, respectively, as well as their comparisons with the official parameters and their maximum and minimum standards governed by the legislation of the Ministry of Agriculture, Livestock and Supply (BRASIL, 2009) through the provisions of Decree No. 6,871, of June 4.

Table 1: Official physical-chemical parameters versus laboratory analysis of the caipirinha sample

parameters	Standards		Result of analysis	detectable limit
	Minimum	Maximum		
Alcohol content in v/v, at 20°C	$\geq 15$	$\leq 36$	$17,9 \pm 0,05$	0,5
Titrate acidity in g/100 g	1	---	$0,51 \pm *$	---
Sugar, in sucrose, in g/L	$\geq 10$	$\leq 150$	136,44	---
Congener coefficient, mg/100 mL aa	200	650	229,6	---
sweeteners		Absent	ND	---
<b>organic contaminants</b>	<b>Minimum</b>	<b>Maximum</b>		
Methyl alcohol, in mL/100 mL of aa	---	20	$0,065 \pm 0,6$	---
Ethyl carbamate, in $\mu\text{g/L}$	---	210	< LQ	50
Acrolein (2-propenal), in mg/100 mL of anhydrous	---	5	< LQ	1,5
Sec-butyl alcohol (2-butanol), in mg/100 mL of	---	10	< LQ	1,7
n-Butyl alcohol (1-butanol), in mg/100 mL of	---	3	1,6	0,9



<b>inorganic contaminants</b>	<b>Minimum</b>	<b>Maximum</b>		
Copper, in mg/L	---	5	0,055 ± 0,2	---
Lead, in µg/L	---	200	1,70 ± 0,25	---
Arsenic, in µg/L	---	100	≤LD	---
Cadmium, in mg/kg	---	0,02	≤LD	---

Source: Adapted from(BRAZIL, 2009)

\*: values that do not meet the legislation; LQ: Limit of Quantification; ---: no maximum or minimum limits; ≤LD: less than or equal to the detectable limit; mg/100 mL ethanol: milligram per 100 milliliters of ethanol; % v/v at 20 °C: percentage volume by volume at 20 °C; µg/L: microgram per litre.

Table 2: Official physicochemical parameters versus laboratory analysis of the margherita sample

<b>parameters</b>	<b>Standards</b>		<b>Result of analysis</b>
	<b>Minimum</b>	<b>Maximum</b>	
Alcohol content, de a.a.	≥ 0,5	≤ 54	15,95 ± 0,05
sweeteners	Absent		ND
<b>contaminants</b>	<b>Minimum</b>	<b>Maximum</b>	
Methyl alcohol, mg/100 mL de a.a.	---	200	0,03 ± 0,008
Copper, in mg/L	---	5	0,0693±1,639
Lead, in mg/L	---	0,2	≤LD

Source: Adapted from(BRAZIL, 2009).

---: no maximum or minimum limits; ≤LD: less than or equal to the detectable limit; mg/100 mL ethanol: milligram per 100 milliliters of ethanol; % v/v at 20 °C: percentage volume by volume at 20 °C; ND: not determined; a.a: anhydrous alcohol.

Table 2: Official physicochemical parameters versus laboratory analysis of the dulce de milk sample.

<b>Parameters</b>	<b>Standards</b>		<b>Result of analysis</b>
	<b>Minimum</b>	<b>Maximum</b>	
Alcohol content, in %, in v/v, at 20 °C	≥ 0,5	≤ 54	15,00 ± 0,05
sweeteners	Absent		ND
<b>Contaminants</b>	<b>Minimum</b>	<b>Maximum</b>	
Methyl alcohol, in mg/100 mL of anhydrous alcohol	---	200	0,13 ± 0,001
Copper, in mg/L	---	5	0,0868±14,68
Lead, in mg/L	---	0,2	0,0021± ,270

Source: Adapted from(BRAZIL, 2009)

---: no maximum or minimum limits; mg/100 mL ethanol: milligram per 100 milliliters of ethanol; % v/v at 20 °C: percentage volume by volume at 20 °C; ND: not determined.

In the comparisons carried out (Table 1), it is shown that the caipirinha meets the quality identity parameters of the Ministry of Agriculture, Livestock and Food Supply, except for the acidity parameter titratable in citric acid, in which the legislation allows at least 1 g/ 100 mL of sample and 0.518 g/100 mL of sample was found. According to Normative Instruction No. 35 (BRASIL, 2010) beverages must meet the identity and quality

standards defined in current legislation, however, the legislator does not define in this Normative Instruction a punishment for non-compliance with this requirement. The drink will be adapted to identity and quality standards by adding a certain amount of lemon pulp to meet the minimum limit of citric acid in the titratable acidity.

As for the analysis of "sweeteners", despite being a mandatory parameter, both in caipirinha and in mixed

alcoholic beverages, it was not carried out, given that no type of sweetener is added in the formulation of the drinks, the result would certainly be absent. The samples of margherita and dulce de milk, Tables 2 and 3, respectively, freshly prepared, fit the quality identity standards in the Ministry of Agriculture, Livestock and Supply.

Table 3: Concentrations of chemical elements analyzed via ICP-MS in standard samples.

Chemical element		C-T0	M-T0	DL-T0
arsenic	mg/L	≤LD	0,0025 ± 0,0004	0,0058 ± 0,008
Cadmium	mg/L	≤LD	≤LD	≤LD
Lead	mg/L	0,0017 ± 0,003	≤LD	0,0021 ± 0,003
Copper	mg/L	0,0554 ± 0,0063	0,0694 ± 0,0016	0,0902 ± 0,014
Tin	mg/L	≤LD	≤LD	≤LD
Iron	mg/L	0,17 ± 0,030	0,25 ± 0,25	0,31 ± 0,044
Magnesium	mg/L	15,87 ± 1,51	18,59 ± 0,40	23,75 ± 3,42
Manganese	mg/L	0,10 ± 9,64	0,14 ± 7,36	0,29 ± 91,94
Potassium	mg/L	223,38 ± 21,42	327,90 ± 23,00	574,99 ± 0,159

≤LD: less than or equal to the detectable limit; mg/L of sample: milligram per liter of sample.

The results found for the contaminants Cu, Pb, Ar and Cd of the 3 alcoholic beverages are well below the minimum limits established by the Ministry of Agriculture, Livestock and Supply. Because the minimum concentrations found are considered as contaminants, there is no implication, on the contrary, their absence characterizes the quality of the beverage.

According to (Lima & Filho, 2011), the presence of some chemical compounds makes it difficult to prepare beverages, so some of these elements must be controlled, such as manganese (0.3 mg/L-1), lead (0.1 mg /L-1) and iron (0.1 mg/L-1). In the three formulations, a higher iron content was found than recommended by (Lima & Filho, 2011), which can cause precipitation of salts, reaction with dyes and aroma/flavor substances.

## 1.2 Color analysis

Instrumental color analysis is usually performed in colorimeter-type devices, however, smartphones are currently being used as an alternative tool for colorimetry,

Table 4 shows the content of a series of chemical elements in the three samples of alcoholic beverages. Only Cu, Pb, Ar and Cd have maximum and minimum limits required by current legislation. Although most of these chemical elements are not considered as contaminants by the current legislation, there was a need to know their contents based on the proposed formulation.

as described in the literature by several authors, such as: (Almeida, 2021; Cerutti; et al., 2018; Cunha, 2019; Lucas et al., 2021; Ravindranath et al., 2018). This technology was used in this work in order to analyze the variation of color parameters between the storage times of the samples at the two temperatures evaluated. The color parameters L, Chroma and HUE were analyzed to elucidate the reactions that occurred in samples of caipirinha margherita and dulce de milk stored at 30 and 40 °C for a period of time from zero to 150 days.

Figure 1 represents the way of reading the dispositions in the CIELAB color system, where L\* represents the luminosity, its values vary from 0 (black) to 100 (white), -a\* (green), a\* (red), -b\* (blue) and b\* (yellow) these last two are the color coordinates. The parameters C\* and h are derived from the previously mentioned colorimetric coordinates, C\* is the chromaticity or saturation of the color (“brightness”) and h (HUE) indicates the tone of the color, whose measurement is given in degrees, (ROSSINI et al., 2012).

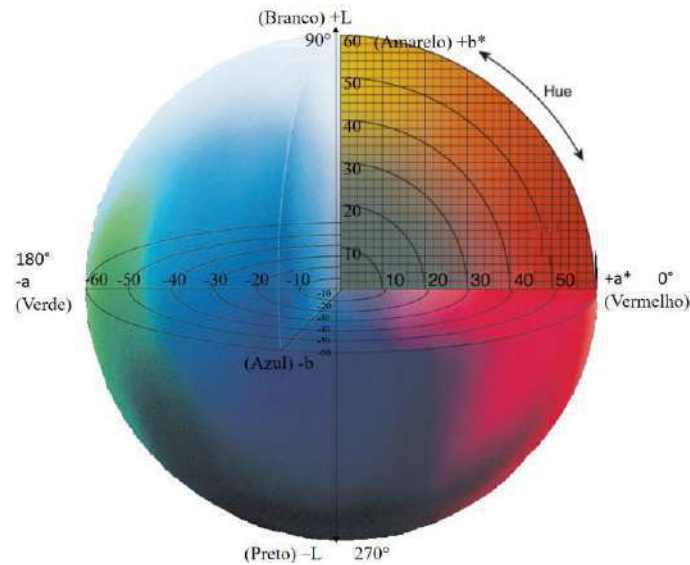


Fig.1: Representation of the CIE L\*, a\*, b\*, chroma and HUE color space.

Source: Adapted from (Minolta, 1990)

Tables 4 and 5 show the comparison of means and standard deviation of the results of the color analysis for caipirinha, margherita and dulce de leche stored at 30 °C and 40 °C, respectively.

Table 4. Means, standard deviation and comparison of means by the Tukey/Kruskal Willes test at the 5% significance level of samples of caipirinha, margherita and dulce de milk stored at 30 °C.

Time	CAIPIRINHA			MARGHERITA			DULCE DE LEITE			
	L	CROMA	HUE	L	CROMA	HUE	L	CROMA	HUE	
averages Standard deviation	T0	<b>60,13<sup>a</sup> ± 0,54</b>	16,04 <sup>c</sup> ±	149,40 <sup>b</sup> ±0,5	<b>52,95<sup>e</sup> ± 0,25</b>	26,99 <sup>c</sup> ± 0,55	103,47 <sup>a</sup> ±	<b>44,20<sup>c</sup>±0,61</b>	34,54	42,55 <sup>a</sup> ± 0,90
	T1	<b>60,63<sup>a</sup> ± 0,96</b>	15,52 <sup>c</sup> ±	153,55 <sup>a</sup> ± 2,0	<b>60,57<sup>a</sup>±1,86</b>	27,32 <sup>c</sup> ± 0,17	62,40 <sup>c</sup> ± 0,00	<b>55,40<sup>a</sup>±0,95</b>	40,20 <sup>c</sup>	37,15 <sup>b</sup> ± 0,38
	T2	<b>58,98<sup>b</sup> ± 0,38</b>	19,05 <sup>b</sup> ±	138,47 <sup>c</sup>	<b>59,00<sup>b</sup> ± 0,5</b>	27,68 <sup>c</sup> ± 0,3	63,60 <sup>c</sup> ± 1,39	<b>53,88<sup>b</sup> ± 0,6</b>	44,26 <sup>b</sup>	36,42 <sup>b</sup> ± 1,21
	T3	<b>59,40<sup>ab</sup>±0,41</b>	18,24 <sup>b</sup> ±	141,00 <sup>c</sup> ±1,8	<b>62,80<sup>a</sup> ± 0,36</b>	32,36 <sup>a</sup> ± 1,32	93,50 <sup>b</sup> ± 1,01	<b>55,89<sup>a</sup> ± 0,6</b>	46,54	36,80 <sup>b</sup> ± 0,71
	T4	<b>59,75<sup>ab</sup>±1,97</b>	21,40 <sup>a</sup> ±	122,40 <sup>d</sup>	<b>56,20<sup>d</sup> ± 0,1</b>	30,01 <sup>b</sup> ± 0,60	63,37 <sup>c</sup> ± 0,06	<b>55,93<sup>a</sup> ± 0,0</b>	37,34 <sup>d</sup>	43,73 <sup>a</sup> ± 0,68
	T5	<b>59,05<sup>b</sup> ± 0,68</b>	21,45 <sup>a</sup> ±	120,00 <sup>d</sup>	<b>58,33<sup>c</sup> ± 0,39</b>	30,67 <sup>b</sup> ± 0,65	61,92 <sup>c</sup> ± 1,65	<b>55,93<sup>a</sup> ± 0,0</b>	37,94 <sup>d</sup>	35,90 <sup>b</sup> ± 0,00

Means that do not share the same letter per column are statistically different at the 5% significance level; data in bold indicate nonparametric distribution and were performed in Kruskal Willis.

Table 5. Means, standard deviation and comparison of means by the Tukey/Kruskal Willis test at the 5% significance level of samples of caipirinha, margherita and dulce de leche stored at 40 °C.

Time	CAIPIRINHA			MARGHERITA			DULCE DE LEITE											
	L	CROMA	HUE	L	CROMA	HUE	L	CROMA	HUE									
Standard deviation	60,1	<b>b</b> ± 0,538	16,4	<b>c</b> ± 0,82	149	<b>a</b> ±	53,0	<b>d</b> ± 0,2	27,0	<b>f</b> ± 0,54	103	<b>a</b> ±	44,2	<b>a</b> ± 0,61	34,5	<b>d</b> ± 0,63	42,5	<b>a</b> ± 0,90
	65,1	<b>a</b> ± 0,465	16,7	<b>c</b> ± 0,59	140	<b>b</b> ±	56,0	<b>c</b>	32,0	<b>e</b> ± 0,37	59,7	<b>b</b> ± 1,1	37,6	<b>c</b> ± 2,22	39,6	<b>bc</b> ±	33,4	<b>c</b> ± 0,85
	64,3	<b>a</b> ± 0,545	24,7	<b>b</b> ± 0,63	102	<b>c</b>	58,5	<b>b</b> ± 0,8	35,0	<b>d</b> ± 0,55	60,0	<b>b</b> ± 0,0	41,2	<b>bc</b> ± 0,18	41,4	<b>ab</b> ±	33,4	<b>c</b> ± 0,58
	59,1	<b>c</b> ± 0,189	31,4	<b>a</b> ± 0,26	59,0	<b>e</b>	56,4	<b>c</b>	43,4	<b>a</b> ± 0,95	56,1	<b>c</b>	41,2	<b>bc</b> ± 0,77	42,1	<b>a</b> ± 0,52	31,7	<b>c</b> ± 0,73
	55,9	<b>d</b> ± 0,189	25,2	<b>b</b> ± 0,82	61,7	<b>d</b>	59,8	<b>a</b> ± 0,4	37,6	<b>c</b> ± 0,75	58,9	<b>b</b> ± 1,2	35,5	<b>c</b> ± 5,59	37,3	<b>c</b> ± 3,14	35,5	<b>b</b> ± 1,46
	60,8	<b>b</b> ± 0,271	24,0	<b>b</b> ± 0,70	63,5	<b>d</b>	61,3	<b>a</b> ± 2,5	41,6	<b>b</b> ± 0,18	58,3	<b>bc</b>	42,8	<b>ab</b> ± 0,37	31,5	<b>d</b> ± 0,11	41,6	<b>a</b> ± 0,30

Means that do not share a letter per column are statistically different at the 5% significance level; data in bold indicate nonparametric distribution and were performed at Kruskal Willis

Through the values described in Tables 4 and 5, the luminosity parameter (L) of the caipirinha samples showed a significant difference over the storage time, in the same way the chroma and the HUE showed changes in color at the level of 5 % of significance. (Harder et al., 2007) state that the chroma values can be interpreted as the ratio of the parameters a\* and b\*, that is, the real color of the samples, its reading is performed from the center (zero) to the ends; consequently, the caipirinha samples showed a significant change in color, becoming more saturated. The value of the HUE angle of the caipirinha reduced significantly over time, following the green hue, with the passage of time it became more yellow.

The margherite samples stored at 30 °C showed an oscillatory luminosity behavior, possibly caused by reactions that were still in progress, but it can be observed, in general, that this parameter increased significantly over time, in most of the analyzed times, as seen in Table 5. These oscillations were also noticed in the chroma and HUE of the same sample, these results being significant in the color variation of the samples. Martins (2009) found a similar oscillation behavior, however in the total color difference. The chroma increased significantly at the 5% level of significance, indicating an increase in the saturation of the sample, and the Hue angle also reduced significantly, at first the sample was yellowish, becoming orange over time.

The color changes suffered by the dulce de leche samples shown in Table 4, express well the results obtained in the analysis of comparison of color averages, where the luminosity showed a significant change in T0 in relation to the other 5 storage times at 30 °C and chroma showed significant increases, no similarity was seen in any of the dulce de leche samples stored at 30 °C, the HUE value underwent significant reductions by Tukey's test at 5% of significance.

Storage time and temperature act directly on the darkening of the analyzed samples, this is noticed when Tables 4 and 5 are compared. For caipirinha, the L values, despite fluctuating, were similar at the beginning and end of storage. Chroma increased and HUE values decreased, at the 5% significance level, indicating saturation and color change (from greenish to orange) during storage. The behavior of margherita samples stored at 40 °C was similar to that of caipirinha samples at 30 °C, with regard to chroma and HUE parameters. Brightness and saturation increased, while the hue went from yellowish to orange.

The behavior of margherita samples stored at 40 °C was similar to that of caipirinha samples at 30 °C, with regard to chroma and HUE parameters. Brightness and

saturation increased, while the hue went from yellowish to orange.

The dulce de leche samples stored at 40 °C (Table 5) were presented in an unusual way, the results obtained variations at the level of 5% significantly over the storage time in the 3 parameters of the color space analyzed L, chroma and HUE. However, in general, it can be seen that the samples, close to 150 days of storage, had a tendency to initial color.

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## Challenges of agricultural entities in financial reporting: Case of Albania

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Received: 25 Jul 2022,

Received in revised form: 15 Aug 2022,

Accepted: 22 Aug 2022,

Available online: 31 Aug 2022

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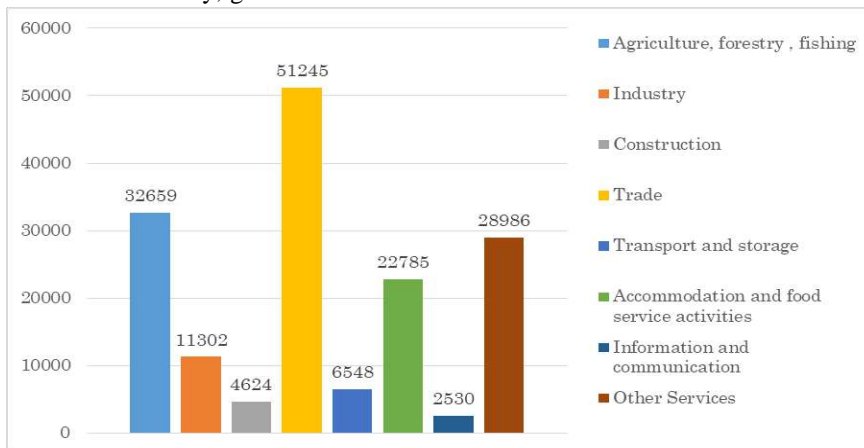
**Keywords—** *financial reporting, biological  
assets, accounting challenges, fair value,  
decision enhancing information*

**Abstract—** *Agriculture sector remains an engine of Albania's economic growth, statistical data indicates that agriculture accounts for as much as 20% of GDP or in employment about 50% of the active power. According to data published from INSTAT in 2016 the number of registered economic units was 321,358, where 10% were engaged in the agricultural sector or about 1,287 entities operating as natural person or legal person and 31,372 farmers who have an agricultural activity. For the purpose of financial reporting, all entities registered in tax authorities, should use the improved accounting standard number 13 for the recognition and evaluation of biological assets. The implementation of this standard is important by making comparable accounting information on biological assets offered by these companies which exercise economic activity in the field of biological assets. But when we consider accounting procedure problems, it is noticed that exits a small amount of information about the rules, techniques, and list of accounts that guide us to a correct and believable view. We have come to the conclusion that besides the other arguments this phenomena occurs because, agricultural accounting has not been developed as a course in any faculty in our country meanwhile the Faculty of Economics and Agribusiness has added to its curriculum during the last three years. For this reason, we have undertaken in this paper the challenge to find out which are the crucial problems faced by Albanian entities during financial reporting and some of the solutions that will help these units to provide the appropriate information for tax intention and for owners to take the right decisions so they can have a sustainable business. To come to the right conclusions we will conduct a review on the literature on the evolution of accounting in agriculture in Albania as well as in the world. Likewise, preliminary data will be provided through interviews with the makers of financial reports, which will be analyzed descriptively.*

**I. INTRODUCTION**

In our country, agriculture is considered as a very important sector of the economy, has employed 47.8% of the population and works only 24.31% of the agricultural land. However, it is noted that the growth rates of this sector are lower than those of the economic growth declared by the government. That is why, given the recent

developments in the context of European integration challenges, agriculture is seen as an ever-increasing priority aimed at the production and marketing of healthy products. Small and medium-sized entities in the agricultural sector play an important role in reducing poverty and economic development in the country.

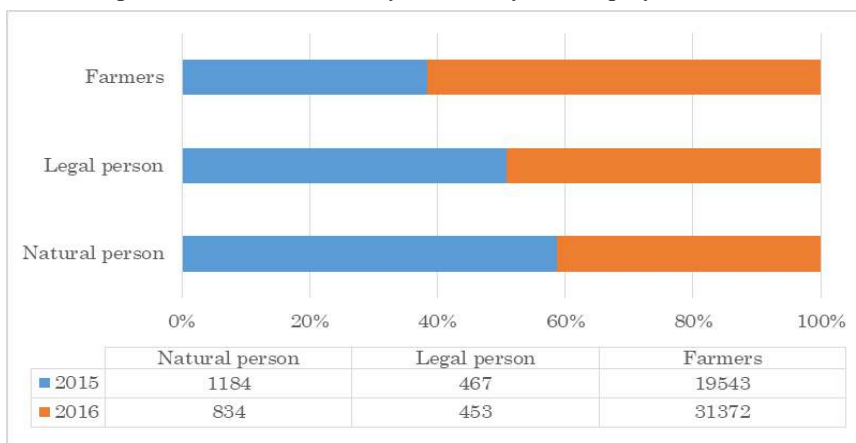


Graph 1. Active enterprises by economic activity

Source: Business Register INSTAT 2016.

Enterprises with 50 and more employed to producers of goods which are parts "Agriculture, forestry and fishing, Industry, Construction", are concentrated in manufactured activities. Enterprises with main activity "Trade" and "Accommodation and food service activities" dominate with 46.1% of total active enterprises. Albanian economy

is focused mainly in trade activity as well as for new registrations. Enterprises registered during 2016 in trade activity are 21.6 % out of 35.3% during 2015. Approximately 91.0 % of enterprises are enterprises from one to four employed. The major part of them 74.8 % has only one employee out of 61.8 % in 2015.



Graph 2. The structure of agricultural units during 2015 and 2016

Source: INSTAT 2016.

According to the data published by INSTAT, for 2015, NIPT has 19,543 farmers or 38% while in 2016 the number of registrations has increased to 31,372 farmers or 62%. For 2015, the number of agricultural units registered as a natural person is 1184 or 59% whereas for 2016 we

see a decrease in registrations going to 834 units or 41%. In 2015 and 2016 the number of entities with agricultural activity registered as a legal entity is respectively 467 units and 453 units. If in 2016 there are registered about 321,358 units of which 10% deal with agricultural activity or about

1,287 entities operating as a natural or legal person and 31,372 farmers who have an agricultural activity.

As in any other branch of the economy, the agricultural sector regularly reports its activity. In recent years, changes in the reporting field have affected the sector as well. The internal and external developments highlighted adaptation and harmonization, to gradually transition to the implementation of international accounting and financial reporting standards. The difficulties and costs to implement their full version made local standards to be drawn up and entities would report in a differentiated manner according to the definitions made in Law no. 9228, dated 29.04.2004 "On Accounting and Financial Statements", as amended by Law no. 9477, dated 09.02.2006, as well as in DCM no.742, dated 07.11.2007 "Criteria for the selection of entities that have to apply international accounting standards".

After its creation in 2004, the National Accounting Council drafted and published the National Accounting Standards, among which was KAS 13 for biological assets. This Standard was designed to be IAS 41-oriented. With the good intention of alleviating the burden of financial reporting and lowering the cost of accounting, it was determined that biological assets are measured only on a cost model basis. In July 2014, the MRS itself also changes, with effective effective January 1, 2015. Improved KAS 13 for the portion of biological assets allows their valuation with the fair value model, but without excluding the discounting method of fluctuations. For the purpose of financial reporting, all entities registered with the tax authorities should use the recognized accounting standard for the recognition and assessment of biological assets 13. The implementation of this standard is important by making comparable accounting information on biological assets provided by these companies that exercise economic activity in the field of biological assets. The main purpose of this paper is to highlight the problems encountered in the accounting practice of biological assets records in Albania.

## II. LITERATURE REVIEW

*"Price is what you pay, value is what you get." – Warren Buffett*

One of the most challenging aspects relating to accounting for biological assets can arguably be the measurement thereof. IFRS for SMEs, Section 34 "Specialised Activities", paragraph 34.4, specifies the measurement of biological assets as follows:

*"An entity shall measure a biological asset on initial recognition and at each reporting date at its fair value less*

*cost to sell. Changes in fair value less costs to sell shall be recognised in profit or loss." (In limited circumstances, an entity would be allowed to depart from the requirement above, but this article will be limited to the discussion of the application of the fair value model.)*

IFRS 13 was developed as a guide on the determination of fair values for the components of the financial statements (IASB,2013)

*"Fair value is defined in IFRS 13 as the price that market participants on the measurement date would be paid to transfer a liability, or be received to sell an asset" (IASB, 2013).*

Fair value measurement should take into account the highest and best use of an asset regardless of the actual use thereof (IASB,2013). To determine the highest and best use, market information is needed as the value of the asset should be maximised, even if the intention of the organisation is not to sell it in a market.

### Definition and Objectives of Agricultural Accounting

Agricultural accounting can be explained as a specialty accounting which primarily records financial and monetary transactions throughout agricultural activities, classifies financial transaction in respect of types, estimates production costs incurred during the cultivation of agricultural goods and then reports those financial according to their purposes. The objectives of agricultural accounting can be listed as follows (Doğan, 1975; Aras,1988; Beneke, 1966; Talim, 1973).

- Estimation of actual costs pertaining to agricultural goods,
- Determination of sale prices of goods obtained from agricultural activities,
- Fair and well-balanced allocation of dividends among enterprise partners following profit-loss estimation,
- Assistance to farmers and enterprises in estimation of tax base,
- Monitoring intertemporal financial and physical aspects of agricultural enterprises,
- Monitoring the movements in quantity and value pertaining to agricultural goods,
- Performance of cost analysis, followed by rational precautionary measures,
- Assistance to agricultural enterprises in budget planning for the future,
- Assistance in education, training and research services, ect...



### Accounting in Agriculture: valuation models for biological assets

IAS 41, the first-ever international financial reporting standard on agricultural activity, represents the most comprehensive and far-reaching departure from historical cost accounting to date, provoking a broad range of theoretical and practical problems that might hamper its widespread adoption (Elad, 2004). Although historical cost is the most common valuation basis for biological assets, a variety of proxies for fair value are used, such as net present value, independent/external valuation, net realisable value, and market price, both within and across countries. As such, IAS 41 has failed to enhance the international comparability of accounting practices in the agricultural sector (Elad and Herbohn, 2011).

*“Agriculture is not an appropriate type of business for introducing earlier recognition of profit, before it is recognized through sale of the product, in place of the present, more prudent, historical cost approach”.* (Institute of Chartered Accountants in England and Wales in IASC, 1998)

On one side, previous literature concerning the cultural and institutional impacts of the IAS 41 in accounting harmonization in agriculture (Elad and Herbohn, 2011) has revealed that Anglo-Saxon countries have a straight relationship with this standard and are receptive to fair value measurement. The information asymmetry, contractual efficiency and managerial opportunism are factors that also explain the adoption of fair value (Quagli and Avalone, 2010). Another international study concerning IAS 41 is developed by Elad (2004), which has provided a worldwide comparison between Europe, Africa and Australia. He has concluded that fair value is more suitable than historical cost to those biological assets that have an active market, and more comprehensible to the users of the information.

### III. METHODOLOGY

This study is designed and implemented in order to bring data and facts about how agricultural entities make financial statements and realize the recognition and valuation of biological assets.

The questionnaire consists of six sections, each with a different objective. The first section of the questionnaire aims to categorise the farm of the respondent concerned, while the second section seeks to establish the purpose for which financial statements are prepared. The main objective of the third section is to present a situation in which an active market exists and whether the farmers have confidence in market established prices. The fourth

section treats the most popular basis of the valuation of biological assets and the way in which the valuation method may be influenced by the market factors. The fifth section purpose is to determine the challenges or limitations of the fair value determination while the sixth section establishes the significance of each challenge and, thus, forms the basis of the conclusions and recommendations. To achieve the goal of this paper, besides the primary data provided by the questionnaire prepared for the specialists of the main statements, are used secondary data taken from INSTAT as well as the publications of Albanian and foreign authors who have dealt with the problems of accounting procedure in agriculture.

Data analysis method

#### Mean

The arithmetic mean, more commonly known as “the average,” is the sum of a list of numbers divided by the number of items on the list. The mean is useful in determining the overall trend of a data set or providing a rapid snapshot of your data. Another advantage of the mean is that it’s very easy and quick to calculate.

#### Standard Deviation

The standard deviation, often represented with the Greek letter sigma, is the measure of a spread of data around the mean. A high standard deviation signifies that data is spread more widely from the mean, where a low standard deviation signals that more data align with the mean.

#### Pie Charts

A pie chart (or a circle chart) is a circular statistical graphic which is divided into slices to illustrate numerical proportion. (Wikipedia, Pie chart) Pie charts are generally considered to be the most illustrative method of presenting categorical data and it is for this reason that the researcher adopted this method for the purpose of this research.

Data collection and analysis

During this study, we have collected a considerable number of findings and data, which allowed us a limited empirical analysis according to the aims of this study, the number of interviewees is 20. All survey data was collected through face-to-face interviews with accounting experts and professionals related to the field of agriculture. The preparatory groundwork for the identification of the persons to be interviewed was completed by the authors of this article. The preparation of this study went through several phases: the preparatory phase, the field research, the data entry, the data interpretation and analyses, and finally the written report. The main and the most alarming finding of this survey is related to the non-compliance of accounting standards with the method which agricultural

entities perform their activity. Secondly, this study has come to a conclusion : the majority of those who were interviewed point out that most of the units with an agricultural activity do not use bookkeeping.

**Section 1 : Farm profile**

Section 1 of the questionnaire focused on the profile of the farming activities. The objective of the section was to highlight the fact that farming activities are heterogeneous and may even be influenced by farming methods.

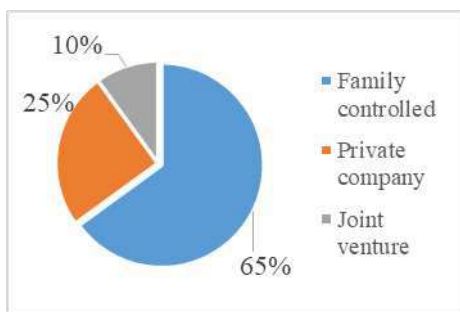


Fig.3 Organisation of farming activities

As per the analysis in figure 3, 65% of the respondents think that most of farmers in Albania are family controlled with 25% only being private company and 10% joint venture .

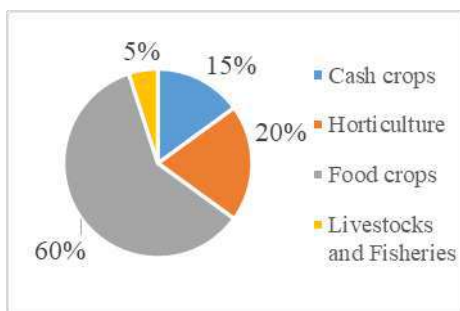


Fig.4 Nature of farming activities

As indicated in figure 4, the accounting experts agree that food crops sub-sector is important with 60% , 20% of the respondents for the horticultural sub-sector, 15% of the respondents for the cash crops sub-sector and only 5% of interviewed for livestock and fisheries.

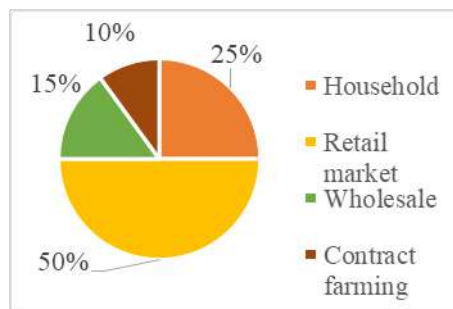


Fig.4 Target market

Question 3 aimed at establishing the target market which, to a large extent, influences fair value determination. As indicated in figure 4, 50% of respondents think that agricultural units are targeting retail market sales, 25% household consumption, 15% wholesale and 10% use contract farming. One of the problems in agricultural sector is not insurance of farms to insurance institutions, this makes the risk to be present even taking into account climate change.This, in turn, may, to a great extent, influence the valuation of biological assets.

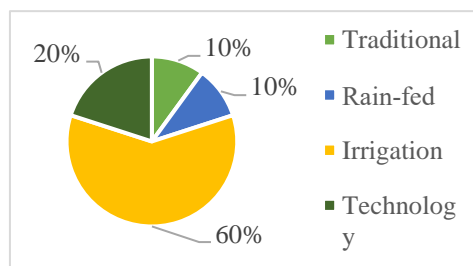


Fig.5 Farming methods

Figure 5 indicates that 10% of the respondents support natural climatic conditions and 27% thinks that irrigation is a good method. To improve productivity in agriculture many farmers have adopted biotechnology and others continued to use traditional method.

**Section 2 : Objectives in preparing financial statements**

The financial statements represent the single most important tool in respect of management’s sharing of information with the various stakeholders of an entity. Question 1 aimed at establishing which components of the financial statements those drafting the financial statements accord the most significance. The respondents were required to rank from 1 (the most important) to 4 (the least important) and 5 for not sure. In order to analyse the findings it was necessary to code the components of financial statements and then to compute the statistical values using the Microsoft Excel 2013.

The results of the statistical analysis are presented in table 6 below with the coding having been done as follows:

- STCOMINC – Statement of comprehensive income;
- STFINPOS – Statement of financial position;
- STECAFLW – Statement of cash flows;
- STECEEQT – Statement of changes in equity; and
- NOTEXPLA – Notes and explanations to the financial statements

Table 6 Importance of the components of financial statements

	N	Min	Max	Mean	Std.Deviation
STCOMINC	20	1	2	1.45	.510
STFINPOS	20	1	4	2.15	1.268
STECAFLW	20	2	5	3.45	1.191
STECEEQT	20	1	5	3.45	.945
NOTEXPLA	20	3	5	4.4	.821

Source: Author(s) calculation.

The statistical analysis of the responses, which is presented in table 6, indicates that most of the respondents were in agreement that the statement of comprehensive income was the most significant for farmers with a highest mean score of 1.45 and a standard deviation of 0.510. Ranked second in importance was the statement of financial position with a mean score of 2.15, with the the statement of changes in equity in third position of importance with a mean score of 3.45. The statement of cash flows was considered as the least important while the respondents were unanimous in not being sure about the use of notes and explanations.

Question 2 aimed at establishing the main reasons why farmers prepare financial statements.

The statistical analysis of the responses indicated the result summarised in table 7 below where the coding was done as follows:

- LOANREQU – Loan requirements;
- SHAREHOL – Shareholders;

- TAXCOMPL – Tax compliance;
- DECISINF – Decision making information; and
- COMPSTAN – Compliance with accounting standards.

Table 7 Reasons for preparing financial statements

	N	Min	Max	Mean	Std.Deviation
LOANREQU	20	1	5	2.7	1.559
SHAREHOL	20	1	5	2.65	1.089
TAXCOMPL	20	1	4	2.5	1.235
DECISINF	20	1	4	3.1	1.334
COMPSTAN	20	2	5	3.85	1.309

Source: Author(s) calculation.

The statistical analysis of the responses, as summarised in table 7, indicates that the majority of farmers prepare financial statements for tax compliance with a mean score of 2.5 and a standard deviation of 1.235. This date support the theoretical assertion that SMEs prepare financial statements for compliance purposes. Second by importance are shareholders with a mean score of 1.33 and a standard deviation of 0.832 and thirdly, the loan requirement with a mean score of 2.7 and a standard deviation of 1.559. The interviewers identified compliance with accounting standards and information for decision making as the least important, in this order. The third question sought to establish the most common basis of preparing financial statements. According to collected data, 70% of the respondents think that farmers prefer to prepare financial statements on a cash basis while 30% prefer on an accrual basis of accounting.

**Section 3 : Access to market**

In the valuation of biological assets, market determined prices are accorded the highest priority. Accordingly, it was considered necessary to evaluate the form in which farmers access the market. This section is focused on the farmers’ knowledge of the existence and functioning of an active market.

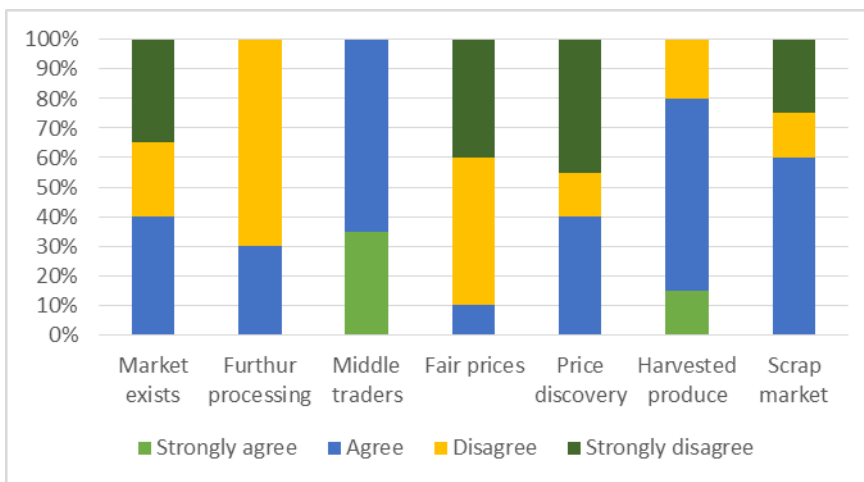


Fig.7 Summary of market accessibility

The results of the evaluation of market accessibility are summarised in figure 7. These results indicate that it may generally be argued that most farmers do not have access to market information. This is also a very clear indication that farmers do not play a role in the pricing of their produce in the market place. This, in turn, to a great extent,

reduces the number of market players and erodes the reliability of market determined prices.

**Section 4 : Valuation of biological assets**

The main objective of this section was to establish a common basis for the valuation of biological assets.

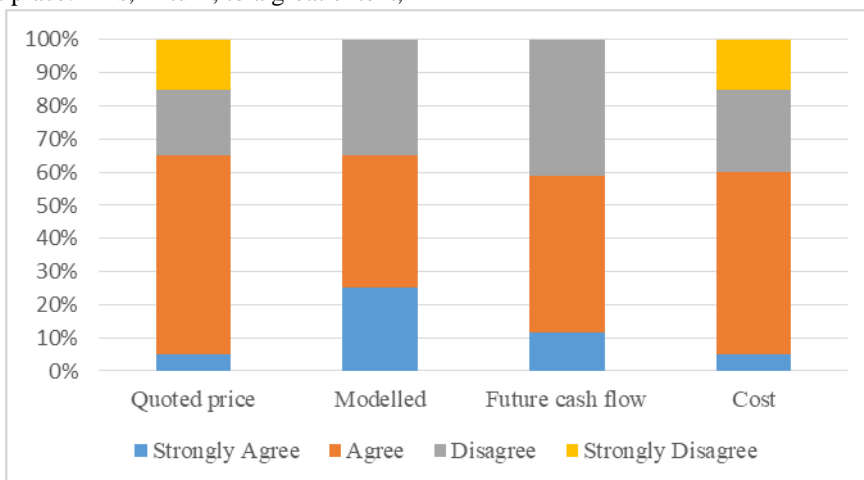


Fig.8 Summary of challenges of valuation of biological assets

As highlighted before quoted price is considered to be the most reliable basis for fair value determination. Evaluation of biological assets is one of the most important steps in the agricultural sector. The farmer make the evaluation using some accounting methods but in Albania are usually used the cost model and the fair value . To get some extra details in this section, we have addressed four questions for the specialists, from the answers received to the first question (referring to the quoted price in an active market), 60% agree and the rest disagree because we do not have stock market in Albania where this price can be determined.It should be noted that there are contemporary farms that their shares are quoted on the stock exchanges

of neighboring countries. Regarding other questions, the main problem faced by domestic farmers is the non-compliance of the national accounting standard 13 with the way these farms perform their activity. Farmers not are clear for the application of standart therefore use the cost model for the valuation of biological asset.

**Section 5 :Challenges in fair value estimations**

The aim of this section was to establish the challenges in respect of fair value estimation. The results of section 5 are summarised in figure 8. The use of a fair value model by agricultural activity entities remains an issue that needs to be treated by specialists and not just

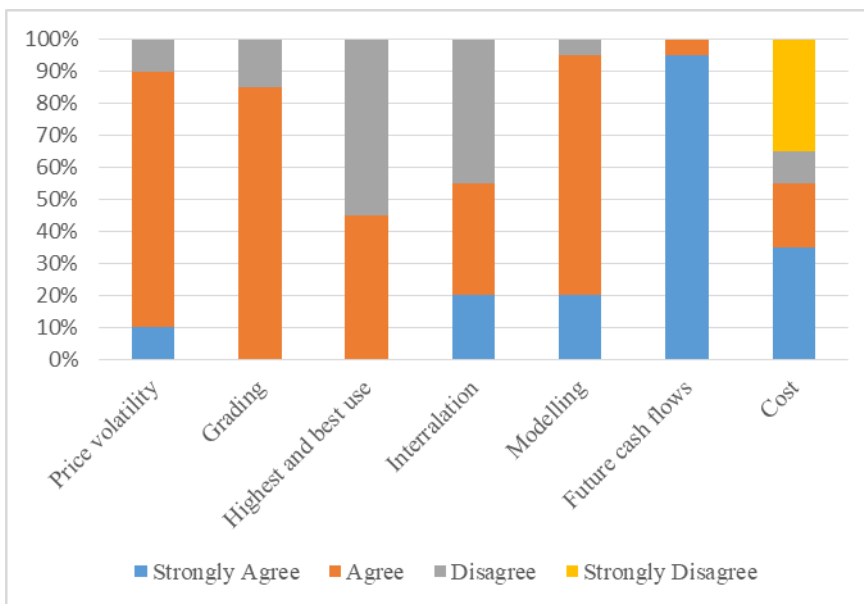


Fig.9 Summary of challenges of valuation of biological assets

According to figure 9, price volatility, highest and best use factors and future cash flows are considered to be most significant challenges in respect of the valuation of biological assets.

**Section 6: Ranking of the challenges**

The aim of this section was to establish the order in which respondents would rank the different factors in terms of these factors constituting a challenge in the determination of fair value. The respondents were required to rank the factors from 1 for the most challenging to 6 for the least challenging.

- PRINMARK – Principal market is inaccessible and establishing the highest and best use of biological assets is impractical;
- USERGRPS – The information requirement of the different user groups is dynamic and ever changing;
- COSTPREP – The cost of preparing and presenting financial statements on the basis of fair value is higher than it would be using any other basis;
- PREKNOWL – As a result of limited knowledge, we rely on consultants or external experts in the estimation of the value of biological assets;
- DIVERSIT – The diversity and interrelationships of agricultural activities impede the valuation of biological assets;
- CULTTRAD – The cultural and traditional practices of agricultural activities impede the

valuation of biological assets (sentimental attachment or taboos).

Table 9 The challenges for the valuation of biological assets

	N	Min	Max	Mean	Std.Deviation
PRINMARK	20	1	3	2.1	.912
USERGRPS	20	1	5	2.35	1.309
COSTPREP	20	1	5	2.75	1.410
PREKNOWL	20	2	6	4	1.376
DIVERSIT	20	2	6	4.65	1.348
CULTTRAD	20	2	6	5.15	1.268

Source: Author(s) calculation.

According to the results, the accessibility of the principal market and the changing information needs in the valuation of biological assets are considered to be the most challenging. Ranked second is the impact of fair value on the cost of preparing and presenting financial statements, while ranked third is the knowledge of the drafter of the financial statements. Ranked in fourth position is the diversity of agricultural activities and cultural practices.

Case Study : farm analysis in Albania

"Besa Agro Invest" is an entity with status sh.pk, established in 2014 and based in Durres. This entity was registered at QKR in the same year when started the

activity in the agricultural sector "Cultivation of various agricultural crops and their wholesale and retail trading. Cultivation of olive, vineyards, fruit trees for the purpose of trading their wholesale and retail products and by-products. Seed and seedlings production and their trading

". For 2015, the financial statements have been prepared in accordance with national accounting standards. From the statement of financial position we can notice that the biological assets are presented separately from other items of the entity's assets and are valued with fair value.

Besa Agro Invest  
Statement of financial position  
31.12.2015

Farm Assets		Liabilities and Owners' Equity	
Cash	13,872,495	Current Assets	5,744,039
Accounts receivable	14,430,996	Total liabilities	5,744,039
Inventory	1,972,528		
Biological assets	1,763,147	Paid in capital	180,000,000
Delayed expenses	3,496,332	Retained earnings	(8,561,733)
Total Current Assets	35,535,498	Earnings	(9,525,141)
		Total capital	161,913,125
Other assets	113,393,703		
Biological assets	16,208,581		
Delayed tax assets	2,519,382		
Total Long-term assets	132,121,666		
<b>Total Assets</b>	<b>167,657,164</b>	<b>Total Liabilites and Owners' Equity</b>	<b>167,657,164</b>

Besa Agro Invest  
Statement of comprehensive income  
01.01.2015 - 31.12.2015

Revenues	3,658,281
Change in inventory	620,555
Work performed by the entity	17,863,808
Others incomes	24,000,000
Materials	(11,990,200)
Labor expenses	(22,218,848)
Depreciation and amortization	(11,099,226)
Other operating expenses	(16,491,102)
Financial expenses	3,612,209
Profit before tax	(12,044,523)
Income tax	2,519,382
<b>Net profit after tax</b>	<b>(9,525,141)</b>

From the information provided by the entity itself in the notes section the short term biological assets consist of the following items:

Voice	Value
Wheat	139.163
Vegetables	1,272,712
Beans	351.272
<b>Total</b>	<b>1,763,147</b>

The following is the extent to which the number of biological agents is lower than the following:

Voice	Quantity	Value
Apricot	4000	5,215,228
Peaches	1000	963.731
Nectarines	5000	5,372,756
Pears	3200	2,673,673
Plum	2800	1,983,193
<b>Total</b>	<b>16000</b>	<b>16,208,581</b>

Explanation for performance voices as well as biological assets is as follows:

Voice	Value
Revenues from the sale of agricultural product	3,658,281
Change in inventory status of PG and PP (Work performed on short-term biological assets - vegetables)	620,555
Work performed by the entity and capitalized (Work performed on long-term biological assets - fruit trees)	17,863,808
<b>Total</b>	<b>22,142,644</b>

Specifically, the fair value model requires value reporting real at the reporting date, regardless of the carrying amount of assets. Fair value may exceed but may be even lower than the value accounting bookkeeping. As a model of assessment creates even plus value and minus value. These differences, only in the case of biological agents, appear at all times by giving the results the efficiency of the economic unit can be effected. On this case a plus value is a source of incomes for the entity. Changes in the assets and liabilities of the parent company are presented in the balance sheet of the financial position. Courses, other than the other activities, and the same as the short-term ones, will result in the result of the period of time being translated. Nonetheless, each of which is the date of reporting, treatment, and the reduction of the incapacity of the active person, is shown in the model. In this way, the model does not overwhelm the fluxes, and the effects on the skin are the same. The biomarker's abilities are high-quality economics, and the assessment of active peelings.

Following also shows the revaluation of long-term assets by type of fruit tree. The new value is due to the prices of the economy and the importance of the fairness of the economy. Evaluation of these activities is commonly

associated with the appropriateness that would mean that the biological activities of the process have been successfully developed. During the accounting period the assets change from quality and quantity. The fruit tree seedlings for 2014, the economy and economy, and its viability, at the end of 2015 are year-olds. Even in the market prices, the market is somewhat different than the apple. From the values presented, the explanatory notes are the same for each of the following types of fruit, including the following:

The explanation for the performance rumors as of biological assets is as follows:

Voice	Volume	Cost Value	Unit Cost
Apricots	4000	5,215,228	1,303.81
Peach	1000	963,731	963.73
Nectarine	5000	5,372,756	1,074.55
Pears	3200	2,673,673	835.53
Plum	2800	1,983,193	708.28
Total	16000	16,208,58	

If the entity evaluated the long-term biological assets at fair value at the reporting date, the values presented would be as follows:

Item	Quantity	Price	Value with price
Apriots	4000	513.75	2,055,000
Peach	1000	411.00	411,000
Nectarine	5000	513.75	2,568,750
Pears	3200	500.00	1,600,000
Plum	2800	400.04	1,120,112
Total	16000		7,754,862

#### IV. CONCLUSIONS AND SUGGESTIONS FOR FUTURE RESEARCH

Considering the current data and analysis about valuation models of biological assets, this paper analyzes the conclusions taken by questionnaires and As a main rule, the IAS 41 requires biological assets to be measured at fair value less costs to sell. Ideally, firms that use the unreliability clause of fair value should correspond to the firms that are unable to report biological assets at fair value. Based on some literature and given the results obtained, this paper concludes that there are other reasons related to country and firm environment that could explain this behaviour.

Firstly, with the agency and accounting choice theories, the suggested firm-level drivers, biological assets intensity, firm size, listing status, regulation expertise and sector have a significant positive impact on the probability of the fair value measurement of biological assets.

Secondly, during the analysis we noted that doesn't exist an active market, which is very important. It is also interesting to note that the recognition of unrealised gains and losses arising from physical or price changes in biological assets.

Thirdly, the standards related with valuation of biological assets should be improved by the national committee of accounting. As noted earlier, some preparers and auditors of financial statements have voiced concern over the applicability of the fair value model to small and medium-sized agricultural entities. This paper concluded, that because of the measurement problems in inactive markets and developing countries and for cost-benefit reasons, that SMEs should be required to use the fair value through profit or loss model only when fair value is readily determinable without undue cost or effort. When that is not the case, we concluded that SMEs should follow the cost-depreciation/impairment model.

Finally, the study highlights the positive and combined impact between regulation expertise and the sector with fair value measurement of biological assets.

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# Water quality of Guamá river in the surroundings of an insular environmental protection area in Belém - Pará, Brazil

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Received: 31 Jul 2022,

Received in revised form: 20 Aug 2022,

Accepted: 26 Aug 2022,

Available online: 31 Aug 2022

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**Keywords**— *Environmental protection, Water quality, Guamá river.*

**Abstract**— *The current research has as objective analyze the water quality of Guamá river in the surroundings of Combu island, insular area of Belém - Pará, through the following parameters: thermotolerant coliforms, E. coli and chlorophyll a. Six samples were collected in low tide, in rainy periods and in strategic points of the river, near tourism areas. After the collection were submitted to quantitative test technique with enzymatic substrate to the result of more probable number (MPN) to thermotolerant coliforms and E. coli. To chlorophyll a, the samples were submitted to the method of extraction and reading in the visible spectrophotometer. The results showed values above of the legal limits of 1,000 MPN/100 ml determined by CONAMA 357/2005 for thermotolerant coliforms and E. coli, with mean of 7,001 MPN/100 for the first and 2,330 MPN/100 ml for the second. About the chlorophyll a, although the values do not pass the legal limit of CONAMA 357/2005 of 30 µg/L in all collection points, with mean of 4,73 µg/L, the index of trophic state - ITS result in indication of river eutrophication. It can be highlighted the deficiency in basic sanitation services in Combu island, which interferes both in the quality of Guamá river, with high concentration of coliforms indicatives of fecal contamination, and in the health of local population, which demands the use of water for survival, but that has the potential risk of waterborne diseases in the most vulnerable communities.*

## I. INTRODUCTION

The regular normalization for protection of environmental areas in Brazil emerged in 1981 with the National Politic of Environment and posteriorly the law

9,985/2000 that created the National System of Nature Conservation Units - SNUC, which determine that it is objects of protection inside the Units of Conservation - UC's the spatial territories and its environmental

resources, including the inherent water resources conservation.<sup>[1] [2]</sup>

Considering that the maintenance of water quality are related with the sanitation condition of communities that use that resource, insular areas demands attention for the relation with water resources that surrounding it, and in that sense, the insular area of Belém have 42 islands with 332.04 km<sup>2</sup> spread in the Amazon estuary and among them the Combu island was considered through the Ordinary Law 6,083/1997 a Environmental Protection Area - EPA of sustainable use, allowing the human occupation for use of the natural resources with condition of equilibrate use and economic viable.<sup>[3] [2] [4]</sup>

However, despite being legally supported as an EPA, the Combu island suffers from several problems related to the inefficiency of basic sanitation, mainly related from the sanitary sewage and provide of potable water for the population. Although existing treatment of the waters of Guamá river for population supply, the water with quality do not reaches the insular regions, forcing the riparian population to use the water resource of direct form or through the onerous acquisition from unknown origins.<sup>[5] [6]</sup>

In front of this relation of the island with the river, the evaluation of hydric quality through the parameters which can indicate if the water resources are adequate for use becomes central, following that, when the locality involves problems with sanitation, analysis of microbiological agents becomes relevant because help as contamination indicators, highlighting the necessity of prevention related to waterborne diseases.<sup>[7]</sup>

In this perspective, it can be highlighted the necessity of the implantation of basic sanitation services, through the Law of Basic Sanitation n° 11,445/2007 which points sanitation services as “water supply, sanitary sewage, urban cleaning and management of solid residues performed in adequate way for public health [ ... ]”.<sup>[8]</sup>

When the sanitation don't follow the population increasing, negative ramifications both in water resources and population's health can emerge and, in this context, the irregular disposal of sewage in waters constitute in a source of pollution which can interfere not only in the microbiological quality but also in the irregular growth of algae because of the enrichment of nutrients, compromising even more its use.<sup>[9]</sup>

Thus, it is clear the necessity of instruments of monitoring the receptor body, aiming to evaluate the pollution impacts and hydric contamination through field activities in the area, surrounding population study and

laboratorial analysis of physical-chemical and microbiological parameters.<sup>[10]</sup>

In Brazil, the CONAMA regulates the maximum limits that the water body can reach according with each parameter, being as principal the Resolution 357/2005, however, despite of uncountable legal references exist to be followed, the deficiency of monitoring associated with basic sanitation represents health risks to population and others living beings.<sup>[11]</sup>

Therefore, the following research aims to evaluate if the Guamá river, in the surroundings of Combu island, insular area of Belém capital, has been showing negative results in superficial water quality through analysis of microbiological parameters (thermotolerant coliforms and E. coli), the chlorophyll a and its index of trophic state - ITE.

## II. MATERIAL AND METHODS

### 2.1 Research locality

The study area was Guamá river, near the Combu island, with 06 points of collection, embracing both the river and the Combu igarapé, a Environmental Protection Area - EPA that is part of the insular area of Belém, located in the outfall of the Guamá river, bordered in north for the river, in the south for Furo São Benedito, east by the Furo Paciência and west by Guajará bay, in a area of 16 km<sup>2</sup>, according to Fig. 1. <sup>[12] [13]</sup>

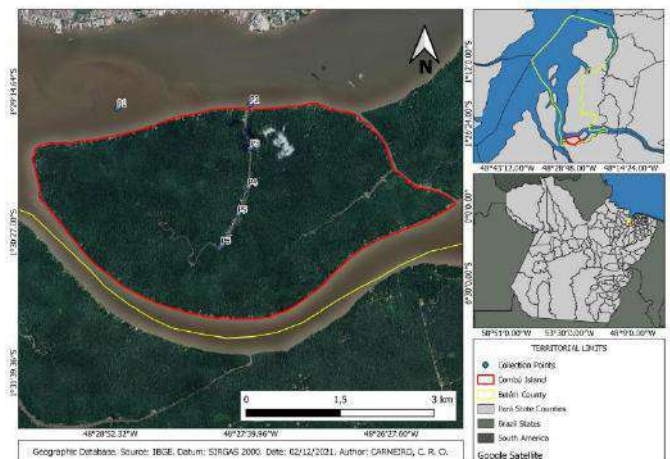


Fig 1: Combu island, insular area from Belém county, Pará. Source: Authors, 2021.

In relation of Guamá river, with 700 km of extension approximated, the research focused in the waters of the EPA, in the sub-basin of the lower Guamá, where the river border Belém by south, with right border corresponding to the city rim and the left border is the place of Combu island. <sup>[14]</sup>

The Combu island is a touristic point due to its many stilts restaurants, with a population of 1,800 inhabitants, mainly vegetation of mangrove and other part of economics performed by extractivism of products as açai, cupuaçu, chocolate between others.<sup>[15][16]</sup>

**2.2 Research approach**

The initial methodology was focused in the theoretical research in the scientific literature inherent of water resources, basic sanitation and water quality. In parallel, it was performed an exploratory research *in loco* to collection of data related to the water samples for analysis. The approach was quantitative to the organization of the first data acquired.

**2.3 Collection and data analysis**

The collected data aims at the results which could indicate the water quality relating them to the legislation limits - CONAMA 357/2005. The criteria for choosing the points are related to the existence of economic activities, in case of touristic points and presence of nearby communities, which are potential sources of sanitary sewage.

The acquisition of the samples occurs from technique activities in the studied area, for water collection in 06 points of the river, with location presented in table 1, embracing the Guamá river and Igarapé of Combu, where it is located the restaurants in stilts form, where the locomotion is by small boats.

Table 1: Geographic localization of the collection points

Point	Geographic Coordinates UTM	
P1	01° 29' 22.7" S	048° 28' 48,5" W
P2	01° 29' 20.8" S	048° 27' 40.2" W
P3	01° 29' 43.4" S	048° 27' 40.0" W
P4	01°30' 03.5" S	048°27' 41.2" W
P5	01°30' 17.4" S	048° 27' 46.5" W
P6	01°30' 33.5" S	048° 27' 55.0" W

Source: Authors, 2021.

The field research was conducted in 2021, rainy period in low-tide, with observance of storage and

conditioning following the methodology of Cetesb (2013)<sup>[17]</sup> and following the protocol of sampling water, according to Standard Methods for Water and Wastewater. The flasks with samples for analysis of chlorophyll *a* were with 1 L of capacity in amber glass e for the bacteriological essays it was used collectors of 100 ml.

The sample analysis were from the following parameters: thermotolerant coliforms and E. coli, where the More Probable Number (MPN) was determined by the technique of quantitative test with enzymatic substrate, performed by the Central Laboratory of Pará - LACEN and analysis of chlorophyll *a* concentration, through the spectrophotometric method, where the samples were vacuum filtered and the chlorophyll extraction obey the method described by Cetestb (2014)<sup>[18]</sup>, performed by the Laboratory of Amazon Water Quality - Labágua.

With the results of chlorophyll *a*, it was possible to perform the classification of the Index of Trophic State - ITS of the sampling points, following the methodology by Lamparelli (2004)<sup>[19]</sup>, adapted for tropical environments adopted by Carlson (1977)<sup>[20]</sup>, for temperate climates. As the studied area being a river, the equation used for obtaining the Index of Trophic State is according to lotic environments:

$$IET (CL) = 10x (6 - ((-0.7 - 0.6x(\ln 2)) - 20)$$

Where

CL: chlorophyll *a* content measured in the water surface, in µg.L-1;

ln: natural logarithm

For the ITS classification, it were follow the limits of the six different trophic level for rivers: ultraoligotrophic (IET ≤ 47); oligotrophic (47 < TSI ≤ 52); mesotrophic (52 < TSI ≤ 59); eutrophic (59 < ETI ≤ 63); supereutrophic (63 < ETI ≤ 67); hypereutrophic (IET > 67).

The results treatment was performed through descriptive statistics and comparative graphics between the obtained concentrations and the established legal limits. It was used for the graphics elaboration the Microsoft Excel 2010 and for map elaboration the Arcgis program.

**III. RESULTS AND DISCUSSION**

The table 2, through descriptive statistics, compares the obtained data with the legal scope according to CONAMA 357/2005, presenting the mean values, standard error, maximum and minimum values.

Table 2: Obtained results of thermotolerant coliforms, E. coli and chlorophyll *a* parameters

	Mean	Standard error	Minimum	Maximum	MVA
CT nmp/100ml	<b>7.001</b>	2.076	3.736	17.109	1000 nmp/100ml
<i>E.Coli</i> nmp/100ml	<b>2.330</b>	1.829	947	5.811	1000 nmp/100ml
Clorofila <i>a</i> µg/L	<b>4.73</b>	1.018	2.81	8.55	30 µg/L

\*MVA – Maximum value allowed. Source: Authors, 2021.

It can be noticed that the thermotolerant coliforms and *E. coli*, in the majority of the samples, the bacteria concentration results in values above the permissible by the legal limits of 1,000 MPN/100 ml, according to the Fig. 2 below:

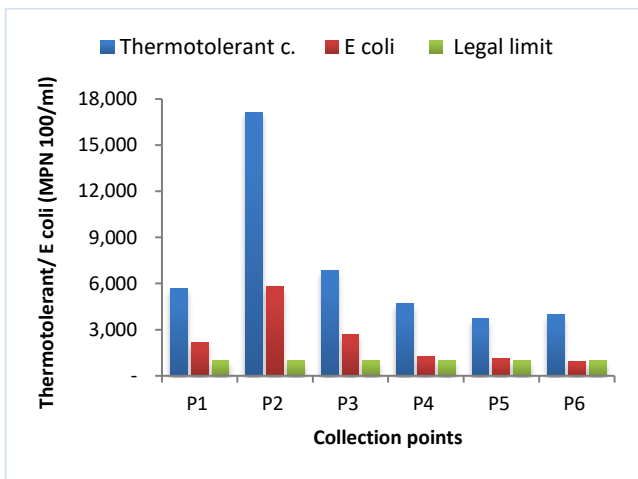


Fig. 2: Results of thermotolerant coliforms and *E. coli*  
Source: Authors, 2021

In the thermotolerant coliforms group, the central characteristics is the subgroup that constitute the total coliforms, whose bacteria can ferment the lactose in 44-45° C (±0.2) in 24 hours, and the *E. coli* that highlight itself in this group for being the unique species with exclusive habitat in the human intestine or in homeothermic animals, thus, both parameters are indicators of fecal contamination, however, the last one with higher specificity.<sup>[11] [21]</sup>

The chlorophyll results indicate the biomass quantity of algae, relating the water quality analyzed with the excessive growth of algae. The results showed that the quantity of Chlorophyll *a* in the collection points presented results below of the established limits according to the legislation, that is 30 µg/l.<sup>[22]</sup>

### 3.1 Thermotolerant coliforms

In relation to the thermotolerant coliforms, all the samples showed concentrations above the limit for freshwater, class 2, according to the legislation (1,000 MPN/100 ml), with mean of 7,001 MPN/100 ml, reaching the maximum value in point 2 with 17,109 MPN/100 ml and minimum value in point 5 with 3,736 MPN/100 ml.

Thermotolerant coliforms are important water quality indicators, because points in a water sample the probable bacteria concentration existed, and these ones are different from the total coliforms, because ferment lactose produces gasses in 24 hours with temperatures varying between 44.5 and 45.5 °C. Its presence is mostly found in fezes, soil and vegetation, thus, its presence in superficial waters could be related with sanitary sewage.<sup>[23]</sup>

In the study area, one of its characteristics is its proximity with the collection points with touristic areas, where the local possess commercial establishment, as restaurants in stilts form, as Fig. 3:



Fig. 3: Restaurants in stilts in Combu island. Source: Authors, 2021.

Furthermore, the existence of riparian communities in the area increase the domestic sewage production, that jointly with the poor infrastructure of sanitation potencialize the load of pollution released in Guamá river. This fact is corroborated with other surveys about rivers near riparian communities, with precary sanitation.<sup>[24] [25] [26]</sup>

Important issue that comes up in riparian communities is that their living way is directly related with the necessity in having water for many uses, as for consumption (potability) and recreation of primary contact (bathing), that leads to the concern of legal limits adequation for these uses.<sup>[27]</sup>

Besides CONAMA 357/2005, that classifies the water bodies and gives environmental guidelines, the Healthy Ministry, through the ordinances regulates the threshold parameters for water potability for human consumption, nowadays regulated by Ordinance GM/MS n° 888 of May 4<sup>th</sup>, 2021, which changed the attachment XX of the Consolidation Ordinance GM/MS n° 5, of September 28<sup>th</sup>, 2017, where it determines that the bacteriological standard of water for human consumption, both general coliforms and *E. coli* must be absent of these microorganisms, i.e., for human consumption the water must be absent of any bacteria of the coliforms group.<sup>[28]</sup>

About the bathing, freshwater rivers class 2 can be destined to recreation of primary contact, since respecting the bathing limits of CONAMA 274/2000. This resolution classifies the water for bathing as Proper, subdivided in Excellent, Very Good and Satisfactory, and the Improper category, the obtained values in the last sampling mustn't be above of 2,500 MPN/100 ml for thermotolerant coliforms, therefore, it can be noticed that for all the highlighted uses, the results showed that the waters can be improper, due to the fact that the concentration mean for thermotolerant coliforms (7,001 MPN/100 ml) surpasses the legal limits.<sup>[29]</sup>

In general, Amazon river receivers of domestic sewage are marked by the presence of thermotolerant coliforms. As the Guajará bay is an important receiver of Belém county, surveys showed values of this parameter above the legal limits according to CONAMA 357/2005, both in rainy and non-rainy period, with maximum reaching 486,775 MPN/100 ml.<sup>[30]</sup>

In the urban border of Guamá river, it can be registered many points of anthropic activities, as touristic shores, open air fair, private ports, universities, communities and others<sup>[31]</sup>. Ergo, the domestic sewage load received from the many activities is released directly in the river, and in that sense, results with elevated concentration of thermotolerant coliforms also were found in points of releasing of urban sewage in the Guamá river, with values reaching  $629.4 \times 10^4$  MPN/100 ml.<sup>[32]</sup>

### 3.2 Escherichia Coli

Beyond the thermotolerant coliforms, it was analyzed the *E. coli* parameter, that is included in the thermotolerant group, however is considered a high enteric bioindicator, because the bacteria has its primary habitat in the human intestine and in warm-blood animals.<sup>[23]</sup> This parameter also presented concentrations above the value determined by legislation (1,000 MPN/100 ml) in 5 of the 6 points.

With a mean of 2,330 MPN/100 ml, it reached maximum value in point 2, with 5,811 MPN/100 ml and minimum value in point 6 with 947 MPN/100 ml. The analysis of *E. coli* showed contamination in superficial waters, once it possesses high fecal specification, where its presence indicates the water body contact with non-treated water, because these microorganism survive for only a few days out of its primary habitat, respectively 1 day in superficial waters, 1.5 days in sediments and 3 days in soil.<sup>[33]</sup>

It can be observed that beyond the contamination indicate recent time, the results mean of *E. coli* are out of the parameters not only for CONAMA 357/2005, but also for bathing parameters (2,000 MPN/100 ml) and potability (absence), where bathing, 50% of the points was above 2,000 MPN/100 ml.<sup>[28] [29]</sup>

High concentrations of *E. coli* were equally found for surveys in rivers that supply riparian communities in Moju county, Pará state and that have multifunctionality for the community, with results pointing 2,755 MPN/100 ml with detection of strong anthropic pressure, and situation of sanitary risk without potability and potential of waterborne diseases.<sup>[34]</sup>

A survey about parasitic infections through parasitological exams was performed in riparian communities in Santarém county also in Pará state, which results indicates that the communities are exposed to infection risk due to the deficiency of sanitation and the socio-environmental conditions, whose water for consumption generally don't have treatment, with origins directly from the river or shallow wells with inadequately storage, situation similar to the studied area from this study.<sup>[35]</sup>

The impact from the precarity of the sanitation and its relation with the microbiological quality of the water has been boosting surveys not only for microorganisms concentration detection, but also has been promoting the search for solutions about the qualitative scarcity and minimizing the problems presented through disinfection techniques.

In this sense, the surveys about disinfection techniques as chlorination and its negative effects (cancerogenous subproducts presence), has been directing researchers for

alternative techniques of disinfection, but more advanced, as the microfiltration, advanced oxidation processes and electro dialysis, however, the implementation suffers from impasses due to the absence of investments, making its applicability limited and often leading communities to the use of social technologies.<sup>[36] [37]</sup>

Thus, it can be observed that the impasses in riparian communities are huge in reason of the distance from urban centers and the transportation, usually using river ways. Therefore, the problems are mostly because the sanitation condition absence, water use necessity that generally are contaminated and the creation of ways for containing the problems from contamination through accessible techniques of disinfection that generally in underdeveloped countries its implementation is harder.

### 3.3 Chlorophyll a and Index of Trophic State – ITS

About the concentration of chlorophyll *a*, the results presented values below the legal limit (30 µg/L for freshwater rivers, class 2) as shown in Fig. 4.

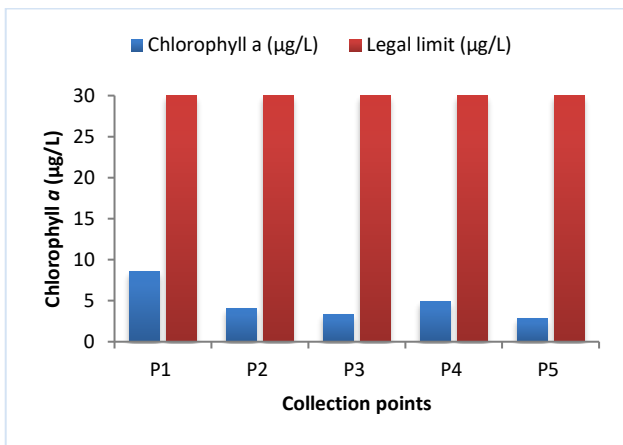


Fig. 4: Chlorophyll a. Source: Authors, 2021.

The concentration mean of chlorophyll *a* between the points was 4.73 µg/L, with maximum value in point 1, with 8.55 µg/L and minimum in point 5, with 2.81 µg/L. It can be highlighted that in point 6, although the collection performed, it did not reach the limit of detection by the spectrophotometer.

The results demonstrated coherency with other surveys in similar study areas, that in the same river in Belém county, it was concluded that the low values of chlorophyll *a* was related with the characteristics of muddy water, with low transparency, clayish material in suspension, turning the water blurred and promoting the decreasing of photic layer, which limits the increase of phytoplankton mass.<sup>[38]</sup>

In other surveys in the area, the values do not surpass the legal limits, which suggests that in the rainy period the

results were associated to the superficial flow of waters from precipitation, favoring the carrying of sediments to the water body.<sup>[39]</sup>

However, with regard to the trophic state, the mean of the Index of Trophic State - ITS, between the points was 62.85, whose most points were classified as eutrophic, with the exception of point 1, whose result was hypereutrophic and the point 4 which was supereutrophic, according to Table 3:

Table 3: Index of trophic state in collection points.

Collection points	Chlorophyll <i>a</i> (µg/L)	ITS	Classification
P1	8.55	68.67	<b>Hypereutrophic</b>
P2	4.07	62.25	<b>Eutrophic</b>
P3	3.31	60.46	<b>Eutrophic</b>
P4	4.91	63.87	<b>Supereutrophic</b>
P5	2.81	59.04	<b>Eutrophic</b>
P6	*U.D	-	-

\*U.D. – undetectable. Source: Authors, 2021.

These classifications followed the limits of the six different trophic levels for the rivers, namely: ultraoligotrophic (IET ≤ 47); oligotrophic (47 < TSI ≤ 52); mesotrophic (52 < TSI ≤ 59); eutrophic (59 < ETI ≤ 63); supereutrophic (63 < ETI ≤ 67); hypereutrophic (IET > 67), where each level seeks to assess the availability, quality and effect of the inclusion of nutrients present in the water, responsible for the disorderly and excessive growth of algae or macrophytes in the aquatic environment.<sup>[19]</sup>

The trophic state classified as eutrophic was the index with the highest incidence in the collection points, which indicates that the Guamá river in the region that bathes the Combu island, has been affected by anthropic activities, is eutrophic and with negative influences on the water quality, interfering with the multiple uses it has.

In surveys about Amazon waters, index classified as eutrophic were found in rivers as the Guajará Bay, with mean of 62.47 and supereutrophic in Bolonha lake, important spring within a urban environmental protection area in Belém, with values reaching 66.86.<sup>[40] [41]</sup>

High values of ITS suggest origins in the use and occupation of soil and loads of sewage discharged in the river without treatment, contributing to the increase of nutrients, causing eutrophication. Thus, improvement in the sanitation services are necessary aiming to minimize the found problems.<sup>[42]</sup>

#### IV. FINAL CONSIDERATIONS

The study area has been undergoing changes in the quality of water that serves the riparian community, where despite being an insular region, the disorderly growth of the nearby urban population has potentiated the increase in the load of effluents in the Guamá River.

Regarding the Brazilian normative of CONAMA 357/2005, the average of the parameters Thermotolerant Coliforms and *E. coli* presented legal non-compliance, and as both are bioindicators of contamination of fecal origin, the sanitary issue of the Island raises an alert. Descriptive statistics showed that the nonconformity of these parameters reach high values of bacteriological concentration in the waters that bathe the island, far beyond the legal limit allowed.

Regarding the uses of water resources for human consumption and for primary contact leisure, the results ended up showing that the Guamá River is also in disagreement with the legislation on bathing and drinking. As for the chlorophyll *a* values, in addition to complying with current legislation for freshwater rivers, class 2, the results are also consistent with the characteristics that the rivers in the region carry, such as the presence of sediments that end up limiting the photic layer in the river waters, an important factor for the growth of algae and other aquatic photosynthetic organisms.

Although these values are legally adequate, the average of the Trophic State Index indicates that the river is eutrophic, so attention turns again to the health issue of the island, since the increase in nutrients in the water intensifies the eutrophication process of rivers.

Thus, considering that the city of Belém has low coverage of basic sanitation, especially sewage collection and treatment, the polluting load that goes directly to the receiving body, associated with the lack of sanitation also on the island of Combu, are factors that can be relate to the results found, raising a concern about the need to monitor and verify the impacts both on the society that uses the water resource, and on the quality of the river itself.

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# Analysis of State Civil Responsibility in Climate Litigation Conflicts, in the Context of the Elevation of Environmental Causes to the Human Rights Protection Category

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Received: 25 Jul 2022,

Received in revised form: 21 Aug 2022,

Accepted: 25 Aug 2022,

Available online: 31 Aug 2022

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**Keywords—** Climate Litigation, State Civil Liability, Human Rights.

**Abstract—** The objective of this article is to present the transformation of the Climate Litigation theme, under a contemporary context, inserted in the approach within the category of human rights and in the face of the phenomenon of globalization of environmental issues. We sought to analyze the opposite context to the traditional discourse of punishment of the private sectors, such as entrepreneurs and individuals for environmental attacks. Thus, the purpose was to bring to light that the State has gone from a mere spectator of environmental causes to the main agent in legal matters, inspection, and applicator of penalties to violators of environmental policies. Failure to do so may result in liability. Notwithstanding the Paris Agreement, which governs measures to reduce greenhouse gas emissions from 2020, does not establish penalties for violators of the goals established for countries, there is a tendency, within the scope of domestic law, for state accountability in demands of Climate Litigation. Through the analysis of concrete cases, such as *Massachussets et al v. Environmental Protection Agency*, the case *Lliuya v. Rwe*, and other genuinely Brazilian cases, sought to present the trend of the judicialization of climate issues, supported by the mainstay of state responsibility, through legal institutes that allow the civil, administrative and criminal conviction of the public entity. The article was produced by the descriptive method, with data and qualitative bibliographic research. Now, if it is the guarantor of fundamental rights such as the right to life, health, food security, property and if it authorizes the consumption of natural resources and the approval of environmental projects, why not demand the parameters of sustainability in the context of public policy?

## I. INTRODUCCION

The growing legal demands related to the emission of greenhouse gases, called "GHG", are the result of a transformation of values in which climate issues are of deep concern today.

The recent environmental disasters, caused by hurricanes, tsunamis, droughts and floods, are almost mostly related, directly or indirectly, to atmospheric pollution (Martine, Eustáquio, 2019), which caused changes in a hitherto invisible and imaginary theme that became the main concern for the future and survival of humanity.

Initially, these climatic events were seen as sporadic events, resulting from the very transformation of nature, however, over the years, there was an interconnection between them and a greater frequency of environmental disasters on the planet. The search for scientific knowledge has increasingly brought human actions closer to the negative consequences of environmental issues.

The point of intersection between them is that it is not only possible to see economic losses for nations, but the direct impact mainly on the most needy and vulnerable populations, which generates risks to the existential minimum such as food security, health, human dignity, access to water, property rights, etc.

The change in view of the climate crisis theme is justified by its elevation to the category of Human Rights. Currently, the theme is no longer a simple environmental issue, whose concern is only related to the preservation of water and mineral resources and the preservation of terrestrial biomes. The theme gained contours of survival of humanity, from a context of globalization of environmental issues.

In this scenario, the role of the State arises both as a guarantor of compliance with environmental legislation, and, on the other hand, as a civil liability for damage to the environment, resulting from its own action or by private violators of environmental rules.

The research will initially address the evolution of the approach to climate change with its current focus on human rights and its implications and threats to fundamental rights.

The civil liability of the State will also be analyzed, with its current trend, in climate litigation conflicts, with the analysis of specific cases highlighted, decided or in progress in Brazil and abroad.

To act in the preservation of the environment, it is necessary to prepare society on aspects of climate change and preservation of the future of humanity. Several mechanisms emerge to prevent and repress environmental violations, from legislation, social awareness and disputes in institutional and legal spaces (MANTELLI G., NABUCO J. and BORGES C. 2019).

In the field of public policies, the State has the role of guarantor of environmental preservation. In this context, civil society plays its role of collection, so that it can efficiently and adequately carry out the mechanisms of environmental protection. The judiciary enters this scenario in order to demand and encourage the executive to protect the environment, and this, in turn, needs the normative and regulatory frameworks approved by the legislature.

It should not be forgotten that climate litigation is also related as an inducer of change in the private and business sectors. The positive influence of public opinion encourages the adoption of conscious consumption, in order to select increasingly demanding markets for companies that have an environmental commitment at their core. (OSOFKSKY, 2010, p.10)

Climate disputes can be understood, in general, as lawsuits that require decisions from the Judiciary or administrative bodies that expressly address issues, facts or legal norms related, in essence, to the causes or impacts of climate change (MANTELLI G. , NABUCO J. and BORGES C. 2019).

The approach to the issue of litigation, in its conceptual basis, as well as its legal nature, implies putting pressure on the Legislator and Administrator State to promote climate regulation measures, by guaranteeing the cut of greenhouse gases and stimulating the production of renewable energies.

For this, skillful judicial measures are used to implement the principle of prediction and precaution, in order to avoid environmental catastrophes and promote sustainable development, in addition to guaranteeing the protection of human rights.

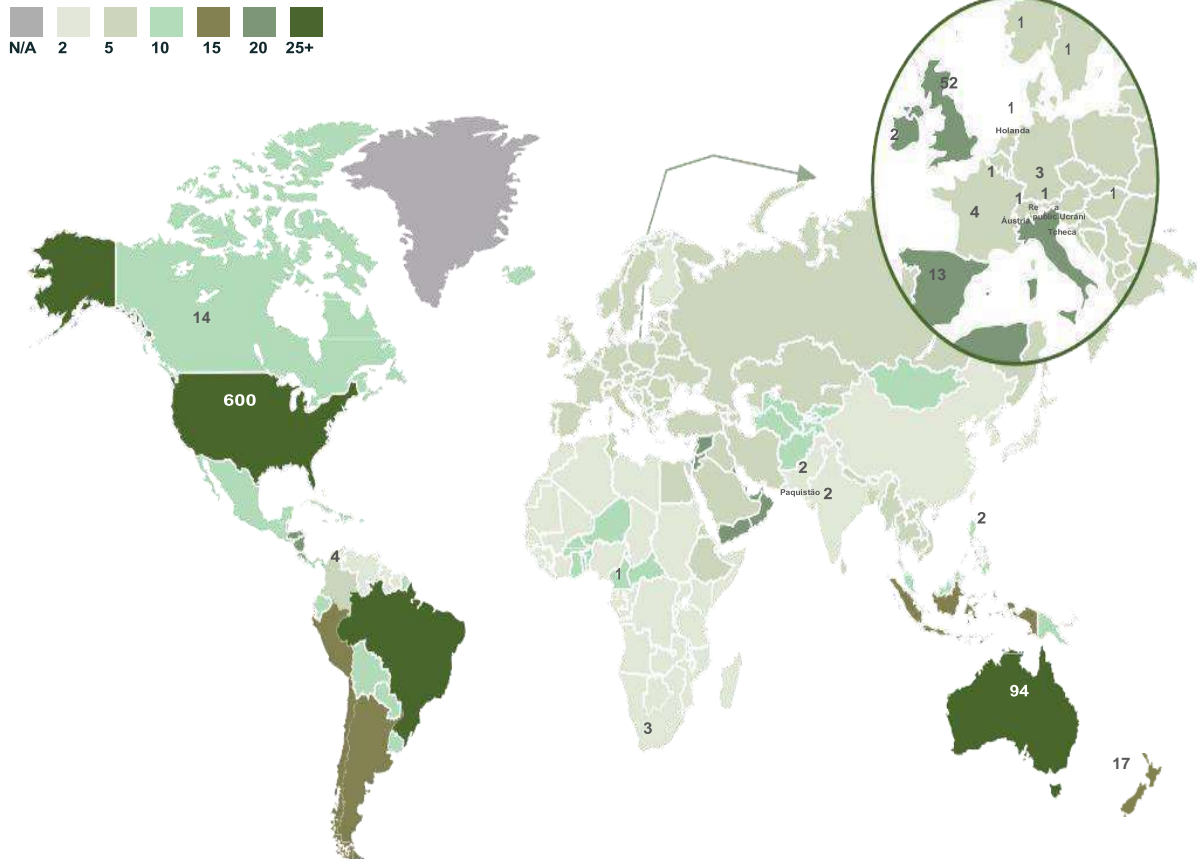
## II. CLIMATE LITIGANCE

### 2.1 BRIEF EVOLUTION OF THE THEME

In this sense, as described by Khan (2017), the negative effects on human rights related to the causes of climate change are diverse, which pose risks to fundamental rights. Thus, one can highlight the right to life, property, state protection, cultural rights, such as the preservation of indigenous, riverine, quilombola traditions and the right to citizenship, related to the increase in migratory waves,

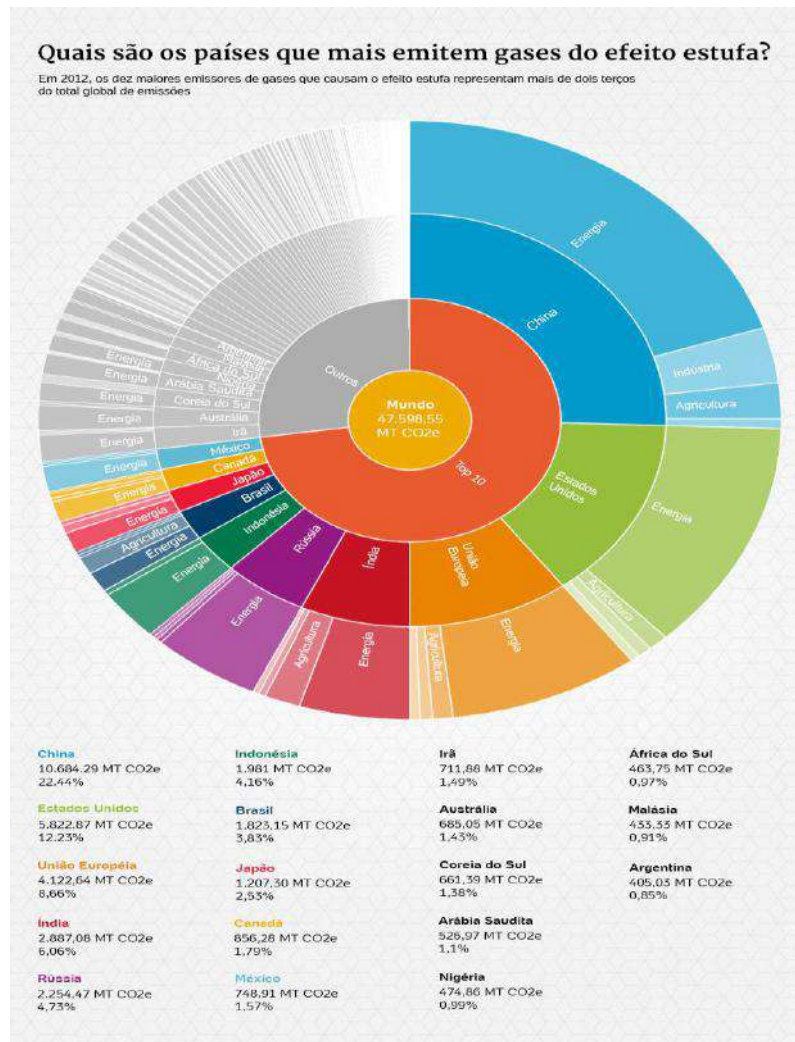
armed conflicts and even the disappearance of entire nations (IBA, 2004).

On the subject, as can be seen in the figure below, it is possible to verify the proportionality of the number of conflicts involving climate litigation and climate legislation in the world. The numbers indicate the amount of climate litigation in countries in 2018, and the colors indicate the number of climate laws.



Source: CONECTAS DIREITOS HUMANOS (2019).

The American supremacy in this regard is impressive. Despite being the second largest polluter, as shown in the table below, it is also verified that it has the largest global engagement on the subject.



Source: Worlds Resources Institute<sup>1</sup>

The concern with climate issues is rooted in American legislation, which is why the amount of demands on American soil is justified. A turning point took place in 2017, when, despite popular pressure, the President of the United States, Donald Trump, formally left the Paris Agreement, ratified in 2015.

However, in February 2021, President Joe Biden resumed the country's entry into the Agreement, committing to the reduction of pollutants, according to the established goals.

This policy implied a new twist on the subject. The emission of gases by the United States, from 2012 to 2021, there was a reduction to 11% of the total of gases, while in the same period, China increased to 27% its participation in this regard.

It appears that the promise of carbon neutralization by 2060, as predicted by the Paris Agreement, is far away.

However, cases of climate litigation gained worldwide prominence, in which regional conflicts became causes that have international reflexes and repercussions, as we will see in the analysis of some specific cases of climate litigation.

### III. CIVIL RESPONSIBILITY IN CLIMATE LITIGATION CONFLICTS

The approach to civil liability for environmental damage reveals itself to be a progressively current and always timely legal issue (Custódio, 1996).

The issue surrounding the issue of liability for damage to nature always brings contradictory reflections. If, on the one hand, the use of natural resources is justified as a way of guaranteeing the minimum livelihood of human beings, on the other hand, invasive human actions significantly compromise these resources and, currently,

<sup>1</sup> 10 countries that produce more than 68% of global emissions: Available at: <https://www.johannes-friedrich.com/>, accessed 3/20/2022.

have brought together nations in search of a common good, the survival of planet earth.

The environment enshrined in the so-called Third Generation Rights, which assists the entire human race in a subjectively indeterminate way, cannot be seen as a “*res nullius*”, but as a right for all.

In addition to the protective and preservative measures provided for in § 1, I-VII, of art. 225 of the Federal Constitution, in its § 3 it deals with the criminal, administrative and civil liability of those who cause damage to the environment.

The theory of integral risk in matters of environmental responsibility prevails in the current Brazilian jurisprudential system. Therefore, exclusions of liability, such as fortuitous event or force majeure, are inadmissible. In the event of damage, identified the author and the causal link, liability is inherent (Cavaliere Filho 2020).

However, as well observed (Tartuce, 2011), although in Brazil the theory of integral risk has gained strength in the doctrine and understanding of the Courts, there are many doctrinal attempts to minimize its reach. In any case, the essence of objective civil liability lies in proving the causal relationship between the agent's action or omission and the damage or risk of the latter to the environment.

And how to prove that some human activity was a decisive factor in triggering a certain environmental catastrophe? Or, on the other hand, how to prove, negatively, that such an action did not contribute to a certain climatic phenomenon? - is the so-called diabolical proof - expression originating in canon law in which it is stated that only the devil could produce negative proof. This is the challenge of the Judiciary in climate litigation conflicts.

An emblematic case on the current issue is that of the Peruvian farmer Saul Lliuja who filed a lawsuit in Germany, at the Essen Regional Court, against the largest German electricity producer, Rheinisch-Westfälisches Elektrizitätswerk AG (Rhenish-Westphalian Power Plant or RWE) , located in the Essen region, north of the Rhine.

In short, the farmer stated that the melting of glaciers in the high mountains in the city of Huaraz, in Peru, was linked to the large amount of carbon dioxide, CO<sub>2</sub>, emitted by the German energy company.

Despite the German court not recognizing the “*conditio sine qua non*” between human activity and environmental catastrophe, Saul’s action led to the recognition of the possibility of judicialization of the dispute in the supreme court that culminated in a series of demands and regulation of the aforementioned company. .

As seen, the tendency of the theme is to transgress beyond the positivist question, which in the conception of Kelsen, 1996 “the basis of validity of a norm can only be the validity of another norm”. It is close to natural law ideas, which represents a system of intersubjective norms of conduct different from the system constituted by norms established by the State (positive law).

### 3.1 CIVIL LIABILITY AND FUTURE ENVIRONMENTAL DAMAGE

Although the possibility of liability for future environmental damage is already admissible, both in its doctrinal and legal aspects, this environmental responsibility lacks characterizing descriptions. This is because there is still no solid legal theory that can have support, applicability and operability.

However, jurisprudence, both in domestic law and in international environmental litigation issues, has made an effort to bring together the elements of damage and liability of the causes or even potential harmful agents of environmental damage.

And what would that basis be? It appears that the law already admits future damages in civil matters, as in the case of loss of profits in which it is possible to measure potential losses that the party may suffer.

As Professor Paulo Bessa Antunes teaches, Brazilian Courts have long faced difficulties with regard to the subject, since the materiality of the evidence, in terms of doctrine and legislation, is essential for the characterization of civil liability. Therefore, how to impute responsibility for a damage, even if predictable, however difficult to measure? The author talks about this topic.

“Brazilian Courts have had an extremely restrictive understanding of the concept of environmental damage and, consequently, of the legal interest of the environment. In general, they have adopted a stance that demands actual damage and not just potential damage. It seems to me that the principle of caution in environmental matters has not been applied and observed, which, as is well known, is one of the principles of Environmental Law”. (Antunes, Paulo Bessa 2006, 5th ed. Pg. 169).

However, it is necessary to consider the protection of future generations with regard to the possibility of future environmental damage, from the perspective of a legal mechanism for investigation, assessment and management of environmental and ecological risks.

To justify future environmental damage, it is possible to do so through a new Theory of Risk (Abstract Risk Theory), in a different sense from the classical theory exposed in the Theory of Concrete Risk, which requires the occurrence of damage to impute the civil responsibility.

As explained by Delton Winter de Carvalho, contrary to what occurs in the Theory of Concrete Risk, one cannot demand the occurrence of real and concrete damage, as a “sine qua non” condition, for the attribution of strict liability to the dangerous and risky activity. , with regard to future environmental damage, under penalty of losing its preventive meaning.

Thus, in the face of a scenario of probable environmental damage, the future consequences of this damage must also be foreseen, for the purpose of preventing and minimizing the consequences. In this sense, Professor Delton Winter teaches:

Thus, the Law must be envisaged not only as a corrective element, of post factum incidence, but also as a risk management instrument, acting preventively to the effectuation of environmental damages. Future environmental damage is exactly the dogmatic notion produced by Environmental Law to enhance communication about ecological and environmental risks in Law. For this reason, it is up to us to state that, under the dogmatic notion of future environmental damage, there is a notion of risk as legal communication for observation and formation of links with the future.

By requiring the plaintiff to prove the actual damage, the Courts, in fact, impose the entire burden of judicial proof on the plaintiffs, weakening the polluter's strict liability. Furthermore, it is important to note that Environmental Law exerts its protective function, also in relation to future generations, as a result of the concept of intergenerational equity, which is one of its main aspects. However, future damage, many times, cannot be proved by plan, coming to materialize, only, with the passage of time.

### **3.2 STATE ENVIRONMENTAL RESPONSIBILITY IN CLIMATE LITIGANCE CONFLICTS**

One of the main challenges with regard to litigation is state accountability for environmental damage.

The topic causes controversy when it comes to the imposition of GHG reduction policies on Nation States. To implement this policy, drastic changes are necessary, which

may reflect, at first, on the economy, on employability, on the competitiveness of companies, high investments in cutting-edge technologies to reduce pollutants. This can have negative consequences for commercial competition between nations.

The current world treaty in force, ratified by 195 countries (IPCC, 2019), the Paris Agreement, which replaced the Kyoto Protocol in mid-2020, does not establish coercive means in case of non-compliance.

The problem is that non-compliance with the Agreement itself does not generate a legal penalty for the country that violates the rule. Through the analysis of the entire document, there is no mention of punishment for violation.

Therefore, if the international regulations themselves do not establish punitive guidelines, on the other hand, how to encourage the engagement of participating countries? In addition, if it is not possible to establish coercive means at the international level, at the domestic level, what would be the commitment of the Nation States to create and comply with environmental legislation.

Notwithstanding the failure of penalties at the international level, there is a growing tendency in litigation conflicts to hold the State responsible, for the omission of norms, inspection or incentives to environmental sustainability.

Currently, 76% of climate litigation takes place in the United States (Wedy, 2021). The country has become a reference on the subject, through the engagement of civil society, companies and the State itself, either sporadically or coercively, with the help of the judiciary, despite being the second largest emitter of greenhouse gases in the world.

One of the outstanding North American cases on the subject was Massachusetts et al v. Environmental Protection Agency. In this specific demand, the US Environmental Protection Agency (EPA) had refused to regulate carbon dioxide emissions from new motor vehicles, even after a request by 19 US non-governmental organizations.

After several clashes, the result culminated in a new regulatory framework and the understanding of a model of judicialization of climatic-environmental conflicts. This is because the North American Supreme Court understood the EPA's competence to regulate the emission of gases from new and used motor vehicles.

And, moreover, regarding the questioning of the illegitimacy of the judiciary to establish guidelines or levels of emission of pollutants, the Honorable Court judged that it did not interfere with the American administrative competence, since the judiciary does not have the technical,



scientific capacity to enter into this matter, however judged that the state environmental agency has the resources to regulate this matter.

This pressure exerted by the litigants resulted in the reform of existing regulations, such as the air pollution law and the US national environmental policy.

This case represents a valuable example of how legal proceedings can serve as a tool to provoke government actions in the field of climate change without violating the principle of separation of powers (Bernardo, 2017).

In Brazil, even though the matter has an embryonic legal nature, if compared to the American model, there are trends of state accountability. On the subject, one can cite the decision in ACP filed by the MP of São Paulo, in 2017, against the Environmental Company of the State of São Paulo (CETESB) mentions the importance of restinga areas for adaptation to sea level rise .

At the national level, ADPF 708 on the functioning of the National Climate Change Fund (Climate Fund), presented at the Federal Supreme Court in June 2020, can be pointed out as the first great example of climate litigation in Brazil. In that action, we seek to discuss the direct affectation of the right to a healthy and ecologically balanced environment provided for in article 225 of the Federal Constitution and to compel the Executive to guarantee the regular functioning of the Climate Fund.

The judicialization of this issue represents an unprecedented opportunity to advance the climate debate in Brazil based on International Environmental Law in relation to the State's responsibility for damages arising from climate change and violations of international agreements signed by Brazil (GIURIATO, 2021).

Therefore, there is this strong trend of state accountability on the subject. This is because it has mechanisms of regulation and environmental inspection. On the other hand, if the private company has authorization to operate from the public entity, it becomes difficult to hold it accountable, since state approval is presumed to have fulfilled the legal requirements, including environmental ones, for operation.

But this context was decisive in putting pressure on governments and polluters to deal with global warming effectively.

#### IV. CONCLUSION

The institutes of collective actions in the field of climate litigation have increased considerably since 2006. In this context, the role of the judiciary in the conduct of proceedings stands out, so as not to always interfere with

the competence of other powers and in order to preserve their independence.

The elevation of environmental issues to the category of human rights caused a greater concern and commitment of the various authors in search of sustainability and less risk to the environment.

The differences of opinion between the countries and the non-compliance with the goals established in the Paris Agreement in force are, without a doubt, great challenges for the subject.

The imputation of state responsibility both internationally and in the field of national law is a strong tendency to mitigate climate conflicts.

Climate litigation must be mitigated with the implementation of commitments assumed by the country and, also at the international level, judicialization is an essential tool that can be used in the search for environmental public policies.

Through the analysis of the research, it is concluded that it is possible to file actions to the detriment of public agents so that they pay attention to climate change when planning the planning of urban spaces or analyzing environmental impact studies of specific projects, with the possibility of intervention in the technologies, methods and safety to be adopted by the enterprises under analysis.

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## Prevalence of burnout syndrome in gynecology and obstetrics residents at the Maternal-Infant University Hospital of São Luís-MA.

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Received: 30 Jul 2022,

Received in revised form: 22 Aug 2022,

Accepted: 26 Aug 2022,

Available online: 31 Aug 2022

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**Keywords—** Burnout. psychological stress. quality of life. resident physicians.

**Abstract** —Objective: Characterize and evaluate the prevalence of SB in physicians residing in the specialty of Gynecology and Obstetrics at the University Hospital Materno Infantil, Federal University of Maranhão, in São Luís, linking the epidemiological characteristics in order to identify risk factors. Method: Epidemiological questionnaires were used to define the variables and the Maslach Burnout Inventory (MBI), the most used instrument to evaluate SB. Results: From this, it was observed that the prevalence of SB among the above-mentioned residents is 80.8%; individuals who have renumbered activity outside the home have a higher personal achievement than those who do not have it; 2nd and 3rd year has a higher personal achievement level than first year residents. Conclusion: No significant differences were found in any of the SB variables in relation to age, marital status, gender, whether or not to have a child, whether or not to have pain / discomfort in the last 6 months, in relation to CH of weekly work outside the residence and the time of medical performance before entering the PRM (Medical Residency Program).

## I. INTRODUCTION

In professional practice, several psychosocial stressors are present, some related to the nature of their functions, others related to the institutional and social context in which they are performed. These stressors, if persistent, can lead to Burnout Syndrome (BS).[1]

The first research on BS is the result of studies on emotions and ways of dealing with them, developed with professionals who, due to the nature of their work, needed to maintain direct contact with other people.[2]

BS is directly related to the decrease in quality of life, it can be observed that the international scientific literature

shows many controversies about the concept and the term "quality of life", from synonyms such as "health conditions" and "social functioning" ", even about its own definition.[3]

Currently, a range of instruments has been established for the quantification and study of quality of life, with several semantic divergences, however, both adopt a biometric, psychometric and economic view of health.[3]

Economic changes, work accumulation, overtime and difficulties with technology potentiate health, emotional and interpersonal relationship problems within

organizations. These factors cause a decrease in productivity and compromise the motivation to work, having an impact on the very image of the organization.[4]

Therefore, the importance of analyzing the behavior of quality of life scores, as well as the formation of ideals that adapt the organizational conditions of work to the needs of workers, in this case, medical specialists in training.[4]

Medical residency as a model of internationally applied specialization, is the moment in which the young doctor - recently graduated, most of the time, is faced with more intense adverse situations than at any previous moment in his life.[5]

It is subjected to an excessive workload (officially with an upper limit of 60 hours per week - extrapolated in several situations), compared to most regular workers (which cannot exceed 40 hours), combined with insecurity in relation to their education and training in service, the tension of the hierarchy between residents of different years, preceptors and other employees of the hospital staff, not to mention the need for working hours outside the teaching hospital to supplement the income.[5]

BS is a chronic stress reaction, which causes indisposition and discomfort in the individual, resulting from a work situation. It can be easily observed when individual expectations related to professional practice are revealed through a non-corresponding reality, giving rise to a feeling of failure and impotence.[1]

The syndrome has a high prevalence in professionals in direct contact with people and exposed to an overload of work, presenting greater depletion of energy, lack of professional fulfillment, emotional exhaustion, depersonalization and reduced professional fulfillment or a feeling of incompetence.[1]

The implementation of Quality of Life at Work occurs when the work unit and the people involved in it as a whole are looked at, what he calls the biopsychosocial approach, which represents the differential factor for carrying out diagnoses, campaigns, creating services and implementation of projects aimed at the preservation and development of people while working at the company. This justifies the performance of behavioral analysis to quantify this measure in search of improving labor parameters.[5]

The objective of the study was to evaluate the prevalence of Burnout Syndrome in resident physicians of the Gynecology and Obstetrics specialty at the University Hospital Materno Infantil, Federal University of Maranhão, in São Luís.

## II. METHOD

A descriptive, observational, cross-sectional study was carried out with a quantitative approach with an epidemiological study type. This model was chosen because it encompasses, among other advantages, low cost, speed, objectivity in data collection and the ease of obtaining a representative sample of the population. [6]

The study population included resident physicians regularly enrolled in the Gynecology and Obstetrics specialty at the Hospital Universitário Materno Infantil, of the Federal University of Maranhão, in São Luís, regardless of gender, being over 18 years of age and being active in their particular position. in the study period.

Exclusion criteria were resident physicians of the Gynecology and Obstetrics service who are licensed, on leave due to illness or health problems, and residents absent during the research period.

According to data collected through data collected from the Department of Medical Residency in Gynecology and Obstetrics, the number of officially registered residents who fit the population studied was 26 (twenty-six), which constituted the sample for the study, considering that none were excluded after applying the criteria.

Data were collected through interviews and the application of an epidemiological questionnaire from the Maslach Burnout Inventory (MBI), a survey used to measure nuances in the pathological process of Burnout syndrome.

Residents are distributed in all sectors of the hospital, however, data collection and completion of research forms were carried out in the auditorium of the Hospital Materno Infantil, where they meet weekly to carry out theoretical activities, in such a way, that there is no harm in their daily practical activities. This action took place in July 2018.

The interview was applied after submission and approval on Plataforma Brasil and the research participants signed the Free and Informed Consent Term.

Participants initially answered the questionnaire with questions of a sociocultural approach, organized by the authors, which will address information such as: demographic, social, labor characteristics, opinion about working conditions, assistance services and physical and mental health care provided to these workers, level of personal engagement, mood peculiarities, ways of working and number of hours worked, followed by the most used instrument to assess BS, the MBI – Maslach Burnout Inventory, developed by Christina Maslach Susan Jackson in 1978.[7]

It is a questionnaire containing 22 items with 5 response options (Likert-type scale 1 to 5) which assesses the feelings and attitudes of professionals in their work on the following subscales: Emotional Exhaustion, Depersonalization and Decreased Personal Fulfillment. Each of these dimensions encompasses a certain group of questions that together represent its quantification. The Emotional Exhaustion and Depersonalization subscales indicate greater wear in the highest scores, while the Decreased Professional Achievement has the opposite direction, indicating greater wear in the lowest scores.

The MBI instrument is used to assess how workers experience their work, according to the three dimensions mentioned above, and uniquely identifies the Burnout Syndrome indices according to the scores of each dimension.[2]

To analyze the prevalence of the syndrome as a whole (the three dimensions grouped together), the criteria by Grunfeld et al. (2000), in turn, consider the diagnosis of burnout when the individual scores a high level in emotional fatigue or depersonalization, or a low level in personal fulfillment.[8]

The inventory is self-applying totaling 22 items. This questionnaire has its American version, in which the frequency of the response is evaluated through a scoring scale that varies from 0 to 6.[2]

Robayo and Tamoyo (1997 apud Borges et al., 2002) translated and adapted the MBI into Portuguese, in which individuals must respond according to a scale from 1 to 5.[9]

This Portuguese version was formulated due to the difficulty that certain people encountered in answering many items in the inventory, due to the high specificity of the original scale criteria. The version adapted to

Portuguese, despite considering only a five-item scale, uses the same type of frequency categories as the American version, that is, 1 for never, 2 for a few times a year, 3 for a few times a month, 4 to indicate a few times a week and 5 for daily.[10]

Data were evaluated using the IBM SPSS Statistics 20 (2011) program. Initially, descriptive statistics were applied, that is, graphs and frequency tables of all variables to obtain a demographic profile of the sample of the interviewed resident physicians. Then, ordinal variables related to Burnout Syndrome were calculated, they are: Emotional fatigue, Depersonalization and Personal fulfillment. Then, descriptive statistics of these ordinal variables were performed. And to assess the association of sociodemographic variables with these Burnout variables, the chi-square test of independence was used.

Then these three ordinal variables were evaluated by the nonparametric tests of Mann Whitney and Kruskal Wallis, when in the evaluations, of two groups or more than two groups, respectively. In all tests, the level of significance for rejecting the null hypothesis was 5%, that is, a value of  $p < 0.05$  was considered statistically significant.

In addition, graphs and tables made in Microsoft Excel 2010 software were used, and Microsoft Word 2010 software was used to produce and format the text.

### III. RESULTS

Regarding the year of residence, age, gender, having or not having children, exercising a paid activity in addition to the residence, working hours outside the weekly residence, time of medical practice before the residence and presence of pain or discomfort in the last 6 months, with presence or absence of absence, table 1 was obtained:

Table 1 - Frequency distribution of socio-demographic variables (N=26)

Sociodemographic	N	%	sociodemographic	n	%
<b>Year of residence</b>			<b>Weekly extra residence hours (n=19)</b>		
R1	10	38,5	6 a 10	3	15,8
R2	7	26,9	11 a 15	2	10,5
R3	9	34,6	16 a 20	4	21,1
			21 a 30	7	36,8
<b>Age</b>			31 a 40	2	10,5
20 – 25	5	19,2	> 40	1	5,3
26 - 30	15	57,7			
> 30	6	23,1	<b>Time of medical practice before residency</b>		
			< 1	12	46,2

<b>Gender</b>			1 a2	8	30,8
Female	18	69,2	3 a 4	5	19,2
Male	8	30,8	≥ 5	1	3,8
<b>Marital status</b>			<b>Type of contract</b>	<b>Overtime hours extra (n=19)</b>	
Single	18	69,2	Administrative contract	10	52,6
Married	7	26,9	Verbal Contract	9	47,4
Outro	1	3,8			
			<b>Pain/discomfort 6 months</b>		
<b>Sons</b>			Yes	24	92,3
Yes	19	73,1	No	2	7,7
No	7	26,9			
			<b>He took time off work to take care of his health</b>		
<b>Paid activity outside the residence</b>			Yes	7	26,9
Yes	19	73,1	No	19	73,1
No	7	26,9			
<b>Which one?</b>					
Duty	18	94,7			
Nursery	1	5,3			
Total	26	100,0	Total	26	100,0

Source: Research Protocol, 2019.

The general distribution of SB variables among residents is shown in Table 2:

Table 2 - Frequency distribution of Burnout Syndrome variables in all residents.

Síndrome de Burnout	n	%
<b>Emotional fatigue</b>		
Medium	10	38,5
High	16	61,5
<b>Despersonalização</b>		
Low	2	7,7
Medium	6	23,1
High	18	69,2
<b>Realização pessoal</b>		
Low	19	73,1
Medium	6	23,1
High	1	3,8
Total	26	100

Source: Research Protocol, 2019.



Table 3a - Frequency distribution of S. Burnout questionnaire variables

Quiz	n	%	Quiz	n	%
<b>1. I feel emotionally drained from my work.</b>			<b>6. Working with people all day takes a lot of effort.</b>		
Nº/year	4	15,4	Never	7	26,9
Nº/month	10	38,5	Nº/year	5	19,2
Nº/week	7	26,9	Nº/month	5	19,2
Daily	5	19,2	Nº/week	5	19,2
			Daily	4	15,4
<b>2. I feel tired at the end of the workday.</b>			<b>7. Effectively deal with people's problems.</b>		
Nº/ year	2	7,7	Never	1	3,8
Nº/ week	12	46,2	Nº/year	2	7,7
Daily	12	46,2	Nº/month	4	15,4
			Nº/week	12	46,2
			Daily	7	26,9
<b>3. When I get up in the morning and go to another workday, I feel tired.</b>			<b>8. My work leaves me exhausted.</b>		
Nº/year	3	11,5	Nº/year	3	11,5
Nº/month	4	15,4	Nº/month	6	23,1
Nº/week	10	38,5	Nº/week	10	38,5
Daily	9	34,6	Daily	7	26,9
			<b>9. I feel that through my work I positively influence the lives of others.</b>		
<b>4. I can easily understand how people feel.</b>			Nº/year	2	7,7
Nº/ year	2	7,7	Nº/month	3	11,5
Nº/ week	10	38,5	Nº/week	3	11,5
Daily	14	53,8	Daily	18	69,2
			<b>10. I've become more insensitive to people since I've been doing this job.</b>		
<b>5. I believe I treat some people as if they were impersonal objects.</b>			Never	6	23,1
Never	5	19,2	Nº/year	6	23,1
Nº/year	11	42,3	Nº/month	6	23,1
Nº/month	4	15,4	Nº/week	2	7,7
Nº/week	5	19,2	Daily	6	23,1
Daily	1	3,8			
Total	26	100,0	Total	26	100,0

Source: Research Protocol, 2019.

Table 3b - Frequency distribution of the variables of the S. de Burnout questionnaire

Quiz	n	%	Quiz	n	%
<b>11. I am concerned that this job is hardening me emotionally.</b>			<b>15. I don't really care what happens to the people I serve.</b>		
Never	5	19,2	Never	16	61,5
Nº/year	5	19,2	Nº/year	4	15,4
Nº/month	6	23,1	Nº/month	4	15,4
Nº/week	2	7,7	Nº/week	1	3,8
Daily	8	30,8	Daily	1	3,8
<b>12. I feel very vital.</b>			<b>16. Working directly with people causes me stress.</b>		
Never	4	15,4	Never	2	7,7
Nº/year	3	11,5	Nº/year	6	23,1
Nº/month	9	34,6	Nº/month	9	34,6
Nº/week	7	26,9	Nº/week	5	19,2
Daily	3	11,5	Daily	4	15,4
<b>13. I feel frustrated in my work.</b>			<b>17. I can easily create a relaxed atmosphere for people.</b>		
Never	7	26,9	Never	2	7,7
Nº/year	10	38,5	Nº/year	5	19,2
Nº/month	4	15,4	Nº/month	5	19,2
Nº/week	3	11,5	Nº/week	8	30,8
Daily	2	7,7	Daily	6	23,1
<b>14. I think I'm working too much.</b>			<b>18. I feel stimulated after working with people</b>		
Nº/year	4	15,4	Never	1	3,8
Nº/month	8	30,8	Nº/year	3	11,5
Nº/week	5	19,2	Nº/month	4	15,4
Daily	9	34,6	Nº/week	14	53,8
			Daily	4	15,4
Total	26	100,0	Total	26	100,0

Source: Research Protocol, 2019.

Table 3c - Frequency distribution of variables from the S. de Burnout questionnaire

Quiz	n	%
<b>19. I have achieved many achievements in my profession.</b>		
Never	1	3,8
Nº/month	8	30,8
Nº/week	12	46,2
Daily	5	19,2

**20. I feel at the limit of my possibilities.**

Never	5	19,2
Nº/year	7	26,9
Nº/month	5	19,2
Nº/week	6	23,1
Daily	3	11,5

**21. I feel I know how to properly handle emotional problems in my work.**

Never	1	3,8
Nº/year	2	7,7
Nº/month	8	30,8
Nº/week	7	26,9
Daily	8	30,8

**22. I feel that people somehow blame me for their problems.**

Never	6	23,1
Nº/year	6	23,1
Nº/month	8	30,8
Nº/week	3	11,5
Daily	3	11,5
Total		26 100,0

Source: Research Protocol, 2019.

**IV. DISCUSSION**

The study showed that the group of residents evaluated at the University Hospital of the Federal University of Maranhão - Maternal-Infant Unit is composed mostly of the female profile, single, aged between 26 and 30 years, attending the first year of residency, with children, exercising paid outside the residence in the form of a shift, with a weekly workload outside the residence between 21 and 30 hours, with a medical practice time of less than 1 year before the beginning of the medical residency and who report pain or discomfort in the 6 months before the pushing.

These results show that our study is in line with the literature since Fabichak et al. (2014), mentions that in the studied group it was noticed that the sociodemographic profile was composed mainly of female residents, young, single, without children and recently graduated.[11]

As for Lima et al. (2007), the highest frequency was recorded in male residents, with a mean age of 27.2 years and single marital status. [12] According to Martins et al. (2011), the author describes that the sociodemographic profile of his study group is formed mainly by female residents, average age of 27.3 years, without children and attending the first year of residency.[13]

The prevalence of BS among GO residents is 80.8%, surpassing the finding by Martini et al (2010), who found a rate of 75% among resident physicians of the same specialty.[14]

Such prevalence can be justified by the fact that this syndrome mainly affects professionals who deal directly with people, and whose work requires high doses of dedication and involvement, in addition to strenuous working hours and night and weekend shifts.[15]

Regarding the distribution of BS variables, our study shows that the main evidence of residents are emotional fatigue (61.5%), depersonalization (69.2%) and professional fulfillment (73.1) are classified as high.

For Paredes et al. (2008), the BS variables evidenced (emotional fatigue - 47.1%, depersonalization - 55.9% and professional fulfillment - 68.1%) in their study are classified predominantly as low. According to Lima et al. (2007), when specifically evaluating each dimension of the BS, it was observed that emotional fatigue (65.0%) and depersonalization (61.7%) are classified as high by residents, however professional fulfillment (30.0%) is classified as low.[16]

As for Fabichak et al. (2014), the dimensions of DS considered high are emotional exhaustion as well as depersonalization, both with 75%. However, levels of professional achievement were low in 70.8% of residents.[11]

In view of the records in the literature, our results converge with the experiments of other researchers with regard to the variables/dimensions emotional fatigue and depersonalization, however, with regard to professional fulfillment, our study showed that 73.1% of resident physicians reported having high professional achievement, differing from the data found in the literature.

Significant statistical differences were evidenced in this research protocol, taking into account the dimensions of BS in relation to: paid activity outside the residence, those who exercise it and those who do not exercise it, with regard to the dimension of professional achievement resulting in p-value: 0.049, defining that individuals who have extra paid activity have greater achievement than those who do not.

Among the residents who presented pain/discomfort in the last 6 months before the survey, in relation to the dimensions emotional fatigue and professional fulfillment resulting in p-values, respectively: 0.026 and 0.042, it appears that those who left work had a median of greater emotional fatigue and lesser personal fulfillment than those who did not walk away.

Regarding the year of residence, between being in the 1st, 2nd or 3rd year, in relation to the dimension of professional achievement, a significant p-value difference was found: 0.042, demonstrating that 2nd and 3rd year residents have a level of achievement higher than 1st year residents.

In this study, no significant differences were found ( $p > 0.05$ ) in the variables: emotional fatigue, depersonalization and personal fulfillment in relation to age, marital status, sex, having or not having a child, having or not having pain/discomfort in the last 6 months, in relation to the weekly work HC outside the residence and the time of medical practice before joining the MRP.

According to Gouveia et al. (2017), their study identified that the statistically significant differences were: marital status regarding being married or not, with regard to the dimension of professional achievement, revealing the p-value: 0.04; whether or not to have children, with regard to the dimension of professional achievement with p-value: 0.04; having or not having a specialization in the surgical area, sensitizing the emotional fatigue dimension with p-value: 0.03; having pain/discomfort in the last 6 months before the survey, in relation to the emotional tiredness and depersonalization dimensions, with p-value

respectively:  $< 0.01$  and  $0.02$ ; regarding having adequate supervision during the residency, in relation to the dimension of emotional fatigue, with p-value: 0.04.[17]

As for Martini et al. (2004), the data identified by the authors were organized according to the global quantitative for BS dimensions, and the authors identified the following statistically significant differences: year of residence in terms of being in the first or other years, with p-value :  $< 0.01$ ; satisfaction with the residency service in terms of being satisfied or not, with p-value:  $< 0.01$ ; family stress and whether or not to present recent episodes, with p-value:  $< 0.05$ ; marital status in relation to being married or not, with p-value:  $< 0.01$ . In their findings, they indicate that the first year of residence and being single are independent factors that contribute to BS and there is no direct association with having children or not.[14]

According to Martins et al. (2011), their intervention study for SB divided residents into two groups, one experimental and the other control, in which residents were evaluated at two different times, one before the intervention applied, only to the experimental group with information about the SB, and another after the intervention. The global assessment of BS revealed a statistically significant difference with p-value: 0.031 in the depersonalization dimension of the experimental group.[13]

For Paredes et al. (2008), the study identified that the statistically significant differences for p-value  $< 5\%$  were: acceptance and control, with regard to the dimension of depersonalization, revealing the p-value: 0.023; whether or not to have professional bonds, with regard to the dimension of depersonalization.[16]

Zis et al. (2014), indicates that the statistically significant differences were: regarding gender, in the depersonalization dimension with p-value:  $< 0.001$ ; age according to age group, in the dimension of professional achievement with p-value:  $< 0.05$ ; marital status regarding being married or not, in the dimensions of emotional fatigue and depersonalization, with p-value:  $< 0.05$ ; working time in the case of the study according to European guidelines, in the dimension of professional achievement, with p-value:  $< 0.05$ ; as for having adequate supervision during the residency, in relation to the dimension of emotional fatigue, p-value:  $< 0.05$ ; intellectual demand, in relation to the dimensions of depersonalization and professional achievement, with p-value, respectively:  $< 0.05$  and  $< 0.01$ ; management of family conflicts, in relation to the dimensions of emotional fatigue and depersonalization, with p-value:  $< 0.001$ ; autonomy, in relation to the dimensions of depersonalization and professional accomplishment, with

p-value, respectively:  $< 0.05$  and  $< 0.01$ ; paid activity, in the dimensions of emotional fatigue and professional fulfillment, with p-value:  $< 0.001$ . [18]

In view of the previously expressed results, it is possible to evidence that the literature has a wide range of BS associations with different parameters, giving researchers freedom to evaluate several factors that may interfere with the manifestation of BS.

## V. CONCLUSION

In 80 years of history, since the implementation of the first medical residency program in Brazil, there have been no subsidies that discredit the supervised internship model as the gold standard of medical specialization, through which the physician acquires practical experience and applied specialized theoretical knowledge. in service.

It is also observed that this is the moment of professional initiation for the vast majority of physicians, considering the hypothesis that the current level of technical and scientific development in the general training of physicians at graduation is not capable of ensuring the necessary level of training. in the practical activities of all areas, the fact that the medical residency is concentrated in a single area, which in itself, already reduces the scope of the learning area, still offers the opportunity of contact with patients that, sometimes, can be prove insufficient so far.

Allied to all these benefits, it must be considered that this phase of the doctor's life is full of insecurities, fears, demands, lifestyle changes and volatility. It is the moment when the doctor undergoes exhausting working hours, with remuneration below the desired standard and sometimes, the lack of professional recognition and the absence of support from preceptors and/or management, depending on the hospital, may also be added. in which they are inserted.

Within this context, the ideal environment for the development of BS is presented, from which an intoxicating cycle begins to emerge between the increase in emotional fatigue, depersonalization with a consequent decrease in professional fulfillment and the fall in the use of learning and quality. of life of the authors involved, including patient care.

This study, as well as many others, clearly points to the high prevalence of BS in a certain group of resident physicians. It is true to say that Gynecology and Obstetrics shows signs of having a strong association with BS in several studies, however, it should be taken as a warning, in an attempt to minimize stressors, in order to reduce its incidence among residents, improving their quality of life

so that they can provide their best for joint development with the institution that welcomes them.

The exact form of these interventions should be carefully studied, combining representatives of the entity and administrators of the medical education system.

BS is a disease, sometimes with catastrophic losses, and must be managed as such, with the adoption of prevention measures and treatment strategies.

The Medical Residency is probably the moment that most strongly marks the professional profile of young doctors. Medical education institutions are directly responsible for the professionals they train, and results of studies like this one show a delicate situation that residents are going through and raise the discussion of where the problems are and how to change them.

The medical specialization model is far from ideal, it is clear that alternatives must be sought to improve the quality of life of resident physicians. At first, it is up to the managers of the hospitals in which these professionals are inserted, to listen to them, establish desires and main needs, in order to promote their relief, stimulate professional recognition and collaborate for their well-being, so that both learning, when serving the public is done in a pleasant and effective way.

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# Mental Health Strategies in Primary Care: Teaching and Service Articulation, in Tucuruí, Pará, Amazon

## Estratégias Em Saúde Mental Na Atenção Primária: Articulação Ensino E Serviço, Em Tucuruí, Pará, Amazônia

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Received: 20 Jul 2022,

Received in revised form: 15 Aug 2022,

Accepted: 22 Aug 2022,

Available online: 31 Aug 2022

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**Keywords**— Primary health care, Mental health, Health services.

**Palavras-chave**— Atenção primária à saúde, Saúde mental, Serviços de saúde.

**Abstract**— In the Brazilian Psychiatric Reform movement, health professionals, family members, users and managers built new ways of producing mental health care, transforming the limitations of the biomedical model with social exclusion and turning to the territorial-based care model, with the construction of daily care services organized in a network. The general objective of this study is to articulate the teaching and service integration through an initial listening guide in mental health in the Family Health Strategy in the Municipality of Tucuruí-PA. This is a field research study, with a qualitative approach, of a descriptive nature, aimed at nursing professionals, using the technique of data collection with semi-structured interviews. Data interpretation analyzes were performed through content analysis in the categorical-thematic modality according to Bardin's technique, being structured in three thematic categories: sociodemographic profile of the participants, mental health care in the health service and articulation of the network of mental health care. The results show that most participants do not act directly in the mental health demand, carrying out the referral when they detect emotional distress, with difficulties in articulating the network. There is a need to invest in the continuing education of nursing in the face of psychological care, as they do not feel prepared to meet this demand. This research generated as a product an initial care guide in mental health to assist in the nursing consultation and in the reception of people with complaints of emotional distress.

**Resumo**— No movimento da Reforma Psiquiátrica Brasileira,

*profissionais de saúde, familiares, usuários e gestores construíram novas maneiras de produzir o cuidado em saúde mental, transformando as limitações do modelo biomédico com exclusão social e voltando-se ao modelo de cuidado de base territorial, com a construção de serviços de atenção diária organizados em rede. O objetivo geral deste estudo é articular a integração ensino e serviço por meio de um guia de escuta inicial em saúde mental nas Estratégia Saúde da Família no Município de Tucuruí-PA. Trata-se de um estudo de pesquisa de campo, com abordagem qualitativa, de caráter descritivo, direcionado ao profissional de enfermagem, sendo utilizada a técnica de coleta de dados com entrevista semiestruturada. As análises de interpretação dos dados foram realizadas por meio da análise de conteúdo na modalidade categorial-temática segundo a técnica de Bardin, sendo estruturada em três categorias temáticas: perfil sociodemográfico dos participantes, atendimento em saúde mental no serviço de saúde e articulação da rede de atenção à saúde mental. Nos resultados constatam-se que a maioria dos participantes não atuam diretamente na demanda de saúde mental, realizando o encaminhamento quando detectam sofrimento emocional, havendo dificuldades na articulação na rede. Nota-se necessidade de investimentos na formação continuada da enfermagem frente ao atendimento psicológico, pois os mesmos não sentem-se preparados para atender essa demanda. Essa pesquisa gerou como produto um guia de atendimento inicial em saúde mental para auxiliar na consulta de enfermagem e no acolhimento de pessoas com queixas de sofrimento emocional.*

## I. INTRODUÇÃO

Com o movimento da Reforma Psiquiátrica Brasileira, desde o final da década de 1970, profissionais de saúde, familiares, usuários e gestores vêm debatendo e construindo novas maneiras de organizar e operar o cuidado em saúde mental, saindo de um modelo biomédico, tutelar, com exclusão social, restrição dos direitos dos indivíduos com sofrimento mental e voltando-se para um modelo de cuidado de base territorial, mais integral, horizontal, multiprofissional, intersetorial, longitudinal e contextualizado, com a construção de serviços de atenção diária organizados em rede [1].

Os transtornos mentais (TM) são considerados um problema de saúde pública, devido sua alta prevalência em contraponto com a escassez de serviços. As avaliações mundiais afirmam a necessidade de ampliação dos sistemas de saúde, já que a taxa dos que necessitam e não são tratados é elevada, sobretudo nos países em desenvolvimento [2].

Segundo o Caderno de Atenção Básica nº 34 [3], o cuidado em saúde mental na Atenção Básica é bem planejado pela facilidade de comunicação das equipes com os usuários. Devido essas características, é frequente que os profissionais de Saúde se deparem em diversas situações com pacientes em condição de sofrimento psíquico. Contudo, diante de sua importância, a realização

de condutas em saúde mental na Atenção Básica gera muitas dúvidas, curiosidades e receios nos profissionais de Saúde.

Quando o serviço abre um canal de escuta com o usuário, abre uma possibilidade para que as pessoas tragam, para dentro do centro de saúde, as suas queixas, os seus problemas e as suas necessidades. Nem sempre é fácil ouvir. É mais fácil trabalhar com uma ‘queixa-clínica’, uma parte do corpo que dói, uma doença que precisa de medicamento. Quando abrimos A Atenção Básica e a Estratégia Saúde da Família um espaço para o diálogo com o usuário, por mais reduzido que seja, abrimos uma porta para que a ‘vida lá fora’ entre na dinâmica da unidade [4].

Na consolidação do Sistema Único de Saúde (SUS), a Estratégia Saúde da Família (ESF), tornou-se um dispositivo estratégico para mudança do modelo assistencial curativo e hospitalocêntrico para, em suas diretrizes, enfatizar a prevenção de doenças, o controle de agravos e a promoção da saúde. As ações devem ser operadas no contexto territorial e comunitário com atuação multidisciplinar e participativa [5].

Segundo o Guia prático de matriciamento em saúde mental [6], no processo de integração da saúde mental à atenção primária (AP), o matriciamento ou apoio matricial surge como um novo modelo de produzir saúde, fazendo



com que duas ou mais equipes desenvolvam uma proposta de intervenção pedagógico-terapêutica, num método de construção compartilhada. Ele pode ser realizado por profissionais de diversas áreas especializadas.

O matriciamento, formulado por Gastão Wagner Campos em 1999, tem estruturado em nosso país um cuidado somativo entre a saúde mental e a AP, onde as ações devem ser operadas no contexto territorial e comunitário com atuação multidisciplinar e participativo [7].

Neste contexto, estratégias por meio da educação permanente como a prática de ensino-aprendizagem resultam na produção de conhecimentos no cotidiano das instituições de saúde, a partir da realidade vivida pelos atores envolvidos, tendo suas experiências no dia-a-dia como base de interrogação e mudança. É definida, como uma forte vertente educacional com potencialidades ligadas a mecanismos e temas que possibilitam gerar reflexão sobre o processo de trabalho, autogestão, mudança institucional e transformação das práticas em serviço [8].

No recente contexto social, observa-se que a percepção do mundo se modifica a cada momento. Dessa forma, as instituições de ensino têm discutido a urgente necessidade de reeditar seu papel social e o processo de ensino-aprendizado ainda vigente, devendo estimular cada vez mais o pensamento crítico e a autonomia do estudante. Ainda que descrito na Constituição Federal (CF), de 1988, que o SUS deve “ordenar” o processo de formação dos profissionais na área da saúde, pouco se tem visto na prática institucional, alargando a ponte entre a formação dos profissionais e as reais carências do SUS [9].

Com isso, a lei de Diretrizes e Bases da Educação Nacional (LDB) e as Diretrizes Curriculares Nacionais (DCN) incentivam nas instituições formadoras dos cursos da área da saúde a busca por um modelo que possibilite a aproximação da realidade social, incitando o aluno a refletir sobre o meio em que vive e possuir um raciocínio crítico a fim de buscar meios que possam transformar seu contexto [10].

Dessa forma, essa pesquisa tem como finalidade articular a integração ensino e serviço, por meio da implantação de um guia de escuta inicial em saúde mental nas Estratégias de Saúde da Família no Município de Tucuruí-PA.

## II. MÉTODO

A pesquisa foi pautada em um estudo de campo com abordagem qualitativa descritiva. A pesquisa de campo é para Marconi e Lakatos [11] aquela utilizada com o

objetivo de conseguir informações e/ou conhecimento sobre um problema, para o qual se procura uma resposta, ou de uma hipótese, que se queira comprovar, ou ainda, descobrir novos fenômenos ou as relações entre eles.

De acordo com Mattar e Ramos [12], os estudos qualitativos têm como objetivo principal abranger determinados fenômenos em sua profundidade e diante disso, é indispensável realizar a exploração e descrevê-los por inúmeras perspectivas, além de entender as interpretações e os significados que os entrevistados no estudo fazem a respeito destes fenômenos e os correlacionam às suas vivências pessoais.

Segundo Minayo [13], a pesquisa qualitativa é fundamentada em aspectos que não podem ser quantificados, enfocando assim, na explicação e compreensão do processo de interações interpessoais. Essa abordagem de pesquisa trabalha com um universo de significados, crenças, valores, atitudes que representam um espaço mais aprofundado nas relações. Dessa forma, tem alargado sua área de atuação em campos como psicologia e educação.

Em relação ao caráter descritivo, Oliveira [14] relata que ocorre certa dificuldade em diferenciar uma pesquisa descritiva de experimental, e de fato podem gerar certa dificuldade. Dessa forma, a pesquisa descritiva tem interesse em descobrir e realizar a observação fenomenológica, buscar descrevê-la, interpretá-la e classificá-la. É uma forma de análise mais aprofundada do real em pesquisa.

Nesse sentido, o estudo utilizou como público alvo os enfermeiros que atuam em ESF no Município de Tucuruí-PA, compondo um total de 24 profissionais. Nesse estudo, ressalta-se que foi abrangido um quantitativo de 87,5% dos profissionais atuantes na rede básica no município.

Dessa forma, após passar pelo processo de aprovação do Comitê de Ética em Pesquisa (CEP), sob o CAAE: 51381621.7.0000.5171 e autorização da instituição onde ocorreu a pesquisa, a coleta de dados foi realizada no período entre janeiro e março de 2022, utilizando como instrumento para a técnica de coleta de dados a entrevista semiestruturada, que segundo Oliveira [14], constitui-se em um método para obter informações sobre determinado assunto, baseando-se em um roteiro com séries de perguntas abertas e fechadas seguindo o objetivo da pesquisa.

Vale destacar a importância da construção de boas perguntas, da necessidade de sermos boas ouvintes, das interpretações e respostas de forma atenciosa, buscando ser impessoal para que não ocorresse engano quanto a ideologia própria e preconceitos, levando em consideração a valorização do objetivo do estudo.

A coleta de dados constituiu-se por quatro etapas, sendo elas:

1º ETAPA: Houve uma reunião presencial com o secretário Municipal de Saúde e a direção da AB do município, no qual foi apresentada a ideia da pesquisa levando o material do projeto impresso, com interação verbal sobre como seria realizada a pesquisa, sua metodologia e benefícios para o público alvo.

2º ETAPA: Essa etapa foi realizada por acadêmicas do curso de Enfermagem da Universidade do Estado do Pará – Campus XIII sob orientação da pesquisadora principal. As assistentes da pesquisa abordaram os profissionais de enfermagem em seu ambiente de trabalho, com o intuito de apresentar o projeto e seus objetivos. Após a apresentação realizou-se o convite para participação na pesquisa. Foi solicitado à coordenação das unidades uma sala reservada e confortável para a entrevista, contudo deu-se ao profissional a livre escolha de outro local que lhe fosse mais confortável ou adequado.

3ª ETAPA: Aos profissionais que aceitaram participar do estudo foram esclarecidos sobre os propósitos, riscos e benefícios, mediante a leitura do Termo de Consentimento Livre e Esclarecido – TCLE (Apêndice D), no qual constava os termos legais da pesquisa que resguardava aos entrevistados de acordo com a resolução 466/12-CNS, sendo solicitada a assinatura de duas vias do termo (uma para a pesquisadora e outra para o participante). Também esteve evidente ao participante o direito de desistência a qualquer momento da pesquisa, sem nenhum dano ou perda;

4ª ETAPA: Após o diálogo e aceitação de participação da pesquisa e assinatura do TCLE, efetuou-se a entrevista semiestruturada individual, mediante roteiro contendo perguntas abertas e fechadas, elaborada pela pesquisadora. As respostas foram gravadas com o auxílio de um gravador de voz, ocorrendo de maneira individual.

Para a realização da pesquisa utilizou-se um questionário semiestruturado, apresentando 05 subcategorias para melhor organização do raciocínio lógico e entendimento do entrevistado, sendo essas: a identificação, a caracterização social e econômica, o atendimento em saúde mental no município, a articulação da rede de atenção à saúde mental e proposta de intervenção.

Vale ressaltar que, ao todo o questionário aborda 18 perguntas, entre abertas e fechadas, enumeradas e de caráter objetivo e direto, que visa esclarecer a demanda e acesso ao atendimento psicológico ao público atendido na APS, assim como, identificar a visão dos profissionais a respeito da necessidade de melhorias no atendimento em saúde mental do município.

Esse instrumento deu-se respondido pelo profissional de saúde no decorrer da entrevista e preenchido pelas entrevistadoras, no mesmo instante para não haver obstrução de informações e aprovação, por parte do entrevistado, dos dados previamente computados, contando com a gravação dos diálogos para que não houvesse perda de informações pertinentes à pesquisa.

A partir da conclusão da pesquisa de campo e arquivamento dos áudios das gravações, a pesquisadora iniciou então a transcrição e análise dos dados obtidos.

Esses dados foram investigados mediante a análise de conteúdo, proposto por Bardin [15], o qual compreende um conjunto de técnicas e de análise das comunicações que utiliza procedimentos sistemáticos com o objetivo de descrição do conteúdo das mensagens. Logo, esse método descreve as diferentes fases da análise dos conteúdos como: pré-análise, exploração do material, tratamento dos resultados e interpretação. Dessa forma, foi desenvolvido da seguinte maneira:

Pré-Análise: Houve a organização das respostas de forma sistemática e em seguida a leitura das respostas de forma que atingisse a compreensão dos seus significados. As transcrições foram feitas em sua completude no programa Microsoft Office Word 2013 identificando os participantes através da codificação garantindo o anonimato.

Então se delimitou o “corpus” (composto por todos os documentos selecionados para análise como falas de informantes-chaves e relatos importantes), nos quais foram ordenados no conjunto de documentos para serem submetidos a análises. Assim, foram elaborados os indicadores que constituiu a base para a interpretação final. Portanto, essa etapa foi decisiva para a origem da uniformidade de registros e de contexto, recortes, da forma de categorização, da modalidade de codificação e dos conceitos teóricos que poderiam orientar a análise.

Exploração do material: Consistiu na categorização dos dados para que se alcançasse a profunda compreensão dos textos, e a partir da criação das categorias temáticas criadas, ocorreu à realização da descrição das características expressas nos relatos. Essa fase foi feita no programa Microsoft Office Word 2013 no que diz respeito à organização das categorias em gráficos e tabelas, facilitando assim a visualização dos dados para análise.

Tratamento dos resultados obtidos e Interpretação: Nessa fase, os dados gerais da pesquisa são trabalhados para se tornarem significativos e válidos. Diante disso os resultados passaram por inferências e interpretações, de modo a possibilitar categorias em suas dimensões, promovendo assim a construção do saber científico a respeito do objeto pesquisado. Contudo, vale ressaltar que

as variáveis sócio-demográficas foram analisadas por meio das estatísticas descritivas.

### III. RESULTADOS E DISCUSSÃO

Durante a coleta de dados foram convidados 24 enfermeiros no qual 21 puderam ser entrevistados e os demais foram excluídos devido a justificativa de recusa, ou não se encaixar nos critérios de inclusão da pesquisa em questão.

A discussão dos dados foi dividida em três categorias temáticas, sendo a primeira correspondente ao perfil sociodemográfico dos participantes que constitui de idade, sexo, tempo de atuação na saúde, titulação, vínculo empregatício e tempo de atuação na ESF. Nessa primeira categoria as informações foram extraídas da classe I e II do roteiro de entrevista semi-estruturada.

A segunda categoria temática foi denominada atendimento em saúde mental na ESF baseada nas perguntas efetuadas no roteiro de pesquisa e analisadas utilizando diagrama temático categorial para cada análise da investigação. Nessa segunda categoria as informações foram extraídas da classe III. A terceira categoria temática foi denominada articulação da rede de atenção à saúde mental referente as perguntas contidas nas classes IV e V do roteiro de entrevista.

#### A. Perfil Sociodemográfico dos Participantes

Para a caracterização sócio-demográfica dos enfermeiros que fazem parte das Estratégias Saúde da Família neste estudo, foram utilizados seis (6) variáveis: Idade, sexo, tempo de atuação na saúde, titulação, vínculo empregatício e tempo de atuação na ESF. Na primeira há análise de variáveis do perfil pessoal dos participantes: idade e sexo. Na segunda tabela foi possível analisar as variáveis do perfil profissional.

*Tabela. 1: Distribuição dos integrantes da equipe de enfermagem que atua na saúde mental segundo as características sociodemográficas: idade e sexo.*

Característica	n(21)	%
<b>Idade</b>		
21 --- 30 anos	04	19,05%
31 --- 40 anos	09	42,85%
41 --- 50 anos	06	28,57%
51 --- 60 anos	01	4,76%
>61 anos	01	4,76%
<b>Sexo</b>		
Feminino	17	80,95%
Masculino	04	19,05%

Fonte: GOUVEIA, A. O. (2022).

De acordo com a tabela 1, percebe-se que em relação à idade 19,05% (4) pertenciam à faixa etária de 21 a 30 anos, 42,85% (9) entre 31 a 40 anos, 28,57% (6) estão entre 41 a 50 anos, 4,76% (1) entre 51 e 60 e 4,76% (1) acima de 61 anos. Observa-se que integrantes da equipe de enfermagem da faixa etária de 21 a 40 anos, representa um número expressivo. Estes dados corroboram com o estudo de Machado, *et al.* [16], no qual o autor afirma que 36,4% dos profissionais de enfermagem estão na faixa etária de 31 a 40 anos, demonstrando uma profissão de pessoas jovens.

Em relação ao sexo, a tabela 1 demonstra que 80,95% (17) eram do sexo feminino e 19,05% (4) do sexo masculino. Na pesquisa realizada pelo Conselho Federal de Enfermagem (Cofen) [17], vem corroborar com os achados neste estudo ao detectar que 84,6% dos profissionais de enfermagem são do sexo feminino e 15,4% são do sexo masculino, observando-se assim uma profissão no qual a população feminina é predominante.

*Tabela. 2: Distribuição dos profissionais enfermeiros que atuam nas ESF segundo as características profissionais.*

Característica	n(21)	%
<b>Tempo que atua na área da saúde</b>		
<1 ano	01	4,76%
1 --- 5 anos	09	42,85%
6 --- 10 anos	05	23,81%
11 --- 20 anos	02	9,53%
>20 anos	04	19,05%
<b>Especialização</b>		
Sim	18	85,71%
Não	03	14,29%
<b>Especialização</b>		
Saúde Mental	00	0%
Saúde Pública	02	9,53%
Saúde da Família	04	19,05%
Outro	12	57,13%
Não tem	03	14,29%
<b>Tipo de vínculo empregatício</b>		
Efetivo	10	47,62%
Contrato	11	52,38%
<b>Tempo de atuação na ESF</b>		
<1 ano	05	23,81%
1 --- 5 anos	11	52,38%

6 --- 10 anos	02	9,53%
11 --- 20 anos	03	14,29%

Fonte: GOUVEIA, A. O. (2022).

Com relação ao tempo de serviço dos entrevistados os dados demonstraram que ficou entre 06 meses e 25 anos, em que a maior proporção de profissionais mostrou tempo de serviço entre menos de um ano e 10 anos, com total de 71,42% dos entrevistados, da mesma forma evidencia-se no tempo de atuação na ESF, que a maior dimensão está entre menos de um ano e cinco anos de atuação resultando 76,19%, sendo uma proporção significativa com relação às demais.

Diante disso, a pesquisa de Machado et al.[18], sobre os aspectos gerais da formação da enfermagem, identificou que 63,7% dos enfermeiros estão formados há 10 anos ou menos, 38% já possuem 5 anos e apenas 5% tem mais de 30 anos de formação profissional. Ressaltando sob esta análise, que a profissão se encontra em processo de rejuvenescimento em decorrência de um maior número de instituições que oferecem este curso.

Contudo, é notório que apesar da oferta do curso e da acessibilidade a este ter tido um grande crescimento nos últimos anos, muitos estudos enfatizam que esse fator tem gerado uma perda significativa na qualidade da formação profissional, como demonstra os estudos de Colenci e Berti [19] que aplicaram sua pesquisa em 314 enfermeiros para investigar se a formação recebida por esses é apropriada para desempenhar suas funções durante a prática profissional, em que 53,8% consideraram que a formação não atende às necessidades da atividade de trabalho.

Além disso, observa-se que em relação à formação profissional, houve um significativo número de profissionais que possuem pós-graduação 85,71%, tendo 14,29% de profissionais apenas com a graduação, relacionado aos que possuem pós-graduação 100% eram do tipo lato sensu.

Todavia, nenhum dos profissionais inclusos no estudo apresentavam especialização em saúde mental ou aperfeiçoamento na área. Com isso, observa-se que uma formação apropriada, com interesse e comprometimento, qualidade em saúde mental desde o período de graduação e atualizações contínuas na área, podem facilitar ações de saúde pautadas no elo terapêutico na ESF, como o acolhimento qualificado, orientações pautadas na reabilitação do cliente, grupos de apoio e um trabalho coletivo em que se promovam estratégias de promoção à saúde, conforme proposto pela Reforma Psiquiátrica e pelo SUS [20].

Nesse sentido, a exiguidade de formação específica ou a desatualização no âmbito da saúde mental pode dificultar o acompanhamento das mudanças ocorridas nessa área da saúde, nos níveis nacional, estadual e municipal, e consequentemente, gerar uma assistência em saúde que não abranja a totalidade necessária. Ou seja, a formação específica pode ajudar na ampliação dos horizontes e promover reflexões sobre o processo de humanização, solidariedade, respeito, compromisso, julgamento embasado cientificamente, aceitação, liberdade e responsabilidade, oferecendo ao paciente um atendimento de qualidade e qualificado [20].

Ao que tange ao tipo de vínculo empregatício, a tabela 2 demonstra que os profissionais efetivos contabilizam 47,62% e os contratados somam 52,38%, o que caracteriza a maioria dos participantes. Tal dado demonstra a fragilidade do sistema de saúde, tendo em vista que, os profissionais em contrato, em geral, permanecem pouco tempo naquele estabelecimento de saúde, em média 02 anos de acordo com Bernardes [21], o que não permite estabelecer o vínculo necessário com comunidade assistida e, logo, com os pacientes.

Dessa forma, sabe-se que a Política Nacional de Atenção Primária à Saúde infere que as ESF's apresentam, ou deveriam apresentar uma proximidade maior com as famílias e as comunidades a quem oferece atendimento e, a partir de então, se constituiria em um recurso indispensável para o enfrentamento das diversas formas de sofrimento mental de maneira mais ativa [22].

As ESF's caracterizam-se como um conjunto de ações de saúde individuais, familiares e coletivas que envolvem promoção, prevenção, proteção, diagnóstico, tratamento, reabilitação, redução de danos, cuidados paliativos e vigilância em saúde, assim como também, é a estratégia prioritária para a ampliação da cobertura e consolidação da Atenção Primária de Saúde. Logo, o vínculo com as famílias e comunidade é imprescindível para seu funcionamento adequado [23].

#### B. Atendimento em Saúde Mental na ESF

Essa categoria refere-se à compreensão do profissional enfermeiro das ESF frente ao atendimento na demanda de saúde mental. Diante da análise das falas dos entrevistados observou-se ponderações sobre suas compreensões relacionado ao tema em questão, através de respostas breves, mesmo quando eram instigados a expor mais suas opiniões.

Ao serem questionados se atuavam diretamente com demandas de pacientes em sofrimento mental, notaram-se opiniões diversas coincidindo ou não com profissionais de outras estratégias. Em síntese, quando categorizado, observou-se que a maioria dos participantes 17 no total

(81%) informaram não atender diretamente essa demanda e quando detecta alguma situação de adoecimento psíquico encaminha ao médico da unidade ou ao psicólogo. Diante disso observamos alguns relatos:

*[...]não atuo diretamente, sempre encaminho ao médico para troca de receita. [...]* (E1)

*[...]nunca atuei, porém já referenciei. [...]* (E5)

*[...]não. Geralmente não temos esse tipo de atendimento e quando surge encaminho para o médico, porque não me sinto preparada. [...]* (E7)

*[...]diretamente não a gente faz esse encaminhamento para outro estabelecimento, principalmente o CAPS. [...]* (E19)

No entanto, também foi possível identificar que 4 participantes (19%) informaram atuar diretamente com pacientes em sofrimento psíquico.

*[...]sim, devido a APS ser a porta de entrada, então nós estamos diretamente ligadas a atender essa demanda. [...]* (E20)

*[...]atuo, mas não me sinto preparada. [...]* (E17)

*[...]sim, trabalhamos com atendimentos na demanda espontânea. [...]* (E4)

Para complementar a pergunta de que se atuavam diretamente com pacientes em sofrimento psíquico foram indagados se os mesmos sentiam-se preparados para prestar assistência a essa demanda e por unanimidade as respostas foram que não, como podemos observar em alguns relatos:

*[...]preparada? É sempre desafiador o seguimento psíquico, mas não me considero preparada. [...]* (E20)

*[...]não, porém entendo que seja para todos os profissionais ter esse manejo. [...]* (E12)

*[...]ao me deparar com sofrimento psíquico não me sinto preparada. [...]* (E15)

De forma geral os profissionais entrevistados relataram apresentar dificuldades em lidar com pacientes que apresentem queixas de sofrimento emocional e não se sentem preparados para realizar um atendimento qualificado a essa demanda, mas demonstraram interesse em se qualificar. Diante disso, Sousa et al. [24] destaca que a prática de saúde mental é uma atividade que compete como atribuição do enfermeiro, não sendo necessária a especialização específica para prestar um acolhimento adequado e os cuidados iniciais na AB, embora, atualizações e treinamentos à equipe seja crucial para um atendimento integral.

Fernandes, Matsukura e Lourenço [25] relatam que a forma que os profissionais encontram para proporcionar ajuda a demanda de saúde mental é referenciando aos serviços especializados como os CAPS para consulta especializada, o que de acordo com Conte et al. [26] acaba ocasionando uma grande demanda nesse serviço e faz com que sobrecarregue os profissionais que atuam em saúde mental, uma vez que os profissionais generalistas referenciam todos os pacientes com sintomas de sofrimento psíquico, desde casos considerados mais leves à graves, que poderiam ser resolvidos na AB.

Quando questionados se houvessem treinamentos para lidar com esse público, por unanimidade (100%) dos profissionais informaram nunca terem sido treinados para esse atendimento, até mesmo os profissionais com mais de 20 anos de atuação no município.

Conforme Gryscek e Pinto[27] é necessário que a formação e a capacitação dos profissionais da AB superem o conhecimento técnico, que envolve diagnóstico e uso de medicações, e abranjam também habilidades de comunicação, capacidade de trabalhar num modelo ampliado de atenção e manejo de problemas psicossociais. Essas ações por si só já fortalecem o acolhimento e o vínculo, trazendo benefícios na SM. Destarte as equipes das ESF têm grande potencial para prestar os cuidados em SM, principalmente devido ao vínculo que formam com as famílias.

Dessa forma, Frateschi e Cardoso [28] ratificaram os achados nessa pesquisa ao enfatizarem que em relação às fragilidades ou contradições referentes à saúde mental na ESF, há dificuldades em incorporar a assistência à saúde mental no enfoque da APS, devido ao despreparo desses profissionais. Tal fato enfatiza que a maioria dos profissionais não possui formação específica para lidar com os problemas de saúde mental e há falta de capacitações, treinamentos e/ou de atualizações nessa área

constitui um padrão angustiante e promovedor de dificuldades na realização de ações para a resolução de problemas diagnosticados na comunidade.

Além disso, a pouca produção de protocolos e manuais de enfermagem sobre atenção à saúde mental na APS, a verticalização dos programas desenvolvidos pelo Ministério da Saúde e seu carácter autoritário, assim como, o despreparo das famílias para lidar com a pessoa que necessita de tratamento e a ausência ou ineficiência dos sistemas de referências, são fatores que também contribuem para a problemática [28].

Ademais, devido às respostas breves dos entrevistados, foi feito um agrupamento de duas perguntas da entrevista no qual se complementam. Quando indagados sobre o envolvimento dos familiares no cuidado às pessoas em sofrimento psíquico e o que poderia ser oferecido a essas famílias na UBS, observou-se que as opiniões divergiam, contudo, a maioria respondeu que a família se envolve nas situações e que inclusive sofrem junto com o usuário, necessitando também de acolhimento em algumas situações. Como pode ser visto nos relatos:

*[...]sim há envolvimento... acredito que um acompanhamento psicológico voltado para família. [...] (E11)*

*[...]sim existe. Os familiares são fundamentais nesse processo. Esses familiares sofrem junto com o paciente, precisam ser acolhidos e de terapia familiar. [...] (E3)*

*[...]geralmente a família está envolvida sim... atendimento psicológico e como prioridade também. [...] (E10)*

*[...]não existe envolvimento nenhum, largam na rua como se a sociedade tivesse que tomar de conta... ser fornecido informações do que fazer para ter melhor qualidade de vida, porque querendo ou não a família também adoce e muitas vezes não sabe como lidar com paciente em surto. [...] (E17)*

*[...]não, geralmente são negligenciados e a família não presta apoio necessário...*

*Psicólogos todos os dias nas unidades. [...] (E7)*

Com base nisso, é válido inferir que durante a reabilitação dos pacientes em sofrimento mental, o sucesso do tratamento depende do entendimento da dinâmica familiar e da função que a doença assume na família e na vida do próprio paciente, pois, o envolvimento familiar no percurso da intervenção terapêutica de todas as manifestações de uma doença, sejam elas de carácter psicológico ou não, frequentemente torna a intervenção mais efetiva e multiplica os recursos de auxílio ao paciente, em especial a sua adesão ao tratamento [29].

Com isso, por ser o funcionamento familiar tão influente na proteção da saúde ou na manifestação de doenças, torna-se importante instrumentalizar os profissionais que estão na linha de frente, prestando atendimento à maioria das pessoas que procuram o sistema de saúde, para que possam reconhecer os sinais de disfunção e as áreas de capacitação da família, e dar-lhes recursos básicos para poder identificar famílias que necessitam atenção especial [29].

Os estudos de Reinaldo e Wetzel [30] reiteram que as novas diretrizes preconizadas pela Reforma Psiquiátrica visam à melhoria da qualidade de vida do usuário, no resgate de sua cidadania. Logo, essa qualidade de vida poderia, em parte, ser oferecida por meio de um melhor atendimento, redução das internações e período de internação, e, principalmente, a manutenção do usuário no meio familiar através de uma rede de saúde que ofereça suporte para esta família.

Nesse sentido, a ESF deve ter a família como aliada, no tratamento do usuário com transtorno psíquico, em que para sua integração é preciso que o serviço ofereça apoio constante, técnico e humanizado, ofertando atendimento integral a essa família. Os trabalhadores de serviços de saúde devem ter em mente a importância de um co-envolvimento da família dos pacientes nos projetos de reinserção social do indivíduo na comunidade, oferecendo informações e suporte profissional necessário para a família exercer sua função de agente socializador primário do ser humano.

É importante ser levado em consideração, durante a abordagem, que a presença de uma pessoa com sofrimento mental produz alterações no seio familiar, visto que antes da doença, a pessoa apresentava condições de contribuir, não só financeiramente, mas nas atividades domésticas e nas responsabilidades do dia a dia. Desse modo, quando ocorre a modificação no comportamento deste indivíduo, há modificações da rotina familiar, em que sente a falta da ajuda que era compartilhada e ainda arca-se com a responsabilidade de ajudar a pessoa doente [31].

Desta forma, a Equipe de Saúde da Família deve atuar no ambiente familiar, no sentido de amenizar o sofrimento da família e do próprio usuário. Esta ajuda oferecida pela ESF com suporte da equipe de saúde mental pode ser administrada através de visitas domiciliares, atendimento individual e familiar, assim como reunião de grupos na própria comunidade assistida [32].

### C. Articulação da Rede de Atenção à Saúde Mental

Essa categoria refere-se à articulação da rede de atenção psicossocial e ao apoio matricial desenvolvidos entre as equipes de saúde mental e as ESF. Foi observado divergências nas respostas dos entrevistados.

Quando questionados sobre a articulação que a UBS, no qual atua, faz com algum setor de saúde mental do município, a maioria respondeu que faz com o CAPS, mas que essa articulação poderia ser melhor, pois alguns relatam da dificuldade de conseguir atendimento. Observou-se que a articulação citada é com base nos encaminhamentos que são realizados para atendimento especializado no CAPS.

*[...]tem uma boa articulação, mas poderia ser melhor para que pudesse haver um melhor envolvimento, pois falta muita comunicação, visto que eu mesma nem sei quem é a equipe atual do CAPS. [...]* (E5)

*[...]sim, a gente tem a parceria com o CAPS, ele que atua e pega toda demanda do município quando a gente tem alguma situação encaminha pra lá. [...]* (E20)

*[...]tem acesso ao CAPS, porem com dificuldade. [...]* (E1)

*[...]não durante o período que estou. [...]* (E12)

*[...]temos atendimento com psicólogo e assistente social uma vez por semana. [...]* (E10)

Corroborando com essas citações, Garcia et al. [33], observou através das falas de profissionais que há municípios onde não são realizados o matriciamento em saúde mental, mesmo que tenha CAPS e NASF, no qual seriam as equipes responsáveis pelo apoio matricial.

De acordo com Vasconcelos e Barbosa [34], o apoio matricial ou matriciamento é uma estruturação de uma sugestão de intervenção terapêutico-pedagógica, feita de forma compartilhada, no qual envolve duas ou mais equipes. Propondo a realização de uma assistência especializada, promovendo vínculos profissionais e instituindo projetos comunitários terapêuticos, entre usuários e à comunidade.

Quando indagados se o município possui suporte para acompanhar em longo prazo, referenciar e contrarreferenciar o paciente psíquico, notou-se opiniões diversas no qual a maioria destacou não ter esse suporte.

*[...]Não, existe muita dificuldade para esse acompanhamento a longo prazo. Referenciamos, mas dificilmente recebemos essa contrarreferência. [...]* (E03)

*[...]Não, acredito que o município precisa ter melhorias, desde o âmbito administrativo até o financeiro. [...]* (E04)

*[...]Acredito que até certo ponto sim, eu acredito que deve existir, não sei te dizer, mas acredito que há sim um certo suporte. [...]* (E21)

Diante dessas falas observa-se que não há a articulação da rede de atenção psicossocial. Para Treichel et al. [35] a rede de saúde fragmentada e com baixa integração, além disso, a burocratização dos serviços, converte-se uma dificuldade para os pressupostos da proposta matricial, o que prossegue o número de encaminhamentos, decorrendo ainda, a descontinuidade das ações entre os níveis de atenção à saúde.

Os entrevistados foram questionados se haviam reuniões periódicas entre sua equipe e a equipe do CAPS. Por unanimidade foi relatado que não haviam reuniões periódicas, as reuniões acontecem para falar sobre ações, principalmente, no setembro amarelo.

*[...]Não temos diálogo com frequência, as poucas geralmente é pra convidar para ações, principalmente setembro amarelo. [...]* (E16)

*[...]Não, não temos essas reuniões, deixa até uma falha, porque precisamos reestabelecer o vínculo entre*

*CAPS e Unidade Básica. [...] (E19)*

Esse resultado contradiz com o estudo de Fagundes et al. [36] que identificou no cenário geral da pesquisa que pelo menos 60% das equipes declararam realizar as ações de matriciamento na presença de apoio matricial em saúde mental e afirmou que quando ocorre a execução do apoio matricial todas as práticas de matriciamento e estratégias de cuidado são potencializadas.

A ausência de articulações entre o CAPS e a atenção básica, desencadeia a centralização dos serviços, fazendo com que os serviços especializados sejam menos incluídos na comunidade e no território [33].

Dessa forma, evidencia-se que o apoio matricial serve como facilitador na resolução das situações de saúde mental advindas da atenção primária, uma vez que muitos usuários não necessitam chegar ao espaço de serviços especializados como os CAPS. Ademais, a grande maioria dos pacientes que procuram atendimento percorre diversos serviços de saúde e não veem atendidas as suas necessidades, no que se refere à saúde mental [37].

Em consonância, o CAPS tem por prerrogativa atender e tratar pacientes com transtornos mentais graves e persistentes, ficando as demais situações, tais como depressão leve e moderada, ansiedade e esquizofrenia estáveis, a cargo da atenção primária. Entretanto, frequentemente, os profissionais das equipes da atenção primária não se sentem preparados para lidar com essas situações devido à falta de articulação entre o CAPS com a APS e toda a rede atenção psicossocial [38].

Nesse sentido, os trabalhadores de serviços da atenção básica e de serviços especializados em saúde mental demonstram dificuldade em compreender o que de fato é o matriciamento, ou seja, percebe-se que não há clareza acerca da proposta de apoio matricial, muito menos há espaços para debates sobre matriciamento, bem como a respeito de outras estratégias possíveis para propor uma rede de atenção capaz de fazer a articulação e a interligação entre os serviços integrantes da saúde mental. Logo, torna-se claro a fragilidade, a fragmentação ou a inexistência de uma rede de cuidados e a falta de comunicação entre as equipes de saúde, o que inviabiliza de forma significativa o apoio matricial [39].

Dando sequência na entrevista quando perguntado qual a opinião sobre a criação de novos dispositivos de saúde mental e qual motivo considera que dificulta a criação desses dispositivos, foi unânime as respostas relacionadas ao quanto seria positivo para o município a criação de novos dispositivos de saúde mental, melhorando o fluxo de atendimento, ampliando o olhar para a saúde mental, no qual houve um aumento significativo na demanda após a

pandemia, relacionado as dificuldades foram expostas pela maioria que falta investimento e conscientização do poder público.

*[...]fundamental para melhorar a assistência, porém falta investimento na saúde pública [...] (E07)*

*[...]muito importante diante do cenário atual das doenças psiquiátricas, que infelizmente surgem cada dia mais, mas falta boa vontade. [...] (E13)*

*[...]seria ótimo para proporcionar uma maior cobertura, creio que seja falta de interesse por parte dos governantes com políticas para atendimento com maior expansão para todos que procuram atendimento. [...] (E08)*

Os relatos apontados no presente estudo apontam sobre a importância de novos dispositivos em saúde mental, contudo expõe a necessidade de interesse e investimento por parte do poder público no olhar da saúde mental.

Diante disso, esses dados corroboram com o estudo de Jesus e Alves [40] no qual relata que, por parte dos profissionais, compreende-se a visibilidade da criação de novos dispositivos para atender a demanda de saúde mental que está apresentando um aumento significativo, entretanto reforçam a necessidade de não apenas ampliar os dispositivos, mas também disponibilizar ações que contribuam com melhorias na assistência prestada e na estruturação da rede de cuidado local.

Para concluir a entrevista, os participantes foram questionados se acham pertinente um guia que lhes auxiliassem nas consultas, no qual todos os participantes julgaram ser importante para nortear a consulta, qualificando o atendimento e propondo um melhor direcionamento. Nos principais relatos abaixo os enfermeiros discursaram sobre suas opiniões:

*[...]seria uma ferramenta muito importante principalmente para quem atua na atenção primária que é a porta de entrada das pessoas e ao se deparar com situações de saúde mental saber conduzir e direcionar o caso. [...] (E15)*



*[...]sim, são muitos os profissionais, não só enfermeiros, mas toda classe da saúde, não consegue lidar ou não sabe por onde começar em uma consulta de paciente com sofrimento psíquico. (E04)*

*[...]sim, pela melhora no direcionamento dos pacientes com transtorno mental. [...] (E12)*

*[...]seria maravilhoso para nos auxiliar a saber pelo menos o que falar com o paciente e o que perguntar. [...] (E17)*

Promover um guia estruturado de consulta em saúde mental, levando em consideração as principais características a serem abordadas para os profissionais que realizam o acolhimento na APS, permitindo descrever de forma clara as queixas principais, seria de grande relevância para auxiliar o profissional na tomada de decisão de acordo com as situações detectadas.

De acordo com Campos e Rios [41], a veracidade de se organizar uma estrutura que não seja inflexível e que dê suporte e segurança tanto ao profissional quanto à pessoa que será atendida vem facilitar muito o aprendizado de como conduzir uma consulta e como desenvolver as habilidades de comunicação nela.

#### D. Implantação dos Mecanismos de Intervenção Educacionais

Segundo Pasqualli [42] o produto educacional desenvolvido no Mestrado Profissional em Ensino está direcionado para a resolução de problemas e situações presentes no cotidiano, revestindo-se de uma estrutura mais tecnológica que científica, e que a construção do produto deve ser de forma educacional direcionado a melhoria do ensino e promoção da saúde.

O cuidado em saúde mental exige dos profissionais de saúde uma visão holística, devido suas particularidades e complexidades, tornando essencial o uso de ferramentas tecnológicas e científicas que deem suporte aos profissionais no processo de escuta.

Diante disso, como produto dessa pesquisa foi desenvolvido um guia de atendimento em saúde mental na APS para nortear a consulta de enfermagem em saúde mental, visando contemplar uma necessidade de atendimento à uma população que se encontra desassistida.

Esse guia apresenta metodologia clara e objetiva, buscou-se utilizar uma linguagem simples, seguindo as etapas da anamnese na perspectiva de auxiliar o enfermeiro na escuta inicial diante das percepções de sofrimento emocional, visando colaborar com um atendimento continuado garantindo a integralidade da atenção.

Após o término do produto, foi apresentado a direção da AB do município de Tucuruí-PA e agendado uma apresentação para os enfermeiros da rede, que deram seu feedback relatando que acredita que a tecnologia irá contribuir efetivamente com a qualidade no atendimento, na produção e práticas de novos modelos de cuidados em saúde mental.

## IV. CONCLUSÃO

A história das lutas na Reforma Psiquiátrica refletiu além do campo da saúde mental, aliando-se aos meios de democratização e participação social, visando modificar a proteção social e o sistema de saúde do país. Partindo do pressuposto que para continuar o avanço da Reforma psiquiátrica é necessário a intensificação na construção de estratégias de cuidados com base territoriais e a APS mostra-se como um espaço favorável para sua consecução.

Buscou-se através dessa pesquisa compreender como a AB, no município de Tucuruí-PA, tem acolhido e atendido a demanda de saúde mental e como ocorre a articulação com a equipe de referência em saúde mental, nesse caso o CAPS. Procurou-se identificar, ainda, as avaliações e as expectativas dos entrevistados sobre o serviço de saúde mental.

Nesse estudo foi possível observar como é a prática do cuidado em Saúde Mental na APS, o que nos traz diversas reflexões quanto ao primeiro atendimento do usuário com queixas de sofrimento emocional que procura o posto de saúde. Observou-se no primeiro momento que os participantes ponderavam nas respostas sobre suas compreensões relacionado ao tema em questão, percebe-se que é necessário que haja mais investimentos na formação continuada nesse tema, pois, ficou evidente que os mesmos não se sentem preparados para atender essa demanda.

A pesquisa evidenciou ainda que a articulação com os dispositivos de referência em saúde mental se dá através de encaminhamentos para especialistas, foi identificado através dessas análises, de modo geral, que a APS no acolhimento atende à demanda de saúde mental, através de práticas como identificação e encaminhamentos para especialistas, não ocorre a contrarreferência, portanto não há o acompanhamento desses usuários.

Averiguou-se portando, que os resultados deste estudo apontam que os enfermeiros apresentam dificuldades em lidar com a temática da saúde mental, no qual indica a necessidade de fortalecimento de discussões e formação continuada sobre a problemática abordada.

Podemos afirmar que os objetivos dessa pesquisa foram alcançados, bem como foram cumpridas todas as etapas e procedimentos previstos. No âmbito da implantação do produto como instrumento de guia na consulta inicial do usuário com queixas de sofrimento mental, também foi atingido o propósito, visto que houve um curso de formação continuada para direcionar como usar a ficha de consulta e foi disponibilizado um guia prático para condução dessa entrevista inicial.

Os resultados encontrados no estudo em questão, indicam que há muito o que evoluir, em se tratando da inclusão de programas de saúde mental na rotina das UBS, sendo necessário realizar um maior número de abordagens educativas e a implantação do matriciamento no município visando orientar acerca da importância do seu trabalho na detecção precoce e acompanhamento de pessoas com queixas de sofrimento emocional.

## V. AGRADECIMENTOS

Toda a minha gratidão a todos que de alguma forma estiveram comigo nessa trajetória:

A Deus que me deu forças para conquistar cada etapa e me sustentou até aqui.

A minha amada mãe que torceu por mim, que sempre esteve torcendo por mim em cada conquista.

Ao meu esposo por todo apoio, incentivo e paciência, me viu chorar e pensar em desistir mil vezes e em todas as vezes me encorajou e acreditou em mim.

Aos meus irmãos que sempre enfrentaram comigo as mais duras batalhas da vida.

As minhas amigas que sempre trouxeram alegrias e conforto nos nossos encontros.

Aos meus alunos pelas palavras de carinho e incentivo constante durante esse percurso.

A enfermeira Márcia Pontes por ter acreditado no meu projeto e ter dado todo apoio que precisei.

Aos professores que passaram pelas disciplinas transmitindo seu conhecimento de uma forma tão leve em um período que mundo passava por uma pandemia.

A minha orientadora Valéria Regina por tanta calma, dedicação, incentivo e principalmente pela confiança em aceitar o desafio de falar sobre saúde mental.

Ao Programa de Pós-Graduação em Gestão e Serviços em Saúde na Amazônia por me permitir realizar meu sonho de ser mestre e me privilegiar com excelentes docentes, no qual contribuíram pro meu crescimento pessoal e profissional.

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# Old age, sexuality and self-knowledge as a tripod to Achieve Quality of life stimulated by health and education professionals: A theoretical-analytical Study

## Velhice, Sexualidade e Autoconhecimento Como tripé para o Alcance da Qualidade de vida estimulados por Profissionais da Saúde e Educação: Um Estudo teórico- analítico

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Received: 30 Jul 2022,

Received in revised form: 20 Aug 2022,

Accepted: 26 Aug 2022,

Available online: 31 Aug 2022

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**Keywords**— *Old age. Sexuality. Quality of life.*

**Palavras-chave**— *Velhice. Sexualidade. Qualidade de vida.*

**Abstract**— *With the present study, we carried out an investigation into how sexuality is directly linked to the quality of life of the elderly, and how some elements, such as the body and pleasure, become essential for their self-esteem. In this sense, we intend to build a theoretical-analytical research on old age and sexuality in post-modernity, a period in which there is a considerable search for the use of medicines. Our position defends that old age is not synonymous with functional incapacity, but we understand that this elderly individual lives in a quest to rescue the right to a sexual life in old age, which reflects multiple forms of libidinal transformation. It also means understanding it in a broad sense, which goes through tenderness, through physical contacts that erogenize the body, such as the look, touch, voice, rediscovering the first forms of human love. The collected studies point to a direct conjunction between sexuality, sexual pleasure and the quality of life of the elderly.*

**Resumo**— *Com o presente estudo, realizamos uma investigação sobre como a sexualidade está diretamente ligada à qualidade de vida do idoso, e como alguns elementos, como o corpo e o prazer, se tornam essenciais para a sua autoestima. Nesse sentido, pretendemos construir uma pesquisa teórico-analítica sobre a velhice e a sexualidade na pós-modernidade, período em que há uma busca considerável por uso de medicamentos. Nosso posicionamento defende que a velhice não é sinônimo de incapacidade funcional, mas entendemos que esse sujeito idoso vive em*

*uma busca por resgatar o direito a uma vida sexual na velhice, o que reflete multiformas de transformação libidinal. Significa, também, compreendê-la em um sentido amplo, que passa pela ternura, pelos contatos físicos que erogenizam o corpo, como o olhar, o toque, a voz, redescobrimo as primeiras formas de amor do ser humano. Os estudos coletados apontam para uma conjunção direta entre a sexualidade, o prazer sexual e a qualidade de vida do idoso.*

## I. INTRODUÇÃO

Com o presente estudo, realizamos uma investigação sobre como a sexualidade está diretamente ligada à qualidade de vida do idoso, e como alguns elementos, como o corpo e o prazer, se tornam essenciais para a sua autoestima. Nesse sentido, pretendemos construir uma pesquisa teórico-analítica sobre a velhice e a sexualidade na pós-modernidade, período em que há uma busca considerável por uso de medicamentos.

Maataoui; Hardwick and Lundquist (2017), bem como Nóbrega et al., (2017) concordam com o fato de que o envelhecimento e tem sido encarado como um desafio, e exige-se estratégias inovadoras de caráter natural que podem ser benéficas para a saúde psicossocial da pessoa idosa. Cita-se como exemplo a vivência saudável da sexualidade. Nesse direcionamento, define-se sexualidade como uma expressão que reflete a multidimensionalidade da expressão individual quanto aos sentimentos, amor, toque, intimidade, carinho, companheirismo, abraço, afeto, inclusive o ato sexual propriamente dito. Observa-se que não podemos reduzir a sexualidade ao sexo, visto que se trata de um constructo mais amplo caracterizado por sentimentos, pensamentos e cognição.

Somos assonantes com o fato de que a velhice não é sinônimo de incapacidade funcional, mas entendemos que esse sujeito idoso vive em uma busca por resgatar o direito a uma vida sexual na velhice, o que reflete multiformas de transformação libidinal. Significa, também, compreendê-la em um sentido amplo, que passa pela ternura, pelos contatos físicos que erogenizam o corpo, como o olhar, o toque, a voz, redescobrimo as primeiras formas de amor do ser humano.

Os estudos coletados apontam para uma conjunção direta entre a sexualidade, o prazer sexual e a qualidade de vida do idoso, vem despertando, ao longo dos anos, o interesse de pesquisadores das mais diversas áreas

do conhecimento científico, dentre elas, a ciência psicológica (CACHIONI; FALCÃO, 2009).

Em termos metodológicos, traçamos um estudo da velhice no que tange à sexualidade, e elencamos como descritores o corpo e o prazer, tão discutidos já no âmbito da filosofia e da psicanálise. Assegurados pela postura do Ministério da Saúde no Brasil, denota-se que “O envelhecimento é um processo sequencial, individual, cumulativo, irreversível, universal, não patológico, de deterioração de um organismo maduro, próprio a todos os membros de uma espécie” (BRASIL, 2006).

Concordamos com Oliveira et al., (2021) sobre o fato de que há um campo semântico em torno da sexualidade constituído por uma multiplicidade de elementos, desde fatores que advém da gerontologia a atos de cumplicidade, a intimidade, o ato sexual, dentre outros. Nesse sentido, nosso objetivo é realizar uma revisão de literatura da velhice e da sexualidade na pós-modernidade, por meio de um estudo que engloba o corpo e o prazer.

Desse modo, após discutir inicialmente os aspectos teóricos da pesquisa, englobando elementos como a velhice, a sexualidade, seguimos para a metodologia da pesquisa. Em seguida, trazemos algumas propostas metodológicas para qualidade dos idosos.

## II. METODOLOGIA DA PESQUISA

Para composição da presente pesquisa, recorreremos a alguns trabalhos que serviram de base teórico-epistemológica. Para tanto, foram elencados os descritores: velhice, sexualidade, qualidade de vida.

Serviram-nos de fundamento três artigos em idiomas: português, inglês e espanhol. A data que estabelecemos como recorte temporal foram os últimos 5 (cinco anos), a contar de 2022. Exponha-se o quadro com a disposição dos dados.

Quadro I – Disposição dos dados

<b>TÍTULO DO ESTUDO</b>	<b>NOME DOS AUTORES</b>	<b>PERIÓDICO</b>	<b>IDIOMA</b>	<b>ANO</b>
Creating space for relationships	MAATAOUI SL, Hardwick JS, Lundquist TS.	<b>Psychol Serv</b>	PORTUGUÊS	2017;14(3):347-51.
Impact of sexuality in the life of the elderly person: integrative review	NÓBREGA TMA, Vasconcelos SC, Beserra PJF, Bittencourt GKGD, Nóbrega MML.	<b>Int J Dev Res.</b>	INGLÊS	2017;7(10):161-24-32.
Salud sexual en ancianos de un consultorio médico de la familia.	LOBAINa EC, Cortés JTA, Hechavarría GÁP, González PF, Verdecia RR	<b>MEDISAN</b>	ESPAÑHOL	2017;21(7):858

**Fonte:** Criação dos próprios autores

Os critérios de inclusão para a seleção de estudos para tal fase da revisão interativa serão: artigos publicados em português, com os resumos indexados nas bases de dados selecionadas. Para o recorte temporal foi proposto um período de cinco anos. Foram selecionados apenas artigos originais em texto completo. Foram excluídas dissertações, teses, revisões sistemáticas, estudos randomizados, relatos de experiências mesmo que retratassem questões pertinentes à temática anteriormente mencionada. Os estudos que não atenderam aos critérios de inclusão, que apresentem-se em outro idioma que não fossem português, espanhol e inglês, ou que apresentem-se em duplicata, estudos fora do recorte temporal, ou que não possuíssem os métodos selecionados, foram excluídos.

Nesse sentido, para análise dos artigos incluídos/selecionados, ou seja, de todos aqueles que atenderam rigorosamente os critérios de inclusão, foi construído um quadro especificamente para este fim que contemplasse: O título do artigo selecionado, nome dos autores do estudo, idioma, periódico que foi publicado, ano de publicação.

### **VELHICE, SEXUALIDADE E QUALIDADE DE VIDA: discussões iniciais**

Há muito o que se considerar, quando tratamos de uma temática tão densa quanto as questões de Ciência, raça e sexualidade no decorrer dos séculos a qual envolve não apenas uma perspectiva teórica de análise, mas entornos históricos que constituem aspectos psicofisiológicos do sujeito.

De acordo com Oliveira et al., (2021, p. 3)

É possível perceber, por meio de estudos advindos da gerontologia, que cada vez

mais as indústrias midiáticas tem produzido a ideia de que ao tempo cronológico necessita-se acrescentar vida ativa (LIMA; SILVA; GAHARDONI, 2008), necessidade identificada como produto de esforços agenciados nos últimos anos, em grande medida, relacionados ao incremento da produção em ciência, tecnologia e práticas de atenção à saúde dos idosos (LIMA; SILVA; GAHARDONI, 2008), Isso porque a velhice, enquanto condição vital e inevitável, constituinte das dimensões do ser, trata-se de um processo de mudanças universais, pautado geneticamente para a espécie e para cada indivíduo, que se traduz em diminuição da plasticidade, em aumento da vulnerabilidade (NERI, 2008; SILVA, 2006) em acúmulo de perdas evolutivas e no aumento da probabilidade de morte.

Dados do Ministério da Saúde afirmam que a velhice se refere ao ato ou efeito de envelhecer, que significa ficar velho (BRASIL, 2006); parecer velho; durar muito tempo, permanecer, tornar-se desusado ou inútil

(NERI, 2008; SILVA, 2006). Quando se pensa, então, na sexualidade, ou seja, nas diversas produções e estigmas acerca da prática do sexo, as considerações, em grande maioria, enxergam que os idosos são inférteis, que já não podem ter uma vida sexual saudável como, por exemplo, os jovens.

O processo de envelhecimento não conduz a uma fase assexuada, mas tão somente a outra etapa no processo da sexualidade humana, a qual deve ser merecidamente vivenciada e apreciada (Fávero & Barbosa, 2011). As vivências sexuais, independentemente da idade, proporcionam ao casal a possibilidade de se realizar pessoalmente, refletem a intimidade e a cumplicidade e enriquecem as relações humanas. Para os idosos, a sexualidade é fisiologicamente possível, emocional e afetivamente enriquecedora, porquanto fortalece a importância do carinho, do apego, a comunicação, o companheirismo e o cuidado mútuo (URQUIZA, et al., 2008).

Mas é preciso compreendermos que a sexualidade está presente em todas as fases da vida, percorre “um caminho de *faz e refaz*, um caminho instável, em constante processo de transformação, assim como as pessoas, pois é parte indissociável delas” (PIRES, 2006, p.2). Na fase da terceira idade, ou seja, na idade ativa dos idosos, a sexualidade varia tanto quanto os demais comportamentos, mas isso não implica necessariamente uma redução drástica da resposta sexual (PASCUAL, 2002), já que ela depende fundamentalmente da atitude que cada pessoa adota diante da vida. Ocorre de maneira extremamente individual e não se processa do mesmo modo em todas as épocas, nem sequer da mesma forma em todos os indivíduos (PASCUAL, 2002).

Uma visão de cunho psicológico pode ser evidenciada em Memória e Sociedade de Ecléa Bosi (1979). A tese da autora, segundo a introdução do livro feita por Marilena Chauí, é de que o velho não tem armas, nós é que temos que lutar por ele. A sociedade capitalista desarma o velho, mobilizando mecanismos pelos quais

oprime a velhice, destrói os apoios da memória e substitui a lembrança pela história oficial celebrativa. Para Bosi (1979), oprime-se o idoso por intermédio de mecanismos institucionais: a burocracia da aposentadoria e dos asilos; psicológicos: a tutela, a recusa do diálogo, o banimento e a discriminação; técnicos: as próteses e a precariedade existencial daqueles que não podem adquiri-las; e científicos: as “pesquisas” que demonstram a incapacidade e a incompetência social do velho (PORTAL DO ENVELHECIMENTO, 2019).

O trabalho de Bosi, longe de se encerrar na constatação da opressão a que está submetida a memória dos velhos, procura encontrar a gênese dessa opressão. Segundo ela, a degradação senil começa prematuramente com a degradação da pessoa que trabalha. A nossa sociedade pragmática, para ela, não desvaloriza somente o operário, mas todo trabalhador. Bosi conclui que para reparar a destruição sistemática que os indivíduos sofrem na sociedade da competição e do lucro e para que o indivíduo, na velhice, permaneça um indivíduo, seria necessário que ele sempre tivesse sido tratado como um indivíduo. Para ela, a noção que se tem de velhice decorre mais da luta de classes do que do conflito de gerações (PORTAL DO ENVELHECIMENTO, 2019). Disponível em: <https://www.portaldoenvelhecimento.com.br/estudos-sobre-a-velhice/> Acesso em: 25.08.2020.

Ainda de acordo com Oliveira et al., (2021, p. 4),

Na medida em que a sociedade, de uma forma geral, provê recursos financeiros e intelectuais para a existência de uma terceira idade sã, o idoso decadente é visto como relapso e culpado de sua própria decrepitude (PORTAL DO ENVELHECIMENTO, 2019). Debert (1999) enfatiza que a visibilidade conquistada por experiências inovadoras e bem sucedidas decorrentes e consequentes da reprivatização do envelhecimento, fecha o espaço e os olhos da sociedade para as situações de abandono e maus-tratos (PORTAL DO ENVELHECIMENTO,



2019)<sup>1</sup>. Segundo Vala e Monteiro (2004), as representações sociais apresentam uma dimensão funcional e prática, que tem por consequência ser evidenciada na organização dos comportamentos, das atividades comunicativas, na argumentação e na explicação cotidianas e na diferenciação dos grupos sociais. A elaboração e o funcionamento de uma representação podem ser compreendidos por meio dos processos de objetivação e ancoragem.

### PROPOSTAS METODOLÓGICAS PARA QUALIDADE DOS IDOSOS E MELHORIA NO SETOR SEXUALIDADE

Diversas investigações têm demonstrado que a sexualidade entre as pessoas idosas constitui-se em uma necessidade humana básica (WAITE et al., 2017), tornando-se imprescindível para a manutenção da saúde, bem estar e qualidade de vida (QV), o que é reforçado por EYMANN (et al., 2019). Nesse sentido, a qualidade de vida irá envolver a percepção do idoso em relação a todos os aspectos que fazem parte de sua vida, ou seja, reflete a harmonia das realizações em diversas dimensões de sua rotina como a família, espiritualidade, lazer, atividade sexual, trabalho, dentre outras (EYMANN et al., 2019).

A Organização Mundial da Saúde (OMS) constitui a Qualidade de vida como “a percepção do indivíduo de sua posição na vida, no contexto da cultura e dos sistemas de valores nos quais ele vive e em relação aos seus objetivos, expectativas, padrões e preocupações”. Por seu turno, A Organização Pan-americana da Saúde (OPAS) e a Organização Mundial da Saúde, lançaram, em 2018, uma série de propostas metodológica que impulsionaram o ministério da saúde do Brasil a criar a *Estratégia Brasil Amigo da Pessoa Idosa*.

De acordo com Oliveira et al., (2021, p. 3)

A elaboração da iniciativa, que tem por objetivo alcançar o envelhecimento ativo, saudável, cidadão e sustentável para todos os brasileiros, contou com a

colaboração da Organização Pan-Americana da Saúde/Organização Mundial da Saúde (OPAS/OMS, 2018). Isso nos faz pensar que em decorrência do crescimento da população idosa nas últimas décadas, é preciso que estas tenham uma vida mais saudável, inclusive para que possam ser mais ativas no mercado de trabalho. Na Estratégia, o Brasil atende às recomendações da OMS para avaliação e desenvolvimento dos Planos de Ação voltados à adaptação das cidades às necessidades dos idosos (OPAS/OMS, 2018).

Ao todo oito domínios da vida urbana podem influenciar na saúde e na qualidade de vida dessa população:

- Espaços ao ar livre e edifícios;
- Transportes;
- Habitação;
- Participação social;
- Respeito e integração social;
- Participação cívica e emprego;
- Comunicação e informação;
- Apoio da comunidade e serviços de saúde (OPAS/OMS, 2018).

Acerca do envelhecimento ativo, **o que já fora ressaltado por Oliveira et al., (2021, p. 3)**, o número de pessoas com idade igual ou superior a 60 anos vai mais que dobrar no mundo em 2050, passando de 900 milhões em 2015 para cerca de 2 bilhões. Por isso, a Organização Pan-Americana da Saúde/Organização Mundial da Saúde (OPAS/OMS, 2018) acredita ser importante que os idosos de hoje e os do futuro possam envelhecer de maneira saudável e ativa. Ou seja, que a idade avançada não impeça as pessoas de ser e fazer o que querem ou valorizam.

### III. CONCLUSÕES

Em nosso estudo verificou-se que a velhice e a sexualidade na pós-modernidade, não implicam em uma

<sup>1</sup> Disponível em: <https://www.portaldoenvelhecimento.com.br/estudos-sobre-a-velhice/> Acesso em: 25.08.2020

correlação falida nem impossível, nem tampouco é sinônimo de incapacidade funcional, mas entendemos que o sujeito idoso vive em uma busca por resgatar o direito a uma vida sexual na velhice, o que reflete multiformas de transformação libidinal.

Acreditamos que cumprimos que cumprimos com o rito exigido de composição de um artigo, desde as informações coletadas até a correlação semântica dos elementos. Compreender o processo de envelhecimento considerando apenas os seus aspectos negativos impossibilita a percepção de fatores importantes que são vivenciados apenas nessa etapa do desenvolvimento, como a experiência (BRASIL, 2006).

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# Photosynthesis and growth of the sweet sorghum supplemented with silicon

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Received: 29 Jul 2022,

Received in revised form: 15 Aug 2022,

Accepted: 22 Aug 2022,

Available online: 31 Aug 2022

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**Keywords**— *Sorghum bicolor*, *silicate*, *IRGA*,  
*nutrient*.

**Abstract**— Silicon is a major element in plants, being essential for some species and beneficial for others, with important role in plant metabolism. Several families of monocotyledons have the ability to absorb high amounts of this compound, being considered silicon accumulators. This is the case of sweet sorghum (*Sorghum bicolor* L. Moench), a plant with C<sub>4</sub> carbon metabolism, with high photosynthetic activity, and great potential for ethanol production; its residual biomass can also be used for energy cogeneration in sugarcane production systems. The aim of this work was to evaluate the effect of silicon, in the form of sodium metasilicate, on sweet sorghum plants cultivated under hydroponic conditions and without stress of biotic or abiotic origin. There is a linear increase in silicon content in leaves, stalks and roots as a function of increasing doses of this element in the substrate. Silicon supplementation in sweet sorghum increases photosynthesis rates, water use efficiency and leaf biomass. The best dose of silicon for maximum photosynthetic efficiency is 70 mg L<sup>-1</sup> of Si in the nutrient solution.

## I. INTRODUCTION

Silicon (Si) plays an important role in plant-environment relations, as it can promote better ability of plants to withstand climatic, edaphic and biological adversities, with the possibility of increase in both production quality and quantity. The use of Si in agriculture becomes particularly interesting as it is considered a natural antistress agent. Silicate fertilizers can enhance plant resistance to abiotic stresses, including extreme temperatures, salinity, drought, heavy metal toxicity, nutritional imbalance. Silicon fertilization can also increase resistance to various fungal diseases as well as some pests. Some mechanisms of Si that can alleviate biotic and abiotic stresses in plants include: regulation of the activities of antioxidant enzymes; polyamines and phytohormones, as well as lignin biosynthesis; maintenance of plant water balance; increase in mineral nutrient uptake and assimilation; structural alterations;

formation of physical and chemical barriers and improvement of the gas exchange attributes (Haynes, 2017; Luyckx et al., 2017; Etesani; Jeong, 2018).

Ethanol production from sugarcane places Brazil as a world reference in the use of bioenergy. In the off season of sugarcane, there is reduced availability of ethanol, with price increases and risk of shortage. The growing demand for alcohol as fuel has driven the search for alternatives to increase agricultural production of distilleries and industrial yields, reducing production costs and increasing viability of these production plants. An alternative is the use of sweet sorghum (*Sorghum bicolor* L. Moench), either in the off season or as a complement to sugarcane availability. This plant has technical and economic potential for ethanol and residual biomass production for energy cogeneration, considering pilot plantations data collected since the 1980's and the available agricultural

and industrial technology (Durães, 2011; Durães et al., 2012).

Sorghum is a crop able to achieve high photosynthetic rates, with potential to respond to Si fertilization (Meena et al., 2014). Application of 200 ml L<sup>-1</sup> of potassium silicate in pots with soil, increased water leaf potential, leaf area index, net assimilation and relative growth rates, and chlorophyll content (SPAD index), compared to a treatment with the same K (potassium chloride) level, under both normal and water stress conditions (Ahmed et al., 2011, 2014). Studies with sorghum show increased content of this element in its tissues and a positive response to growth and resistance to some stresses of biotic and abiotic origin - drought and salt tolerance (Yin et al., 2014; 2016) and heavy metal mitigation as Al (Bath et al., 2019), for example.

Although many annual crops potentially respond to silicate fertilization, especially in silicon poor soils, few studies have been done with sorghum, notably sweet sorghum. Thus, the aim of this work was to assess the effect of increasing doses of sodium silicate under hydroponic conditions on the production of sweet sorghum dry mass and photosynthesis rates.

## II. MATERIAL AND METHODS

The experiment was carried out in a greenhouse at Embrapa Agropecuária Oeste, in Dourados, Mato Grosso do Sul, Brazil, in 2017. Sorghum plants, variety BRS 511, were submitted to increasing levels of Si in Johnson's nutrient solution, modified (Epstein; Bloom, 2006), with pH adjusted to 6.0. The experiment was installed in completely randomized design with five treatments – (1) 0 mg L<sup>-1</sup>; (2) 10 mg L<sup>-1</sup>; (3) 25 mg L<sup>-1</sup>; (4) 50 mg L<sup>-1</sup> and (5) 100 mg L<sup>-1</sup> (equivalent to 0, 0.36, 0.89, 1.78 and 3.60 mmol) of Si in the form of sodium metasilicate (PA), with five replications, totaling 25 experimental units (one plant per pot of four liters of nutrient solution).

At stage V13, prior to booting (period from elongation start to beginning of flag leaf blade opening), physiological parameters were measured with an infrared gas analyzer (IRGA) – Lcpro-SD (ADC Bioscientific, Hoddesdon, England) in the middle of the leaf blade of the third leaf with visible auricle from the apex. We set up the IRGA to work with environmental conditions throughout the analysis: CO<sub>2</sub> concentration = environment (~378 ppm); air relative humidity = follow environment (65 - 78%); temperature = follow environment (28 - 33 °C); light intensity = environment (~1100 - 1200 μmol m<sup>-2</sup> s<sup>-1</sup>); reading stabilization timing = 135 s.

Readings were taken in the beginning of the morning, between 07:30 hs and 09:30 hs. Although the experiment was conducted in completely randomized design, we used blocks for the IRGA assessments aiming to compensate the day progress (systematic increase in light level and temperature) on readings, as this is a known cause of error. For this, we assessed the blocks in order (B1 - B5). Into each block, treatments were ordered as follows: for blocks 1 and 3, treatments were orderly assessed (T1 - T5); blocks 2 and 4 were assessed on opposite order of treatments (T5 - T1), while block 5 was assessed randomly.

The measured or calculated variables were: photosynthetic rate (A) - assesses the incorporation rate of carbon (C) in biomass, in mol m<sup>-2</sup> s<sup>-1</sup>; transpiration rate (E) - measures the loss of water through the stomata in mol H<sub>2</sub>O m<sup>-2</sup> s<sup>-1</sup>; stomatal conductance (Gs) - the flow through the stomata, in mol m<sup>-1</sup> s<sup>-1</sup>; gradient of CO<sub>2</sub> (ΔC) - carbon dioxide gradient between the outer and the inner parts of the leaf, in μmol mol<sup>-1</sup>; internal concentration of CO<sub>2</sub> (Ci) - carbon dioxide content within the mesophyll available for photosynthesis, in μmol mol<sup>-1</sup>; water use efficiency (WUE) - the relationship between plant CO<sub>2</sub> assimilation and water loss in the same time interval, in μmol CO<sub>2</sub> mol<sup>-1</sup> H<sub>2</sub>O.

After IRGA measurements, plants were collected by separating leaves, stalks and roots, and prepared for dry mass measurement after drying in air-circulating oven at 65 °C for three days. Silicon contents in plant tissues were performed according to Korndörfer et al. (2004). The data was submitted to regression analysis (Ferreira, 2014) and presented in comprehensive graphs, with treatment significance and regression adjustment coefficients.

## III. RESULTS AND DISCUSSION

The supplementation of Si to sorghum plants provided increased leaf dry mass of about 17% when 100 mg L<sup>-1</sup> of Si was supplied. On the other hand, there was no variation in shoot or total biomass (shoot + roots), as there was a tendency of reduction in stalk mass, although not statistically significant (Figure 1). There was increase in sweet sorghum leaf: stalk mass ratio, due to the increased leaf dry mass reported. This represents an increase in the photosynthetic apparatus not translated to increased yield ability, since there was no significant variation in stalk mass.

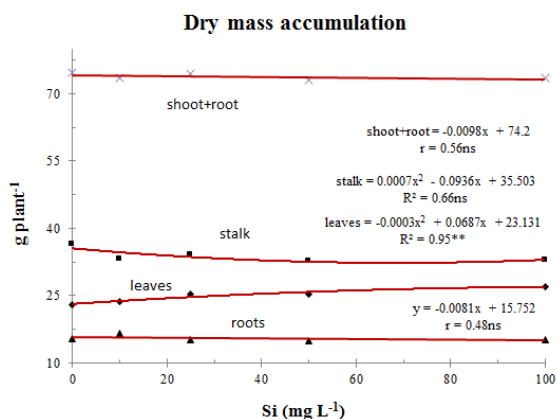


Fig. 1. Dry mass accumulation in sweet sorghum plants at stage V13, submitted to increasing levels of Si in nutrient solution.

Higher leaf production with silicate supplementation may be related to higher specific leaf weight or leaf area index (Ahmed et al., 2011). Ahmed e Aslam (2011) reported increase in foliar biomass with or without induction of water stress in sorghum. As occurred in our experiment, there was a higher mass ratio between leaves and stem, obtained with addition of the Si to the substrate (Figure 2). The increase in leaf biomass in this study may be related to the fact that Si increases the cytokinin biosynthesis in sorghum, as demonstrated by Markovich et al. (2017). Studies show that the cytokinin produced in the roots promotes leaf growth (Salisbury; Ross, 2012).

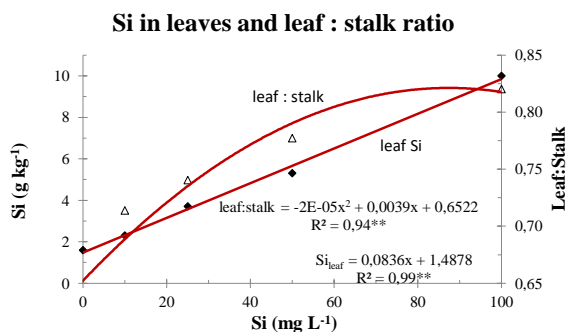


Fig. 2. Leaf : stalk ratio and Si content in leaves of sweet sorghum plants at stage V13, submitted to increasing levels of Si in nutrient solution.

The stomatal conductance (Gs) was not impacted by Si supplementation to plants. It is controlled by a series of internal and external factors, with water availability being one of the main ones. Under hydroponic cultivation and similar environment for all treatments, stomatal conductance remained with little variation as a function of Si level in the substrate and plant.

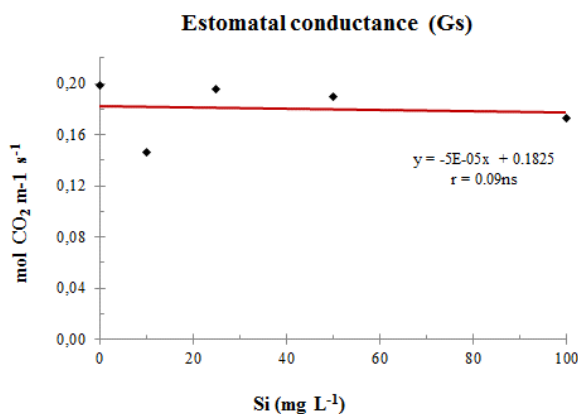


Fig. 3. Stomatal conductance (Gs) in sweet sorghum plants at stage V13, under increasing levels of Si in nutrient solution.

On the other hand, Si supplementation increased the CO<sub>2</sub> gradient (ΔC) between the outer and the inner leaf environments, as consequence of the stomatal resistance to gas diffusion (Figure 4). The higher absorption and incorporation of carbon in the sorghum biomass is corroborated by the drop in the internal CO<sub>2</sub> concentration (Ci) as stomatal conductance (Gs) was not altered (Figure 5).

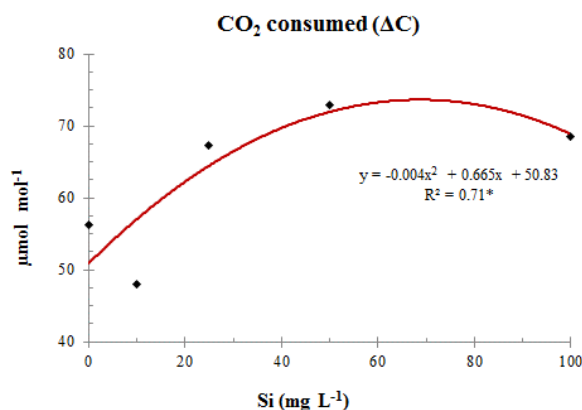


Fig. 4. CO<sub>2</sub> gradient (ΔC) between the outer and the inner leaf environments in sweet sorghum plants at stage V13, under increasing levels of Si in nutrient solution.

This higher incorporation of C in plant biomass promoted by Si is a function of the increased photosynthesis rates (A) with its application (Figure 6). As there was little variation in transpiration (E) with increasing doses of Si on the substrate (Figure 7), water use efficiency (WUE) was increased (Figure 8). This means that the proportion of CO<sub>2</sub> incorporated into the biomass was greater than the amount of water lost over the same time period. Silicon helped improving plant water status by probably allowing shorter periods of stomatal opening, due to a higher ΔC.

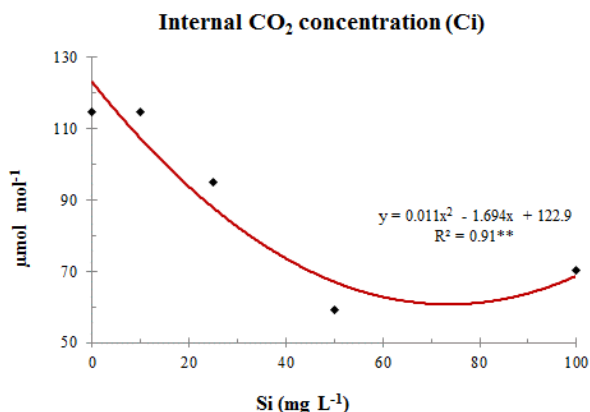


Fig. 5. Internal CO<sub>2</sub> concentration (Ci) in sweet sorghum plants at stage V13, under increasing levels of Si in nutrient solution.

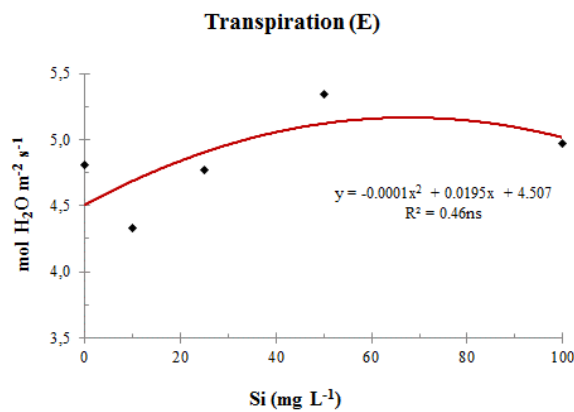


Fig. 7. Transpiration (E) in sweet sorghum plants at stage V13, under increasing levels of Si in nutrient solution.

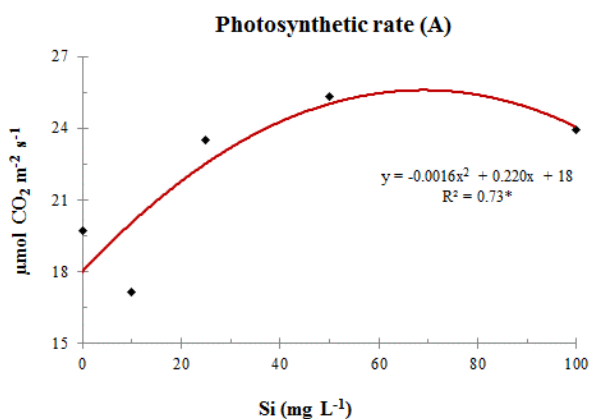


Fig. 6. Photosynthetic rate (A) in sweet sorghum plants at stage V13, under increasing levels of Si in nutrient solution.

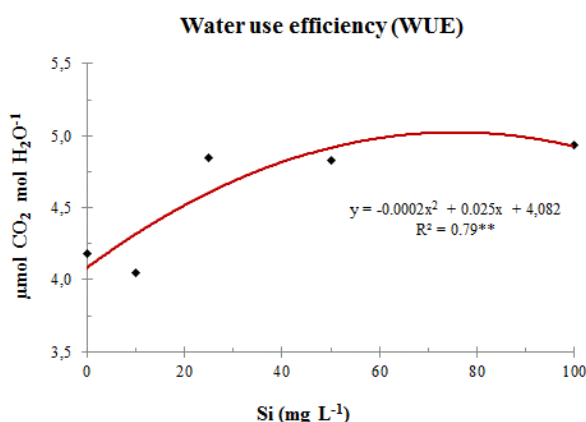


Fig. 8. Water use efficiency (WUE) in sweet sorghum plants at stage V13, under increasing levels of Si in nutrient solution.

The photosynthetic rate depends on the carbon gradient and the rate of CO<sub>2</sub> influx to leaf mesophyll. Taking into account the curves adjusted to the physiological parameters, it seems that the maximum values for CO<sub>2</sub> gradient ( $\Delta C$ ) and water use efficiency (WUE) would be obtained with 83 and 63 mg L<sup>-1</sup> of Si in nutrient solution, respectively, with an average of 73 mg L<sup>-1</sup> Si (Figure 4 and Figure 8). This concentration is close to that obtained for the photosynthetic rate, which was 69 mg L<sup>-1</sup> Si (Figure 6).

Thus, it can be stated that the best dose of Si in the nutrient solution for maximum photosynthetic efficiency is approximately 70 mg L<sup>-1</sup> Si in solution or a Si foliar content of 7.3 g kg<sup>-1</sup> (Figure 2). In this case, the maximum photosynthetic rate was 25.6  $\mu\text{mol CO}_2 \text{ m}^2 \text{ s}^{-1}$  or 40.5 mg CO<sub>2</sub> dm<sup>2</sup> h<sup>-1</sup>. Photosynthetic rates vary widely among species, with sorghum being one of those with the highest values, reaching rates between 50 and 60 mg CO<sub>2</sub> dm<sup>2</sup> h<sup>-1</sup>, depending on environmental and cultivation conditions (Fageria et al., 1997).

Other authors evaluated in some crops, such as rice, the effects of Si on photosynthesis-related parameters, where research shows significant increases in photosynthesis (Gong, 2011; Li et al., 2011). However, sorghum-related studies are scarce. Resende et al. (2014) investigated the effect of Si on anthracnose (*Colletotrichum sublineolum*) infected sorghum plants, reporting that the photosynthetic performance (A, Gs and E) was significantly higher in Si supplied plants. Ali et al. (2013) postulate that the benefits

of Si in photosynthetic parameters may be linked to both indirect effects, such as increased disease resistance, and direct effects, in this case linked to improved plant nutritional balance.

In plants subject to water stress, for example, the effect of Si on maintenance of photosynthetic rates is much greater, probably due, at least in part, to the decrease in transpiration rates (Ma; Takahashi, 2002). In sorghum with irrigated or non-irrigated treatment, Si significantly increased leaf water potential and photosynthesis (Ahmed et al., 2011). Avila et al. (2020) studied the effects of Si in plants of sorghum with two different soil water levels. The silicate treatments increased leaf water potential in plants grown at field capacity and under water deficiency. In the same way, plants grown at field capacity with Si supplementation, showed higher chlorophyll content, photosynthesis and instantaneous carboxylation efficiency. As in our research, stomatal conductance and transpiration were not influenced by Si under ideal conditions of moisture in the substrate. On the other hand, under water deficiency, Si treatments increased these parameters. This higher tolerance of sorghum to water stress can be due to an active osmotic adjustment in roots, triggered by Si supplementation (Sonobe et al., 2011).

Although most studies show the effect of silicon on plants under stress, researches show the direct impact of Si extends to more fundamental metabolic processes. Several genes non-related to stress, associated with primary metabolic processes or unknown functions, are activated or affected by fertilization with Si, as demonstrated for example, by Fauteux et al. (2005), Brunings et al. (2009), Chain et al. (2009), Fleck et al. (2011), Van Bockhaven et al. (2015), and Markovich et al. (2017). These genes are associated with glycolysis, cell wall biosynthesis, amino acid and ethylene metabolism, cytokinin pathway, defence hormones like jasmonic and salicylic acids, among others. As our study, Detmann et al. (2012) obtained an increase in the photosynthetic efficiency on unstressed rice plants. The authors, analysing photosynthetic gas exchange parameters alongside transcriptomic and metabolomic profiling, concluded that Si stimulated the amino acid remobilization by alteration of primary metabolism.

There was no effect on total dry mass accumulation in the vegetative phase, but significant intensification of photosynthetic activity coupled to increased leaf dry mass. Thus, it is possible to suggest the role of Si in stimulating the translocation of photoassimilates from sources (leaves) to sink (panicles), according to the results obtained. As example, Takahashi et al. (1966) and Detmann et al. (2012) report in rice an increase in grain yield. This is related to the fact that Si increases photoassimilation of

carbon, subsequently allowing greater carbon remobilization to the seeds (Meena et al., 2014).

#### IV. CONCLUSION

The silicon supplementation in sweet sorghum increased its content in leaves, stalk and roots, but elevated the dry mass only in leaves. Likewise, there was an increase in photosynthesis, which is related to an increase in the CO<sub>2</sub>, consumed due to higher incorporation rate of carbon in biomass and in the water use efficiency. The evidence of the results obtained in this research, suggests a possible role of Si in stimulating the translocation to the grains of soluble organic compounds, synthesized during photosynthesis.

Therefore, it is suggested to focus future researches on the subject, to verify the effect of Si, without stressful conditions, on grain production in sorghum.

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## The dimensions of sustainability in relation to the dimensions of family farming in irrigated public perimeters

## As dimensões da sustentabilidade em relação às dimensões da agricultura familiar em perímetros públicos irrigados.

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Received: 26 Jul 2022,

Received in revised form: 20 Aug 2022,

Accepted: 25 Aug 2022,

Available online: 31 Aug 2022

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**Keywords—** *Conservar; Sustentar;  
Preservar; Agricultura Familiar; Desvios.*

**Abstract—** *It is known that sustainability is directly linked to the way people should behave in relation to nature and how they should train themselves to conserve or sustain a certain action, system or process. In this sense, family farming, in theory, is more likely to preserve sustainable principles. This work is the result of a bibliographic review, with discussions and reflections by authors who deal with the fundamentals of sustainability in the face of the dysfunctions that family farming has been going through, because despite its relevance to food and nutritional security, it has been moving away from practices that must be sustainable. Thus, the results show that there are deviations from sustainable dimensions in family farming, which is responsible for a large part of food production. At the same time, it is perceived that an effective policy of care is of paramount importance, with regard to investments and guidance on the need to reestablish the dimensions of sustainability in family farming practice.*

**Abstrata—** *Sabe-se que a sustentabilidade está diretamente ligada à maneira como as pessoas devem proceder em relação à natureza e de como elas devem se capacitar para conservar ou sustentar uma determinada ação, sistema ou um processo. Nesse sentido, a agricultura familiar, em tese, é mais propensa para preservar os princípios*

*sustentáveis. Este trabalho é fruto de revisão bibliográfica, com discussões e reflexões de autores que tratam sobre os fundamentos da sustentabilidade diante das disfunções pelas quais a agricultura familiar vem passando, pois apesar de sua relevância para a segurança alimentar e nutricional, vem se afastando de práticas que devem ser sustentáveis. Sendo assim, os resultados mostram que há desvios das dimensões sustentáveis na agricultura familiar que é responsável por grande parte da produção de alimentos. Ao mesmo tempo, percebe-se que é de suma importância uma política efetiva de atenção, no que tange a investimentos e orientações acerca da necessidade de restabelecer as dimensões da sustentabilidade na prática agrícola familiar.*

## I. INTRODUCTION

Sabe-se que a agricultura familiar tem em sua essência tarefas importantes, oferecer alimentos saudáveis na mesa da sociedade, é uma delas. Somado a isso, a sustentabilidade vem se consolidando como alternativa de cuidado, preservação e sustentação em relação à natureza. Nesse sentido, promover ou incentivar a agricultura de base familiar, proporcionará um modelo de desenvolvimento firmado na responsabilidade social, bem como na responsabilidade ambiental e econômica.

Assim, se faz necessário levantar discussões a respeito da sustentabilidade bem como do fortalecimento da agricultura familiar que por sua vez vêm se consolidando em meio as práticas historicamente produzidas da agricultura convencional. Com isso, é urgente conhecer e aprofundar-se em estudos relacionados a agroecologia e no que ela tem a contribuir para uma agricultura sustentável. Assim, Gliessman (2002) nos ajuda a compreender que agricultura sustentável é aquela que cuida e protege a base dos recursos naturais, permitindo uma economia viável divulgando um aspecto social, justo e aberto a todos que se integram à sociedade.

O autor ainda enfatiza que a Agroecologia é a consolidação dos fundamentos e princípios ecológicos no desenho e manejo de agroecossistemas sustentáveis. Com tal argumento, em relação as práticas cultiváveis que direciona para práticas sustentáveis, Gliessman (2002, p. 52) orienta que a única opção cabível é a preservação da produtividade, a longo prazo, da superfície mundial cultivável, enquanto trocamos os padrões de consumo e de uso dela para beneficiar a todos, tanto os produtores, quanto os consumidores, de forma qualitativa.

Nesse entendimento, sabe-se que uma das características da agricultura familiar seria a independência de insumos externos à propriedade, e a produtividade agrícola está diretamente ligada e integrada às necessidades de um segmento familiar. Para esses pequenos grupos familiares e produtores rurais, a agricultura familiar oferece a oportunidade em geração de

renda e vínculo empregatício; sobretudo, aprimora o nível de sustentabilidade perante as atividades da produtividade agrícola. O que permite inferir, que a qualidade da produção é ecologicamente superior a produção convencional.

Nesse sentido, Oliveira et al (2022) enfatizam que o atual modelo de crescimento econômico mundial, direcionado pela globalização e pelos avanços tecnológicos vem contribuindo para a degradação ambiental ultrapassando os limites da natureza. Isso, observa-se em vários canais de comunicação, a agressão que a sociedade tem direcionado para os recursos naturais.

Diante do contexto apresentado, Bertolin et al. (2020) já ressaltava que a agricultura familiar tem a sua significância social e econômica, pois ela também é responsável pelo abastecimento de alimentos, e que esse importante segmento vem sendo excluído das políticas de desenvolvimento para a agricultura convencional e enfrenta problemas devido a competitividade e a força da globalização. Sendo assim, é pertinente trazer uma discussão e análise proporcionada pela pesquisa bibliográfica sistemática sobre os princípios da sustentabilidade no âmbito da agricultura familiar.

Acresce também, que a revisão bibliográfica possibilita conhecer o estado da arte que advém com o estudo de uma temática, e assim responder aos seguintes questionamentos: Como esse setor da produção agrícola se comporta diante da competitividade, da força da agricultura convencional perante um projeto político de desenvolvimento criada para a produtividade das grandes propriedades? Quais os desafios ocasionados pela globalização? Será que os princípios de sustentabilidade permanecem na agricultura familiar diante do desenvolvimento rural convencional?

Esses foram questionamentos que nortearam o desenvolvimento deste trabalho na perspectiva de atender a presente temática. Com isso, muitos são as dificuldades que agricultura familiar enfrenta, frente aos avanços da agricultura convencional, nesse entendimento, é urgente o

enfrentamento para conquistar o avanço dos princípios sustentáveis e de base familiar.

A esse respeito Reis et al. (2018) e Bertolin et al. (2020), compartilham de um importante posicionamento que justifica e mostra a importância dessa temática em assegurar a sustentabilidade frente as disfunções da agricultura familiar. Esse último sintetiza uma reflexão observável nos dias de hoje: “Os agricultores lutam para sobreviver e tornar estas propriedades economicamente sustentáveis nesse mercado globalizado” (bertolini et al., 2020, p. 4). Deste modo, o presente estudo teve como objetivo analisar as dimensões da sustentabilidade frente as disfunções da agricultura familiar.

## II. MATERIAIS E MÉTODOS

Este é artigo é um estudo desenvolvido a partir de uma revisão bibliográfica, que pode se estabelecer como um tipo de pesquisa que se ampara em fontes de estudos científicos para aquisição de resultados e análises de pesquisadores, tendo o propósito de fundamentar teoricamente um tema que o pesquisador deseja investigar.

É nesse contexto que este trabalho se desenhou, entendendo que “a pesquisa bibliográfica, assim como outros tipos de pesquisa deve contribuir para a formação de uma concepção crítica ou a um espírito científico do pesquisador, desenvolvendo-se em observações, análises e deduções interpretada por uma reflexão crítica”. (Prodanov, 2013, p. 44).

Visto o exposto, esta revisão da literatura procurou se atentar para a estruturação do texto científico, que por sua vez se enquadra em uma das fases dos caminhos metodológicos que a pesquisa científica exige, se desenvolvendo em diferentes etapas abordadas na estrutura científica deste trabalho, são elas, a elaboração da problemática a ser questionada, a concepção das hipóteses a ser analisada, a sistematização da coleta de dados, em seguida, as análises desses dados, os resultados e discussões, as conclusões da revisão sistemática bibliográfica, a apresentação e envio do texto científico.

Mostrando isso, é importante destacar aqui, as classificações metodológicas que este trabalho procurou percorrer, decidindo seus caminhos de metodologia, assim, em relação à natureza da pesquisa, o trabalho se constitui como pesquisa aplicada. Isso se justifica se atentado ao que Engel e Silveira (2009, p.35) salientam, desenvolvendo a compreensão que “esse tipo de pesquisa objetiva gerar conhecimentos para aplicação prática, dirigidos à solução de problemas específicos. Envolve verdades e interesses locais”.

Então, foi nesse propósito, enquanto natureza da pesquisa que este artigo se desenvolveu, diante de seu objetivo em analisar as dimensões da sustentabilidade diante das disfunções da agricultura familiar. Nesse entendimento, Nascimento (2016) e Prodanov (2013) posteriormente, relatam que a pesquisa aplicada é destinada à propagação de conhecimento para solução de problemas específicos, é direcionada a compreensão da verdade para determinada aplicação prática em situações particulares.

Além do mais, em relação do ponto de vista do objetivo deste trabalho, a pesquisa se enquadra como exploratória. Prodanov (2013) e Fonseca (2002) permitem entender que ela tem como propósito oferecer mais informações sobre a temática que se investiga, viabilizando o delineamento da temática da pesquisa; orientando a fixação do objeto a ser alcançados, assume em geral, a natureza de pesquisas bibliográficas ou estudo de caso.

A pesquisa exploratória possui planejamento flexível, o que permite o estudo do tema sob diversos ângulos e aspectos. Em geral, envolvendo levantamento bibliográfico, análise de exemplos que estimulem a compreensão. (Prodanov, 2013, p.52).

Para mais, no que concernem os procedimentos Técnicos, ou seja, o processo pela qual alcançamos os dados para a elaboração do texto científico, esta revisão sistemática se justifica como bibliográfica.

Fonseca (2002) e Pladanov (2013) compartilham do entendimento que a pesquisa bibliográfica sistemática vem de reflexões de materiais científicos já publicados, como é o caso deste artigo. Ademais, a revisão bibliográfica deverá refletir o estado da arte em relação aos dados coletados, no intuito de atender o objetivo norteador.

Dessa forma, Evans e Pearsons (2001) destacam que o desenvolvimento da metodologia da revisão bibliográfica sistemática como meio de alcançar evidências para oferecer pilares ao aumento das intervenções e informações científicas vem aumentando significativamente e fazendo uso do espaço das pesquisas primárias, no exercício de tomadas de decisão nas ciências de vários campos.

Assim sendo, Rother (2007) salienta que os artigos de revisão, como outros tipos de textos científicos, são uma maneira de pesquisa que faz uso de fontes de entendimentos bibliográficos ou digitais para aquisições de resultados e análises de outros pesquisadores, com a finalidade de teorizar uma determinam temáticos ou prover de fundamentos científicos o objeto a ser investigado.

Por tanto, nesta revisão bibliográfica, foram analisados artigos científicos que atendessem as dimensões da sustentabilidade antes as disfunções da agricultura familiar nos perímetros irrigados, para tanto, foram examinados artigos de revistas científicas que correspondesse à temática aqui, tratada.

Sendo assim, o quadro de artigos presentes neste estudo culminou em uma sequência enfática de busca, a iniciar pela escolha das palavras-chave. Expressões como: “Sustentabilidade na agricultura familiar”, “Disfunções da sustentabilidade”, “Agricultura familiar e as disfunções da sustentabilidade” “A importância da sustentabilidade na agricultura familiar” e Os desvios da sustentabilidade na

agricultura familiar” foram usadas para a disponibilização no banco de dados do Google Acadêmico.

As etapas proporcionaram a consolidação de uma revisão bibliográfica que oportunizou concretizar um estudo para que atendessem o objetivo desta pesquisa, visando uma análise. Assim, esse método se enquadra como caminho para o desenvolvimento do estudo, acarretando-se a síntese da análise de conhecimentos científicos provenientes de estudos já investigados, como se propôs este trabalho.

A seguir, a retratação das etapas percorridas que proporcionaram os resultados e com isso, o desenvolvimento deste estudo (Fig. 1).

Etapas Percorridas da Pesquisa de Revisão Bibliográfica Sistemática				
1ª Etapa	2ª Etapa	3ª Etapa	4ª Etapa	5ª Etapa
Identificação do tema e seleção da questão da pesquisa.	Estabelecimento dos critérios de inclusão e exclusão	Identificação dos estudos pré-selecionados e selecionados.	Categorização dos estudos selecionados.	Análise e interpretação dos resultados.
Definição do Problema.	Uso das bases de dados.	Leitura do resumo, palavras-chaves e títulos das publicações.	Elaboração e uso da matriz de síntese	Discussões dos resultados.
Formulação de uma pergunta de pesquisa.	Busca de estudos com base nos critérios de inclusão e exclusão	Organização dos estudos Pré-selecionados.	Categorização das análises e informações	
Definição da estratégia de busca.		Identificação dos estudos selecionados.	Formação de uma biblioteca individual	
Definições dos descritores de busca.			Análise crítica dos estudos selecionados.	
Definição das bases de dados.				

Fig. 1: Síntese das etapas percorridas da pesquisa  
 Fonte: Elaborado pelo autor, 2022

### III. RESULTADOS E DISCUSSÃO

Bertolin et al. (2020) faz uma reflexão que nos 60, as políticas públicas do governo brasileiro estimularam a mecanização sem limites, incrementando e fortalecendo a agricultura convencional através de linhas de créditos. Por outro lado, a agricultura de subsistência ficou desassistida, negligenciando-se também todo aparato que a agricultura familiar proporciona ao ser humano, no cuidado com a biomassa e com os seus recursos naturais.

Diante desse reflexo, Quijada et al (2020) também observava que não é de hoje que a agricultura familiar não é prioridade, no que tange a investimentos, pode-se compreender que a agricultura familiar precisa de políticas públicas que objetivem o acesso a linhas créditos, que visem a modernização e o fortalecimento dos pequenos produtores agrícolas. Além do mais, devem ser consideradas a viabilização de assistência técnica e presença de tecnologias, sem esquecer a importância de potencializar os pequenos produtores rurais nos estudos para combater a o mal funcionamento do que deveria ser uma agricultura familiar.

A agricultura familiar é uma alternativa para o que o agronegócio oferece. Bertolin et al. (2020), Reis; Lima; Desiderio (2018) e Giagnocavo et al (2018) compartilham que ela é uma atividade de suma importância para alimentar o mundo de forma saudável, preservando o meio ambiente. Daí a necessidade de potencializar essa atividade da produção, dando condições de sobrevivência para que a integridade da essência continue se estabelecendo como sustentável.

Os autores ainda trazem reflexão sobre o cenário global, há uma necessidade de aumentar a produção de alimentos de uma maneira menos danosa que garanta a sustentabilidade nas produções. Nesse entendimento, compreendem-se que há uma urgência de afirmar entendimentos inovadores, costumes novos, diferentes pontos de vistas, a qualidade de vida e o bem-estar das pessoas, estabelecendo o desenvolvimento econômico sustentável, concebendo o respeito pelos recursos da natureza, com o pleno entendimento que ambos são indispensáveis para a sobrevivência da sociedade.

Reis; Lima; Desiderio (2018), em relação ao modelo de produção tradicional e até mesmo se atentando para a

agricultura familiar já faziam uma reflexão acerca da necessidade de uma articulação integradora envolvendo meio ambiente e vários segmentos e instituições de interesse, reconhecendo a interdependência de todos que se envolvem com práticas rurais e sabem que o caminho para as produções, é a sustentabilidade. Observa-se nas reflexões dos autores, que a prática educativa é indispensável para estabelecer ou refirmar o equilíbrio e ações ecológicas (Silva et al, 2021).

Trazendo uma análise sobre as reflexões de Reis et al (2018), Bertolin et al. (2020), Gemelli e Barreto (2020) em seu estudo, apresenta a preocupação de reafirmar a dimensão e a consciência sustentável nas produções por práticas alternativas agricultura familiar. Pode-se compreender, a partir daí, que essa preocupação se dá devido aos grandes investimentos que a agricultura convencional vem recebendo, o que tem permitido que seja potencializada para atender ao mercado na busca do crescimento econômico, enquanto a agricultura familiar não é vista de tal forma.

Diante do exposto por essas análises, entende-se que a atenção para a sustentabilidade necessita ir além de medidas políticas. Tão defendida por Silva et al (2021), a agricultura familiar deve ser aliada às ações individuais de cada ser humano, em especial, o produtor rural. Ela deve ser resistência, ainda que as condições estejam desfavoráveis, em direção ao domínio de uma agricultura sem princípios ecológicos, que vise tão somente o lucro desenfreado e sem compromisso com a dimensão sustentável.

Partindo desse pressuposto dos autores aqui mencionados, Elias; Belik; Oderich (2019), em seus estudos sobre a construção de um sistema alimentar sustentável e a agricultura familiar, alertam que os recursos naturais são assiduamente entendidos como fontes que não se esgotam, por parte de muitos que não tem compromisso com a sustentabilidade. Os mesmos prosseguem denunciando que as produções agrárias existentes, querem determinar e estabelecer os moldes para satisfazer as necessidades de produção e de consumo do ser humano.

É interessante perceber que ambos os autores atentam para a necessidade de estabelecer um plano sustentável para as produções devido ao sistema alimentar que prevalece nos dias de hoje. Um sistema agrícola que gera degradação ambiental e que não consegue produzir para a população alimentos com qualidade de vida e ecológica. O que se observa é o avanço da insustentabilidade diante dos fatores econômicos, social, cultural e econômico em meio a produções e cultivos que deveria tem uma dimensão sustentável.

Diante disso, Elias et al (2019), adverte que o modelo agrícola dominante e a força política que possui, apresenta a ideia que esse modelo é a única alternativa na produção de alimentos, isso permite entender que essa narrativa contamina até mesmo produções de base sustentável que luta para se estabelecer em meio a um sistema agrícola convencional, agressivo, insustentável e que absorve os grandes investimentos agrários. Diante dessa lógica, a agricultura familiar se vê em condições de ceder ou não ceder para o que pode descaracterizar sua base sustentável.

Em síntese, fazendo uma sistematização desses autores, trazidos aqui, nessa sessão de discussões, compreende-se que diante das disfunções e insustentabilidade nos meios de produção, a missão nos perímetros irrigados é desafiadora, encarregados no projeto de se estabelecerem ou se reafirmarem como um sistema alimentar sustentável. Para isso, alguns fundamentos da agricultura familiar devem ser ratificados, tal como: as conexões com o local de pertencimento; as relações e compromisso com a natureza; as conexões ente produtores, a comunidades e o ecossistema. (Elias et al, 2019).

Assim, é possível entender que tanto Reis et al (2018); Bertolin et al; Elias et al (2019) acreditam que o que faz a agricultura familiar acontecer é a observância para a dimensão sustentável, oportunizando a segurança alimentar, a conectividade com a natureza, a cultura local e sem dúvidas, a biodiversidade. A se afastar, assim, das ambições do produzir por produzir lucros sem considerar as disfuncionalidades na dimensão Sustentável.

Desenvolvendo um estudo sobre sustentabilidade nas produções rurais a partir da percepção do agricultor, Patrich; Grzybovski; Toebe (2017) trazem o entendimento que a sustentabilidade nas produções agrárias é vista como padrão de ações de pequenas propriedades agrárias que considera a evolução das atividades de produção fruto da ação da mão de obra familiar, utilização de técnicas proporcionando a preservação ou o menor impacto possível na natureza e nos recursos naturais.

Esses autores, como os demais, possuem a preocupação de manter o trabalhador rural com práticas dimensionais sustentáveis, defendendo a utilização dos recursos naturais com perspectiva racional, não provocando impactos que agrida a natureza e tudo o que ela oferece. Patrich et al (2017) chama atenção, alertando para a importância da sustentabilidade nos perímetros irrigados, que fazem uso do trabalho familiar, que tem em sua natureza, a produção artesanal e produções pequenas

Visto isso, os autores apresentam essa preocupação, pois entendem que apesar das dificuldades enfrentadas, querem que a agricultura familiar mantenha a sua essência, mesmo cientes que essa atividade agrícola não encontra

amparo nas leis de mercado para potencializar suas produções, fazendo uso de diferentes apoios tecnológicos tais como a agricultura tradicional.

Posto isso, Patrigh et al (2017) ao sistematizar a análise que obteve em seus estudos sobre o entendimento que os trabalhadores da agricultura familiar possuíam a respeito da dimensão sustentável em seus perímetros irrigados, percebe que tais trabalhadores, possuem uma ótica restrita, pois constatou que eles não reconhecem ou estimam a utilização de práticas de produção que desenvolvam suas atividades em um contexto racional, proporcionando, com isso, menor dano possível aos recursos naturais.

Dessa forma, Patrigh et al (2017, p. 222), entende que “a lógica da ação é capitalista, orientada pelas práticas que geram renda suficiente para manter os membros da família, reproduzidas a partir das práticas observadas em grandes produtores rurais, a racionalidade capitalista conduz a um pensamento míope a respeito da sustentabilidade”.

Percebe-se, à luz destas discussões, que devido ao grande avanço e força da agricultura convencional, no que tange a políticas de investimentos, a dimensão sustentável para muitos produtores rurais se apresenta incompatível com as práticas desenvolvidas em meio as propriedades rurais irrigadas.

Então, a escassez de trabalhadores familiares, a pouca lucratividade nas atividades agrárias que avistem as várias produções, e a competitividade desleal da agricultura convencional ameaça despertar para o que pode ser chamado de disfunções na agricultura familiar. Por isso, Bertolin et al. (2020), Reis; Lima; Desiderio (2018), Elias et al (2019) e Santos; Mitja (2011) alertam da necessidade de uma política de capacitação que potencialize, reafirme a necessidade de um contraponto ao meio de produção insustentável, orientando-se, para produções de base sustentável.

Essa preocupação sobre as condições da sustentabilidade em meio às produções rurais, não é recente, isso proporciona espaço para constatar ou perceber que a agricultura familiar e a dimensão sustentável estão em constante fragilidade e ameaça vindas das influências e forças externas. Nesse sentido, Santos e Mitja (2012) justifica esse entendimento trazendo a discussão que os pequenos produtores possuem dificuldades em comercializar seus produtos, constituindo-se em um problema

Outro agravante que o autor aborda a prática da agricultura em cortar e queimar pelos próprios produtores rurais, percebe-se assim, que essa prática vai contra as práticas dimensionais da sustentabilidade, acarretando o desflorestamento acelerado das propriedades rurais que

atinge de forma desfavorável a produção social e econômica da família.

Além do mais, o autor chama atenção, salientando que a floresta é sinônima de reservatório de nutrientes necessários para o cultivo das propriedades rurais, e que a longo ou curto prazo isso poderá gerar o esgotamento ou diminuição dos recursos naturais, gerando uma crise no sistema de produtividade. (Santos; Mitja,2012).

Á vista disto, Silva (2018) também possui preocupações similares dos autores a cima, em relação à dimensão sustentável nas propriedades dos agricultores, entendendo a necessidade e importância do repensamento das práticas ou tentativas de insustentabilidade nas produções agrícolas. Então, assim como, Elias et al (2019); Bertolin et al. (2020) e Silva (2018) proporcionam o entendimento à busca da capacitação, orientação e potencialização para a redução ou eliminação dos erros nas práticas agrícolas, que pode ser compreendida como insustentabilidade rural no que deveria ser sustentável.

Em conformidade com os autores citados neste estudo bibliográfico, Silva (2020) ao se preocupar em conhecer o perfil socioeconômico dos produtores familiares, percebeu insegurança na utilização de agrotóxicos e os riscos de contaminação humana e no meio ambiente, em total desconexão com as práticas de sustentabilidade nas propriedades rurais. Em relação a isso, entende-se que as práticas da agricultura familiar devem proporcionar uma integração e conectividade com a sustentabilidade, mas o que se observa, a partir destas informações, é o desrespeito com a vida, seja ela humana ou ambiental.

Consequentemente, Silva (2020) explica que essas atitudes são devido à ausência de informações sobre os riscos, a baixa escolaridade, a perpetuação de antigas práticas de cultivo, às questões financeiras, o desinteresse pelas consequências posterior, e principalmente à falta de políticas públicas voltadas para o trabalhador do campo, levam para caminhos de incompatibilidade para produções harmônica com a sustentabilidade. Nesse entendimento a prática sustentável deve ser uma política de resistência, como defende (Boychowski, et al, 2020)

Além do mais, Hein; Silva (2019) trazendo um aparato sobre estudos da insustentabilidade na agricultura familiar, revelam que há presença de situações de vulnerabilidade econômica nas práticas da agricultura familiar, provocados por vários fatores que provocam desvios de princípios ecológicos. Então, o sujeito que ambiciona o desenvolvimento em sua forma sustentável, deve se preocupar entender as motivações que geram as mudanças, consequentemente entender como elas se dão para conhecer os mecanismos que ocasionem as mudanças. “A falta de conhecimento ou dúvidas dos agricultores sobre o

tema desenvolvimento sustentáveis é outra, sendo esta uma das principais barreiras” (Laurett et al, 2021, p. 13)

Azevedo e Ramos (2019) realizando uma análise da política e da ação coletiva na agricultura familiar em projetos públicos irrigados, e trazendo o Vale do São Francisco como exemplo algumas disfuncionalidades, revelam desvios de finalidade na prática da produção, índices elevados de abandono, dificuldade e falta de interesse em permanecer no projeto, vendendo assim, os lotes para agricultores empresariais.

Somado a isso, “criação de espaço de lazer nas áreas da produção, trazendo consequências perversas para o meio ambiente e o aumento dos custos individuais para a manutenção de um sistema construído com uma determinada capacidade e que, por causa da substituição, sobrecarrega financeiramente os agricultores que cultivam os seus lotes.” (Azevedo; Ramos, 2019, p.14)

Assim, considera-se à luz de Preiss (2020), assim como Silva (2020) e Hein; Silva (2019) que a lógica de combater as disfunções na agricultura familiar passa por evidenciar a importância de compreender que o caminho agroecológico perpassa por processos de construções dos saberes por parte de todos que se envolvem com agricultura de base ecológica.

Nesse entendimento, Borges et al (2020) e Silva et al (2021) realçam que a sustentabilidade nos sistemas produtivos familiares, torna uma prática diferenciada, tendo em vista os impactos ao meio ambiente de forma positiva. Diante desse entendimento, volta a destacar aqui, uma ação potencializada na perspectiva que a agricultura familiar tem como característica menor impacto ambiental em relação a práticas de cultivos e manejos.

Ampliando essa discussão, Giagnocavo et al (2018) em sua pesquisa traz uma experiência de um estudo sobre a agricultura familiar, ele desconstrói alguns estereótipos contra essa prática agrícola, relatando que a atividade econômica agrícola familiar é predominantemente organizada em torno de modelos de negócios cooperativos, apresenta-se uma variedade de estudos diversos sobre o setor agrícola e cooperativo de crédito de Almería e a exploração de indicadores socioeconômicos e ecossociais, além de indicadores econômico-mercadoológicos.

Ademais, o autor conclui que essa experiência é um demonstrativo de longevidade e sobrevivência, a fim de observar a evolução e os processos de adaptação às distintas demandas econômicas, sociais e ambientais de uma ampla gama de sócios-proprietários. Giagnocavo et al (2018, p. 13) reforça que “apesar das importantes mudanças ocorridas no setor agroalimentar nas últimas décadas, as cooperativas têm demonstrado sua capacidade de adaptação e articulação e mudanças nas necessidades

dos membros e da comunidade e desafios de produção e distribuição”.

Portanto, assim como Giagnocavo et al (2018), Correño (2019), Osório et al (2019) e Enrique et al (2019) possuem entendimentos semelhantes, os mesmos percebem que apesar dos desafios enfrentados pela agricultura familiar, vem gerando emprego, crescimento econômico, desenvolvimento e competitividade.

Nesse sentido, isso visa promover vantagens competitivas por meio de alianças produtivas, alternativas de produção e especialização de mercado. Assim, Correño (2019) e Enrique et al (2019) defendem que é possível manter e fortalecer ainda mais a dimensão sustentável nas práticas agrícolas, pois segundo, Laurett et al (2021) uma agricultura sustentável pode contribuir para a conservação do meio ambiente.

#### IV. CONCLUSÕES

Como foi observado neste estudo bibliográfico, a agricultura familiar necessita de mais atenção, de investimento, de políticas de incentivo e de capacitação para se estabelecer perante a influência que agricultura convencional gera, e que na busca desenfreada de produção e lucratividade, ignoram princípios da dimensão sustentável. Nesse sentido, pode-se sintetizar aqui, com base nas argumentações apresentadas que de fato, a falta de conhecimento, entendimentos técnicos ou dúvidas dos produtores sobre o tema desenvolvimento sustentável, proporciona disfunções na agricultura familiar.

Para mais, outro fator importante das disfunções percebida, é a falta de apoio governamental para tornar os agricultores dos perímetros irrigados mais potencializados em relação as práticas sustentáveis. Assim, não basta só oferecer lotes, é preciso à permanência de ações mais efetivas e presentes por parte da governança.

Conclui-se, que há uma necessidade efetiva de potencializar os pequenos produtores rurais familiares viabilizando assistência técnica, aliada a presença de tecnologias que não agrida o meio ambiente. Os produtores familiares devem ser um forte aliado do desenvolvimento sustentável, e assim, ser uma alternativa para os que buscam equilíbrio ecológico e alimentos livres de produtos que prejudicam a saúde humana e a vida da natureza.

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# Investigation of the Determining Questions in the Selection of Respiratory Masks in the Prevention of COVID Using the DEMATEL Method

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Received: 29 Jul 2022,

Received in revised form: 16 Aug 2022,

Accepted: 23 Aug 2022,

Available online: 31 Aug 2022

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**Keywords—** Prevention of COVID-19,  
Respiratory protective equipment, Masks,  
Multicriteria methods, DEMATEL.

**Abstract—** The World Health Organization recommends the use of respiratory protective equipment, in this context masks, as a way to alleviate the severe acute respiratory infection disease pandemic COVID19 (SARS-CoV-2). This recommendation was made to the general population, not just health professionals or people who are in direct contact with the sick. Generally speaking, there was a lot of publicity for the use of masks, but there was no disclosure of what would be the most important requirements to be considered for the choice. In this context, the objective of this work was to verify the understanding of the community in general about what are the important requirements in choosing a protective mask against pathogens. For this, an analysis was carried out in 200 scientific articles where it was possible to obtain five keywords related to the most important requirements when choosing a mask, namely: comfort, safety, cost, reuse and facial adjustment. An opinion poll was carried out in 4 groups, in which a weighting was requested for each keyword. The first group is composed of five health professionals and five teachers, the second of five students and people randomly chosen from the community. The objective is to study the influential criteria for the choice of respiratory protection equipment using the mathematical method Decision Making Trial and Evaluation Laboratory (DEMATEL) to demonstrate the influence relationship between the criteria. As a result, it was found that the group of professionals considers criteria related to safety and the group of non-professionals considers factors related to cost and reuse, and this demonstrates a higher risk of infection.

## I. INTRODUCTION

As the COVID-19 (SARS-CoV-2) disease pandemic progresses, a debate concerns the use of respiratory protective equipment (RPE), face masks, by healthcare professionals and individuals in the community enters the picture (Cheng et al., 2020). The use of face masks as part of a comprehensive strategy of measures to

mitigate transmission (WHO, 2020; Brazil, 2005). That surgical masks are one of the administrative control measures, which aim to mitigate exposure to pathogens that cause numerous respiratory syndromes, including covid-19 (Brazil, 2005). This premise is confirmed by the National Institute for Occupational Safety and Health when it states that among the protection methods, the use

of personal protective equipment is one of the least effective means of prevention when compared to the use of collective protection equipment, imperative measures or actions that eliminate the danger (NIOSH, 2020), as shown in Figure 1.

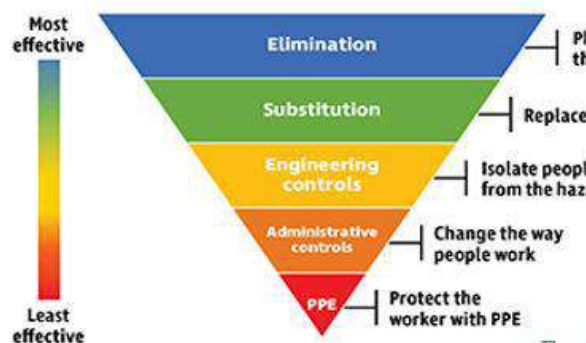


Fig.1 – Hierarchy of controls (NIOSH, 2020)

Cheng et al. (2020) corroborate this statement when they explain that there are concerns that the use of masks may generate a false sense of security in relation to other infection control methods, such as social distancing and hand washing.

For these reasons, it is important to highlight that the EPR does not eliminate the risk but contributes significantly to its mitigation (WHO, 2020; NIOSH, 2020). According to the National Health Surveillance Agency – ANVISA, there are several types of masks for different purposes. Some of them are used for respiratory protection for professionals and other masks have the main function of protecting the community in general, and each activity requires an appropriate type of mask (ANVISA, 2020).

Several types of EPR are being used at this time of pandemic in Brazil. It can be divided into three categories: a) Protective masks for non-professional use; b) Surgical masks and; c) Personal protective equipment (PPE) or respirators (ANVISA, 2020).

In relation to surgical masks, Anvisa Resolution RDC No. 356 (Brazil, 2020) provides, in an extraordinary and temporary way, on the requirements for the manufacture, import and acquisition of medical devices identified as priority for use in health services, due to the international public health emergency related to SARS-CoV-2. And in this resolution, the minimum and necessary conditions for the manufacture of surgical masks are presented.

According to Torloni and Vieira (2019), personal protective equipment or respirators are EPR that must have a Certificate of Approval, registration with ANVISA according to RDC 185/2001 (ANVISA, 2001) and be produced and tested by light of the standards ABNT NBR 13698 (ABNT, 2011).

Regarding non-professional use protection masks, which are a homemade option for protection, there are no standards or legislation available for their production. As a way to guide some good manufacturing, use and conservation practices, ANVISA made available a manual with basic guidelines (ANVISA, 2020). As this type of mask does not comply with a standard for the choice of raw material, design and standardized test criteria, its efficiency are questioned. It is a fact that this type of EPR, easily manufactured at home and reused after washing, raises concerns among authorities about the correct techniques of use, removal and disposal of facial masks, but these techniques can be learned through public education (Cheng et al., 2020).

From what has been said so far, the considerations presented refer to safety in choosing the mask. In another line of thought, studies are carried out considering the comfort of these EPRs. Fikenzer et al. (2020) carried out studies on the effect of RPR during exercise practice and its influence on cardiopulmonary capacity. In their studies Lee et al. (2020) examine the influencing factors that affect the comfort of reusable face masks. Liu et al. (2020) state that wearing masks for a long time alters subjective sensations if physiological reactions such as increased mean skin temperature, change in heart rate and reduced blood oxygen saturation decreases, which ultimately leads to a decline in health and comfort levels.

Regarding aspects of mask reuse, Rubio-Romero et al. (2020) carried out a scientific literature review to identify the main disinfection strategies and determine the effectiveness of masks. In similar studies Seresirikachorn et al. (2021) who outlined their research on N95 type masks, presented existing decontamination methods, and provided evidence-based recommendations for selecting an appropriate decontamination method. Pereira-Avila et al. (2020) draw attention to a risky practice for the reuse of this RPE, which increases the chance of transmission due to ineffective respiratory protection. New scientific evidence regarding the use and reuse of masks, which can be used to support the establishment of guidelines, public policies and educational strategies, promote the adoption of correct practices.

As noted by Pereira-Ávila et al. (2020) the proper use presents itself as a significant premise for the reduction of risk. In a case study of 373 Vietnamese subjects (15-47 years) Huynh (2020) noted that only 22.25% of respondents demonstrate proper EPR use based on WHO recommendations and suggest public communication policies and guidance on the proper use of a medical mask to contain the COVID-19 outbreak. In the same line of research, but for a group of health professionals, Bakhit et

al. (2021) identified, evaluated and synthesized studies evaluating the use of face masks.

The layout of the EPR, that is, the mask that fits perfectly to the face, is fully related to the risk of infection. According to Young et al. (2020) ill-fitting face masks pose risks when exposed to pathological agents. Adjustments to full face masks can help prevent fogging or slippage of the mask and increase test reliability.

A relevant aspect in choosing a type of EPR from the user's point of view is the cost, especially when it comes to non-professional use protection masks, as the cost of these are supported by users, unlike professionals supported by employers.

Based on what has been said so far, five items are considered when choosing an EPR, such as safety, comfort, cost, reuse and facial adjustment. In a survey conducted on abstracts of 200 scientific articles, between 2020 and 2021, it was observed that the items most cited by researchers are: 84% safety, 44% reuse, 34% comfort and 0% cost.

It is a fact that the perception of the significance of the judgment of which item is the most relevant for the choice of EPR varies according to the respondent. To solve this gap, multi-criteria analysis methods assist in this analysis and help decision makers to prioritize the processes of this action (Kijewska et al., 2018).

The Decision Making Trial and Evaluation Laboratory (DEMATEL) mathematical method is intended for the development and evaluation of a hierarchical structure based on expert opinion in order to obtain the level of relationship between complex variables (Li; Mathiyazhagan, 2018; Kijewska et al., 2018). Such methodology helps in the quantification and subjective judgments of respondents (Sara et al., 2015; Kijewska et al., 2018).

There are countless researches that use the DEMATEL methodology in the health areas. Suzan and Yavuzer (2020) studied the cause-and-effect relationships between diseases often seen in medicine. Chen and Li (2020) used patient influence factors to choose medical institutions based on three aspects: patients, medical institutions and government. Both studies aimed at causal classification and classification of the importance of

relevant factors that influence these choices of items analyzed for decision making.

In addition to these researchers, many others have used the DEMATEL tool to investigate accidents, but it is clear that these applications are divided into sectors.

In the context presented so far, this study aims to propose an analysis of the decisive factors for choosing EPR, in two distinct groups (professionals and non-professionals) using the DEMATEL methodology that will contribute to mitigating the weight of bias in judgments (Altuntas; Dereli, 2015) of users in choosing the mask.

## II. METHODOLOGY

The methodology of this proposal is presented in Figure 2, described as:

a) Initially, a bibliographic research is carried out in summaries of 200 articles, in a period between 2020 and 2021.

b) From this research, the keywords (K) are extracted.

c) Two groups are formed to answer the questions proposed in this study (Appendix 1). A group formed by professionals (5 health professionals, 5 teachers, defined as P1.1 to P1.10) and a group formed by non-professionals (5 people randomly chosen from society and 5 students, defined as P2.1 to P2.10). a) The DEMATEL methodology is applied, following the steps (Altuntas; Dereli, 2015; Li; Mathiyazhagan; 2018):

i. All K obtained are grouped in pairs for further analysis.

ii. Respondents are asked to assign a grade to each K obtained, using Table 1 as a reference, obtaining the direct degree of influence of the investigated causes. The notation  $a_{ij}$  indicates the degree is the presentation of the level of influence of the  $K_n$  compared in pairs in the analyst's view.

Table 1 – Raing Influence

Variable	Influence Score
No influence	0
Very low influence	1
Low influence	2
High influence	3
Very high influence	4

$$I = \begin{bmatrix} a_{11} & a_{12} & a_{13} & \dots & a_{1n} \\ a_{21} & a_{22} & a_{23} & \dots & a_{2n} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ a_{n1} & a_{n2} & a_{n3} & \dots & a_{nn} \end{bmatrix}$$

iii. Construction of the Initial Matrix (Matrix I), according to Eq. (1). Eq. (1)

iii. Determination of the Initial Influence Matrix (Matrix Y), obtained by Equation 2.

$$Y = k \cdot I \tag{Eq. (2)}$$

Where:

$$k = \frac{1}{\max_{1 \leq i \leq n} (\max_{i=1}^n (a_{ij}), \max_{j=1}^n (a_{ij}))} \quad (i, j = 1, 2, \dots, n)$$

iii. Obtaining the Total Influence Matrix (T Matrix) by Equation 3.

$$T = Y (I - Y)^{-1} \tag{Eq. (3)}$$

Where I is the Identity Matrix

iv. Obtaining the threshold value ( $\alpha$ ) that will be compared to all elements of Matrix T, in order to analyze whether the elements are a cause or an effect. For the calculation of Linear Value, equations 4 to 6 were used.

$$R_i = \sum_{j=1}^n (t_{ij}) = [t_i]_{n \times 1}, \quad (i, j = 1, 2, \dots, n) \tag{Eq. (4)}$$

$$C_j = \sum_{i=1}^n (t_{ij}) = [t_j]_{n \times 1}, \quad (i, j = 1, 2, \dots, n) \tag{Eq. (5)}$$

$$\alpha = \frac{\sum_{j=1}^n (t_{ij}) \sum_{i=1}^n (t_{ij}) [t_{ij}]}{N} \tag{Eq. (6)}$$

iv. Obtaining the prominence vector ( $R_i + C_j$ ) and the relative vector ( $R_i - C_j$ ).

v. Based on the value obtained from  $\alpha$ , each element of the Matrix T is analyzed, and in this the classification "Cause" is obtained when the element presents a numerical value greater than or equal to the value of  $\alpha$ , otherwise it is classified as "Effect". This identity (Cause or effect) is obtained when  $(R_i - C_j) > 0$  will be "Cause", otherwise, "Effect"

vi. Hierarchization of the "Causes" raised for further treatment of these "causes" or development of an action plan, practices that are present in an accident investigation. And this is defined by the prominence vector ( $R_i + C_j$ ), in descending order.

vii. The Impact Diagram is prepared, based on the Matrix T, which represents a visible structural modeling (Fu et al., 2012) of the causes of accidents (criteria) that contribute directly or indirectly to the occurrence of the final event.

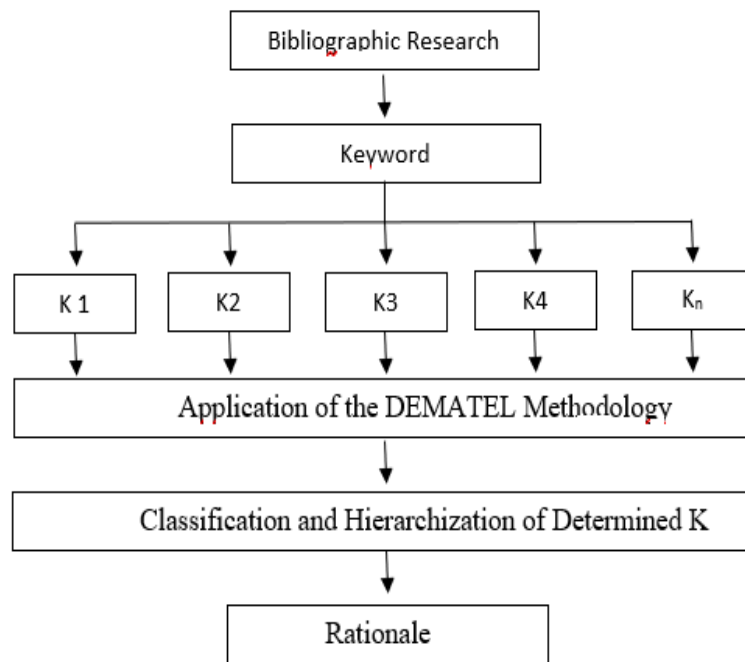


Fig.2: Research flowchart

**III. RESULTS AND DISCUSSIONS**

A survey was carried out, subdivided into two groups, professionals (5 health professionals, 5 teachers) and a group consisting of non-professionals (5 people randomly chosen from society and 5 students). The result of this research can be seen in Appendix 2 and 3, as well as the arithmetic means for each K in pairs.

With these K averages, the DEMATEL methodology was applied in order to classify and weight the observed events (Altuntas; Dereli, 2015; Li; Mathiyazhagan; 2018).

**1.1 Group of Professionals**

Construction of the Initial Matrix, presented in Table 2, using the information obtained in Appendices 2 and 3, and in pairs with the degree of influence between each K, demonstrates the effect that one criterion has on all the others.

Table 2 - Matrix I for the group of professionals

Criteria	K1.1	K1.2	K1.3	K1.4	K1.5
Safety (K1.1)	0	3,50	3,50	3,60	3,40
Comfort (K1.2)	2,80	0	3,30	3,50	3,00
Possibility of Reuse (K1.3)	2,30	2,60	0	2,50	2,60
Face Adjustment (K1.4)	3,80	3,10	2,60	0	3,40
Cost (K1.5)	3,00	1,90	2,50	2,20	0

Table 3 shows the Initial Influence Matrix (Matrix I).

Table 3 - Matrix Y for the group of professionals

Criteria	K1.1	K1.2	K1.3	K1.4	K1.5
K1.1	0,00	0,25	0,25	0,26	0,24
K1.2	0,20	0,00	0,24	0,25	0,21
K1.3	0,16	0,19	0,00	0,18	0,19
K1.4	0,27	0,22	0,19	0,00	0,24
K1.5	0,21	0,14	0,18	0,16	0,00

In Table 4, the matrix of total influence (Matrix T) is presented, as well as the value of  $\alpha$ .

Table 4 - Matrix T for the group of professionals

Criteria	K1.1	K1.2	K1.3	K1.4	K1.5
K1.1	1,08	1,22	1,28	1,27	1,31
K1.2	1,16	0,93	1,18	1,18	1,20
K1.3	0,96	0,92	0,81	0,96	1,00
K1.4	1,23	1,14	1,17	1,01	1,25
K1.5	0,97	0,87	0,94	0,92	0,82
$\alpha = 1,07$					

Table 5 shows the values of  $R_i$ ,  $C_j$ , the prominence vector ( $R_i + C_j$ ) and the relative vector ( $R_i - C_j$ ) and the identities of each criterion are defined (Altuntas; Dereli, 2015; Li; Mathiyazhagan; 2018). For the criteria classified as causes, positive values ( $R_i - C_j$ ) mean that the degree of influential impact ( $R_i$ ) is greater than the degree of influenced impact ( $C_j$ ) (Li; Mathiyazhagan; 2018). It was then observed that events K1.1, K1.2 and K1.4 were classified as causes and K1.3

and K1.5 were classified as effect factors. The safety criterion (K1.1) is the most influential and this fact is justified by the main reason for using an EPR, which is prevention. Regarding comfort (K1.2), classified as cause, it is directly related to the need to use the EPR for long periods of time, a characteristic related to the analyzed group being professionals. This fact was observed by Liu et al. (2020) when they state that wearing masks for a long time alters subjective sensations. In his studies, Huynh (2020) observed that the correct fit on the face is a risk factor for infection, and this fact is observed when analyzing the degrees of influence of the fit on the face criterion (K1.4), that is, for the group of professionals this criterion is associated with security. When comparing the reuse (K1.3) and cost (K1.1) criteria, it is observed that both are classified as effects, that is, (Ri - Cj) negative, and this fact is justified due to the fact that the analyzed group does not bear with the cost of the EPR.

Table 5 - Identification of criteria identities for the group of professionals

Criteria	Ri	Cj	Ri + Cj	Ri - Cj	Identity
K1.1	6,17	5,40	11,56	0,77	<b>Cause</b>
K1.2	5,65	5,08	10,73	0,57	<b>Cause</b>
K1.3	4,65	5,39	10,04	-0,73	<b>Effect</b>
K1.4	5,81	5,34	11,15	0,47	<b>Cause</b>
K1.5	4,52	5,58	10,10	-1,07	<b>Effect</b>

Figure 3 presents the classification categorized into two groups, as a cause group and an effect group (Fu et al., 2012). In the same Figure, it is possible to verify the hierarchy of the group of professionals. And in this it is possible to observe that the criterion that proved to be more relevant was K1.1 (security) followed by K1.2 (comfort) and K1.4 (fit on the face).

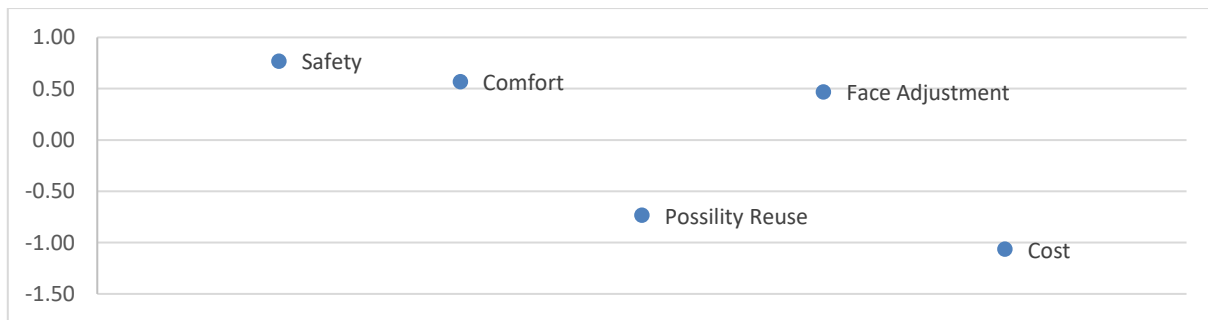


Fig.3: Impact diagram and hierarchy of criteria for the group of professionals

**1.2 Non-Professional Group**

In an application similar to section 3.1, the methodology was applied to the Group of Non-Professionals. Tables 6 to 9 show the results of the DEMATEL methodology.

Table 6 - Initial matrix for the group of non-professionals

Criteria	K2.1	K2.2	K2.3	K2.4	K2.5
Safety (K2.1)	0	3,80	3,60	3,90	3,60
Comfort (K2.2)	3,00	0	4,00	3,60	2,00
Possibility of Reuse (K2.3)	3,10	3,70	0	3,60	3,30
Face Adjustment (K2.4)	4,00	2,60	1,90	0	2,60
Cost (K2.5)	3,30	3,00	3,70	2,70	0

Table 7 - Matrix I for the group of non-professionals

Criteria	K2.1	K2.2	K2.3	K2.4	K2.5
K2.1	0,00	0,26	0,24	0,26	0,24
K2.2	0,20	0,00	0,27	0,24	0,13
K2.3	0,21	0,25	0,00	0,24	0,22
K2.4	0,27	0,17	0,13	0,00	0,17
K2.5	0,22	0,20	0,25	0,18	0,00

Criteria	K2.1	K2.2	K2.3	K2.4	K2.5
K2.1	1,40	1,58	1,57	1,65	1,43
K2.2	1,39	1,20	1,41	1,45	1,20
K2.3	1,48	1,48	1,28	1,54	1,33
K2.4	1,32	1,24	1,20	1,14	1,13
K2.5	1,42	1,38	1,42	1,43	1,09
$\alpha = 1,37$					

Table 8 – Matriz T for the group of non-professionals

Table 12 presents the values of the prominence and relative vectors and defines the identities of each criterion. It was then observed that the K2.1 and K2.3 criteria were classified as causes and the others as effects. Similar to the group of professionals, the safety criterion (K1.1) is the most influential and this fact is justified by the main reason for using an EPR, which is prevention. The comfort criterion (K2.2), for this group, was not considered an influencing factor for choosing a type of RPE, a fact that can be explained by the shorter time of use compared to the other group. Regarding the face fit criterion (K1.4), after applying the methodology, it was classified as an effect, and this fact can be explained by the lack of knowledge of this group regarding the correct sealing of the RPE on the face, which contributes to greater safety. This fact was also observed by Huynh (2020) who observed that the correct fit on the face is a risk factor for infection, which leads to an intensification of public communication policies and guidance on the proper use of EPR. When analyzing the reuse (K2.3) and cost (K2.1) criteria, it is observed that both are classified

as causes, unlike the group of professionals, a fact explained by the fact that this group bears the costs of the EPR. This fact suggests a public communication program aiming to guide the filtration efficiencies of each type of EPR, since it is known that homemade masks do not offer the same degree of protection.

Table 9 - Identification of criteria identities for the group of non-professionals

Criteria	Ri	Cj	Ri + Cj	Ri - Cj	Identity
K2.1	7,62	7,01	14,63	0,60	<b>Cause</b>
K2.2	6,65	6,87	13,52	-0,23	<b>Effect</b>
K2.3	7,10	6,88	13,98	0,23	<b>Cause</b>
K2.4	6,03	7,20	13,23	-1,17	<b>Effect</b>
K2.5	6,73	6,17	12,90	0,57	<b>Cause</b>

Figure 4 shows the impact diagram that demonstrates the classification and hierarchy of criteria. It is noted that the K2.1 (security) criterion was more relevant, followed by the K.2.3 (reuse) and K2.5 (cost) criteria.



Fig.4: Diagram of impact and hierarchy of criteria for the group of non-professionals

#### IV. CONCLUSION

When comparing the findings of this study for the two groups, it is clear that there was a difference in influencing factors. The group of non-professionals tends to find greater security seen in the values obtained for K1.1, K1.2 and K1.4 and the other group considered the criteria related to the cost of the EPR, with the criteria K2.3 and K2.5 obtained higher values. It is evident the lack of association of these criteria, in the group of non-professionals, the perfect fit to the face is a safety factor, as it provides a better seal and, consequently, better protection. As for the fact that this group elects the cost and reuse criteria as the most relevant, it can be pointed out as a greater risk of infection when considering that homemade masks have lower filtration efficiency and do not have efficiency assessment certifications. These two factors suggest a greater communication policy to the general population about the criteria for choosing an EPR based on its prevention effectiveness.

#### ACKNOWLEDGEMENTS

This work was supported by Instituto CEFORES from the Federal University of Triângulo Mineiro.

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### Appendix 1

Name of respondent:

Does the respondent authorize the disclosure of their name in the article and TCC? Yes No ( )

1- In your opinion, what are the most important items when choosing an EPR to protect COVID-19?

2- Using Table 1 as a reference, answer:

Table 1 – Raing Influence

Variable	Influence Score
No influence	0
Very low influence	1
Low influence	2
High influence	3
Very high influence	4

Influence Relationship	Score
Safety & Comfort	
Safety & Possibility of Reuse	
Safety & Face Adjustment	
Safety & Cost	
Comfort & Safety	
Comfort & Possibility of Reuse	
Comfort & Face Adjustment	
Comfort & Cost	
Possibility of Reuse & Safety	
Possibility of Reuse & Comfort	
Possibility of Reuse & Face Adjustment	
Possibility of Reuse & Cost	
Face Adjustment & Safety	
Face Adjustment & Comfort	
Face Adjustment & Possibility of Reuse	
Face Adjustment & Cost	
Cost & Safety	
Cost & Comfort	
Cost & Possibility of Reuse	
Cost & Face Adjustment e Cost	

Appendix 2 – Grouping of Research Results – Professional Group

Influence Relationship	P1.1	P1.2	P1.3	P1.4	P1.5	P1.6	P1.7	P1.8	P1.9	P1.10	Average
Safety & Comfort	3	4	4	3	4	3	3	3	4	4	3,50
Safety & Reuse	4	3	3	3	3	4	4	4	3	4	3,50
Safety & Adjustment	4	3	4	3	4	3	4	3	4	4	3,60
Safety & Cost	3	2	3	3	3	4	4	4	4	4	3,40
Comfort & Safety	3	2	3	3	3	2	4	3	2	3	2,80
Comfort & Reuse	2	4	4	3	2	4	4	2	4	4	3,30
Comfort & Adjustment	3	4	4	3	2	4	4	3	4	4	3,50
Comfort & Cost	3	4	2	3	2	4	2	2	4	4	3,00

Reuse & Safety	1	3	1	2	3	2	2	3	3	3	2,30
Reuse & Comfort	2	3	3	1	3	4	2	3	2	3	2,60
Reuse & Adjustment	1	3	3	1	2	4	2	3	3	3	2,50
Reuse & Cost	2	2	3	1	3	3	2	3	4	3	2,60
Adjustment & Safety	4	4	4	4	4	4	4	2	4	4	3,80
Adjustment & Comfort	4	4	2	3	3	3	4	3	2	3	3,10
Adjustment & Reuse	4	3	2	3	2	2	3	2	3	2	2,60
Adjustment & Cost	4	3	4	4	2	3	4	3	4	3	3,40
Cost & Safety	1	3	3	2	3	4	3	4	3	4	3,00
Cost & Comfort	2	2	2	0	2	3	2	1	3	2	1,90
Cost & Reuse	2	4	3	1	2	2	2	4	3	2	2,50
Cost & Adjustment	1	3	2	1	2	3	2	3	3	2	2,20

*Appendix 3 – Grouping of Research Results – Non-Professional Group*

<b>Influence Relationship</b>	<b>P1.1</b>	<b>P1.2</b>	<b>P1.3</b>	<b>P1.4</b>	<b>P1.5</b>	<b>P1.6</b>	<b>P1.7</b>	<b>P1.8</b>	<b>P1.9</b>	<b>P1.10</b>	<b>Average</b>
Safety & Comfort	4	3	4	4	4	4	3	4	4	4	3,80
Safety & Reuse	4	3	3	4	3	4	4	4	3	4	3,60
Safety & Adjustment	4	3	4	4	4	4	4	4	4	4	3,90
Safety & Cost	4	3	3	4	3	4	4	4	3	4	3,60
Comfort & Safety	3	3	3	4	3	2	4	3	2	3	3,00
Comfort & Reuse	4	4	4	4	4	4	4	4	4	4	4,00
Comfort & Adjustment	4	3	4	3	3	4	4	3	4	4	3,60
Comfort & Cost	1	3	2	3	2	1	2	2	2	2	2,00
Reuse & Safety	3	3	4	3	3	2	4	3	3	3	3,10
Reuse & Comfort	4	4	3	3	3	4	4	4	4	4	3,70
Reuse & Adjustment	3	4	3	4	4	4	3	4	3	4	3,60
Reuse & Cost	4	3	3	3	3	3	4	3	4	3	3,30
Adjustment & Safety	4	4	4	4	4	4	4	4	4	4	4,00
Adjustment & Comfort	2	3	2	3	3	3	2	3	2	3	2,60
Adjustment & Reuse	2	2	2	2	2	2	1	2	2	2	1,90
Adjustment & Cost	2	3	3	3	2	3	2	3	2	3	2,60
Cost & Safety	3	4	3	4	3	4	3	4	3	2	3,30
Cost & Comfort	4	3	2	3	4	3	2	3	4	2	3,00
Cost & Reuse	4	4	3	4	4	4	2	4	4	4	3,70
Cost & Adjustment	2	4	3	2	2	4	2	4	2	2	2,70

# Quality Assurance Requirements Tailoring Approach for Small Satellite Projects

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Received: 28 Jul 2022,

Received in revised form: 22 Aug 2022,

Accepted: 26 Aug 2022,

Available online: 31 Aug 2022

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**Keywords**— *tailoring, requirements, quality assurance, small satellites.*

**Abstract**— *In regulated environments, which have impacts on the society, standards are adopted to determine rules to be followed, since the society expects to receive safe and reliable products and services. Regulatory agencies usually require adherence to requirements established in norms and standards so the product can be approved. In this context, space programs Quality Assurance standards are applicable to satellite projects with a wide responsibility range, from experimental small satellites to manned spaceships. Applying the full contents of these standards may be unfeasible to small missions with low responsibility, considering the cost and schedule constraints inherent to this type of project. Therefore, a customization of the requirements must be conducted in a thoughtful and disciplined manner, considering the project characteristics. The tailoring process presented in this work includes the analysis of the risk to the mission due to the reduction of the set of requirements. Each requirement was evaluated in view of its maintenance, modification, or elimination. This paper presents a process of tailoring mission-specific requirements, using a mission risk rating and the risk analysis tool FMECA. The result was a structured process for tailoring requirements, which provided a subset of Quality Assurance requirements applicable to small satellite projects.*

## I. INTRODUCTION

In Regulated Environments (RE), which have impacts on the society, regulatory agencies standards usually require adherence to standards to demonstrate that a product is safe and reliable [1].

Standards published by committees, international technical entities, or regulatory agencies influence product development through risk-based software process and product guidelines. Typically, each domain of knowledge has its own standard, which has to be customized based on knowledge acquisition from domain experts. Despite the existence of several techniques and methods of knowledge acquisition, mostly based on interviews and analysis, there

is still the need for methods that provide systematic support for customization of requirements [2, 3].

For space projects, the ECSS (European Cooperation for Space Standardization), a regulatory body for European space companies, including the ESA (European Space Agency), has a series of standards containing requirements used in the development of high responsibility and high-cost satellites. The use of these standards, however, is intrinsically associated with the characteristics of each project, such as type of product, role of the product in the system, size of the system and level of risk. According to ECSS System - Description, implementation, and general requirements [4]

Literature reports that low responsibility satellite projects do not necessarily fulfill the whole set of requirements from the standards, due to cost and time constraints. Tailoring these standards may have several drivers, such as dependability and safety aspects, development constraints, product quality and business objectives [5].

The low-responsibility satellites, notably the small satellites, whose denomination in this work applies to those with a mass up to 180 kg, belong to the class of satellites whose share is increasingly representative in the artifacts launched into space accordingly to NASA State-of-the-art Spacecraft Technology Report [6]. Therefore, there is an increasing number of organizations that need to demonstrate adherence with standards-based regulations, and the lack of appropriate processes may have negative consequences such as missing important activities or having limited ways to demonstrate their quality and be recognized in their domain [7].

Since 2013, ESA has released documents related to CubeSats projects, associated with its In-Orbit Demonstration (IOD) program, highlighting:

- Review Objectives for ESA In-Orbit Demonstration (IOD) CubeSat Projects [8];
- Tailored ECSS Engineering Standards for In-Orbit Demonstration CubeSat Projects [9];
- Product and Quality Assurance Requirements for In-Orbit Demonstration CubeSat Project [10].

Although the last document presents tailored requirements for the Product and Quality Assurance disciplines, the tailoring process and the risks associated with the modification are not described.

In 2020, the standard ECSS System Tailoring DRAFT 1 [11] was published, still in a preliminary version, presenting the process for tailoring ECSS standards to CubeSats is, considering economic characteristics and design techniques. According to this document, after identifying the main characteristics, the project must be analyzed to identify cost, schedule, main technical characteristics, as well as critical aspects and specific constraints.

Among these characteristics, the main strategic, organizational, economic or technical characteristics to be considered in a project are:

- Mission objectives (e.g., scientific, commercial, institutional);
- Product type;

- Mission characteristics (e.g., orbit, lifetime, availability);
- Restrictions on the environment in which the project is inserted (e.g., external interfaces, external regulations, purchases);
- Expected cost until final assembly;
- Main impact factors on the schedule;
- Level of commitment (e.g., partnership, supplier) or type of commercial arrangement (e.g., fixed price, reimbursement of expenses);
- Maturity of the project or technology (e.g., recurrent development, level of technical readiness);
- Technical complexity of the product;
- Organizational or contractual complexity;
- Supplier maturity.

This standard also proposes a series of steps for tailoring the ECSS requirements, based on the risks associated with the project. However, the process to be followed is not specified. Additionally, it has on its cover the information that it was published in the preliminary form, so still needs a pilot project to be validated.

Recently, a work on the related topic [12] proposed a method for tailoring Product Assurance requirements for small satellites, in which the requirements were evaluated in blocks, covering the seven disciplines of the Product Assurance area, without addressing the requirements individually.

The present work deals with the tailoring of the Quality Assurance requirements presented by ECSS to small satellite projects, through a process applied to the complete set of requirements of the standard ECSS-Q-ST-20C Rev.2 - Space product assurance - Quality assurance [13]. By applying this process, a minimum subset of requirements to be used in small satellite projects was obtained, meeting the principles of lower cost and shorter schedule, with adequate risk for the mission.

## II. STATE-OF-ART

### 2.1 Quality Assurance Requirements

According to ECSS-S-ST-00C Rev.1 - ECSS System Description, implementation and general requirements [4], the development of a space system is supported by four major branches, represented by knowledge areas: Project Management, Product Assurance, Engineering and Space Sustainability. These areas of knowledge, can be broken down into disciplines. Figure 1 shows the disciplines of the Product Assurance.

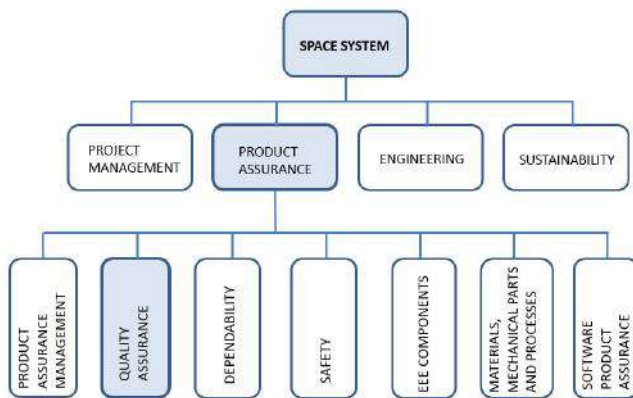


Fig. 1: Development of a Spatial System, with emphasis on the disciplines of the Product Assurance, extracted from [4].

According to ECSS-Q-ST-10C Rev. 1, Space product assurance - Product assurance [14], Product Assurance aims to “ensure that space products meet their defined mission objectives, safely, reliably and with desired availability”.

As shown in Figure 1, the Product Assurance disciplines are:

- Product Assurance Management;
- Quality Assurance;
- Dependability;
- Safety;
- EEE components;
- Materials, Mechanical Parts and Processes; and
- Software Product Assurance.

This work focuses on the analysis of the requirements of the Quality Assurance discipline, presented in ECSS-Q-ST-20C Rev.2 Space product assurance - Quality assurance [13] and the development of a process of tailoring of these requirements aimed at to small satellite missions.

The proposed process was developed from the project classification, given its complexity and cost, considering its exposure to risk related, to the introduced tailoring. The process assesses the risk of not using a requirement, using the FMEA/FMECA tool, shown in ECSS-Q-ST-30-02C - Space product assurance - Failure modes, effects (and criticality) analysis (FMEA/FMECA) [15].

### 2.1 Mission Risk Classification

In the early 2000's [16] in a work entitled The Intelligent Application of Quality Management to Smallsat Programs published in the 19th Annual AIAA/USU,

Conference on Small Satellites, the authors pointed out that the key to the success of small satellite missions is the risk management and the intelligent use of Quality Management principles. In this work, the authors mentioned that, with the challenge proposed in the 1960's by President Kennedy to NASA, to safely take and bring astronauts to the Moon, efforts were made to elaborate design, acquisition, production, testing, qualification and acceptance processes so that human errors are minimized, and failures do not occur. This leads to the understanding that the engineering and assurance requirements of the mission were defined by what was most innovative at that time.

Subsequently, these authors reminded that, with the declining world economy in the following years, a new management culture came into action that began to promote faster, better and cheaper space products (known by the acronym FBC). In this way, the quality system was directed into this new policy to meet the increasingly restrictive cost/benefit ratio. As a consequence, the result in the following decades was the occurrence of disasters, including manned missions.

In this same context, the authors warned that what was lacking in the FBC policy was a fourth decision element: “doing it intelligently”. They state that the risks in small-satellite contexts are either technical risks associated with not meeting requirements or programmatic risks associated with not meeting cost and schedule. Continuing this reasoning, the authors propose the use of the FMEA/FMECA tool, for the assessment of risks, mainly associated with materials and the use of COTS components.

The FMEA/FMECA tool, initially proposed by the aerospace industry in the 1960's, was adopted by the automotive industry in the following decade. Currently, this tool is used in other areas such as medicine, energy generation, among others. In the aerospace area, it is an important tool for risk analysis, mainly used by the Dependability discipline [17].

In 2011, Aerospace published the document Mission Assurance Guidelines for A-D Mission Risk Classes [18], which classifies space missions based on their associated risks. This document proposes that the risk of a mission could be defined based on economic and technical criteria specific to each project and recommends tailoring the requirements for the different engineering areas. The characteristics taken for the risk classification proposed in this Aerospace publication are similar to those proposed by the ECSS in its requirements tailoring document, ECSS System Tailoring DRAFT 1 [11], previously mentioned.

Table 1 shows the characteristics adopted for the mission risk classification, based on the Aerospace publication [19], in which space projects are divided in four classes: A, B, C or D.

Table.1: Mission Risk Class Profiles [19]

Characteristic	Class A	Class B	Class C	Class D
<b>Risk Acceptance</b>	Minimum	Low	Moderate	Higher
<b>Payload type</b>	Operational	Operational or Technology Qualification	Exploratory or Experimental	Experimental
<b>Cost</b>	Highest	High	Medium	Lowest
<b>Complexity</b>	Very high	High	Medium	Low
<b>Mission Life (ML)</b>	$ML \geq 7$ years	$4 \text{ years} \leq ML < 7$ years	$1 \text{ year} \leq ML < 4$ years	$ML < 1$ year
<b>National Significance</b>	Extremely Critical	Critical	Less Critical	Not Critical
<b>Launch Constraints</b>	Very high	High	Medium	Low
<b>Alternatives</b>	None	Few	Some	Significant
<b>Mission Success</b>	All PA measure	Few comprom	Reduced set of PA	Few PA measures

In this context, the Aerospace Mission Classification Guide [18] provides the definition of Mission Assurance requirements based on risk analysis. This guide is based on the documents Risk Classification for NASA Payloads [19] and DOD HDBK34 3- Military handbook: design, construction, and testing requirements for one-of-a-kind space equipment [20]. The risk profiles presented above are associated with technical and quality issues, which can impact the success of a mission. Evaluation criteria are also proposed resulting in a set of characteristics

associated with mission risk, allowing space missions to be categorized into four classes. They are:

- Class A - Extremely critical operating systems, where all practical measures must be taken to ensure mission success, through a minimal risk profile. These are missions with a long-life cycle (typically longer than 7 years), high cost and high investment associated with national interest. This class includes manned missions;

- Class B - Critical operating systems, exploratory and technical demonstrators, in which only minor adjustments are assumed in the application of Mission Assurance standards, to balance cost-effectiveness and ensure mission success. This is achieved through a low risk profile. These are medium lifecycle missions (typically between 4 and 7 years), high cost and with high to moderate complexity;

- Class C - Defined as missions of minor national importance, exploratory or experimental, with a reduced set of Mission Assurance standards applied, resulting in a moderate risk profile. These are short lifecycle missions (typically between 1 and 4 years), with moderate cost and complexity; and

- Class D - These are missions defined as having low national criticality, presenting a higher risk profile. They have a very short life cycle (typically less than 1 year), and a minimal set of Mission Assurance requirements, with low cost and complexity.

The Aerospace Mission Classification Guide [18] schematically illustrates this classification, Figure 2a, showing that, while the amount of Mission Assurance activities increases from Class D to Class A, the Residual Risk to which the project is exposure decreases, and, as a consequence, although a class A mission presents greater risk exposure, its residual risk is lower.

Figure 2b, from the same guide [18], shows that the greater the investment in Mission Assurance, the greater the predictability of the success of the mission, in addition to the lower variability of its success.

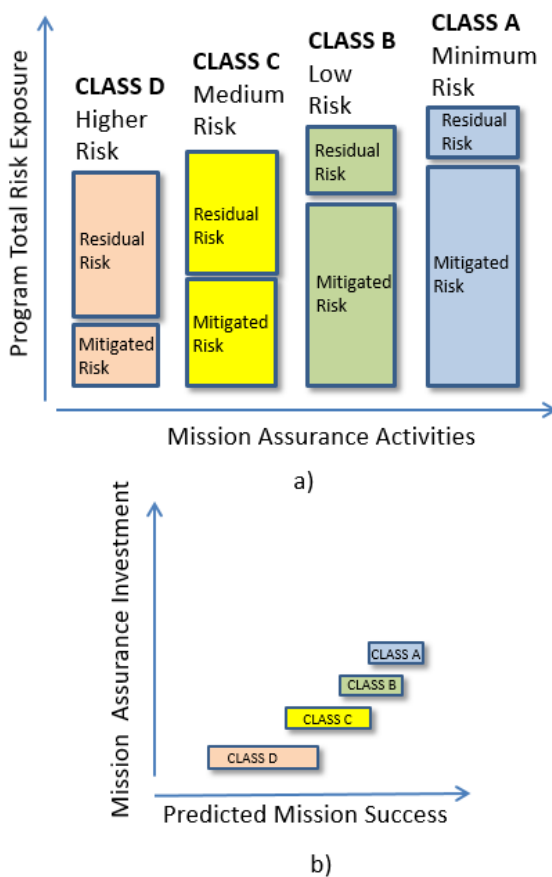


Fig. 2: Adaptation of classification showing Residual Risk and Classes A to D, extracted from [18]

In parallel with NASA/Aerospace activities, ESA developed a process to tailor ECSS standards shown in its IOD project mentioned before. This project brings together the ESA efforts in the construction of CubeSats from 2U to 6U, in several countries, in universities and associated research institutes, and proposes, in the sense of standardization, a minimum set of requirements for the construction of small satellites [9].

Particularly the document Review Objectives for ESA In-Orbit Demonstration (IOD) CubeSat Projects [8] provides an assessment of the documents required for their flight equipment and performs a tailoring of the required engineering standards for CubeSats, as well as indicating the requirements, applicable or not, in each of them. In this document, the indication is that CubeSat projects for in-orbit demonstration, in low earth orbit (LEO), are generally characterized by the following attributes:

- Complete autonomous systems, including platform, payload, ground segment and operations;
- Profile of greater risk acceptance;

- Low level of complexity (compared to other ESA space projects);
- Low cost (< 1M Euro) and short development schedule (<2 years for flight readiness);
- Short operational life (typically <1 year in LEO orbit);
- Single-Point of Failure (SPF) acceptance;
- Limited redundancy (whenever possible within the constraints);
- Limited fault tolerance (whenever possible within the constraints);
- Robust security mode (thermal and energy robustness in any attitude);
- Extensive use of off-the-shelf commercial elements (COTS) - modules that have flight heritage and are supplied by small industrial suppliers at a fixed price;
- Extensive testing focused on the system level (functionality and qualification/acceptance environment);
- Simple project organization with well-integrated teams: single entity for systems engineering, AIV (Assembly, Integration and Verification), and operations, few suppliers or sub-contractors.

These are characteristics with greater acceptance of mission risk and low associated cost.

Within the same project, the document Product and Quality Assurance Requirements for In-Orbit Demonstration CubeSat Project [10] brings Quality Assurance and Product Assurance requirements for satellites classified in the IOD project. It addresses the minimum requirements for quality assurance of a CubeSat.

Other documents available for this project are: IOD CubeSat Deliverable Items List [21] and the IOD CubeSat Deliverable Requirements Definition [22].

### III. METHODS

For the purpose of classifying a space mission, the criteria used by Aerospace [18] shown in section 2.2 are adopted in this work. Based on these criteria, the small satellites addressed in this work are categorized into Classes C and D, with their associated risk profiles.

The document Aerospace Mission Assurance Guidelines for A-D Mission Risk Classes [18] addresses considerations for each class and discipline in the Product Assurance area. These considerations guided the decision-making on maintaining, modifying, or eliminating a certain requirement during the tailoring process carried out for the Quality Assurance discipline, based on the

complete the set of requirements of ECSS-Q-ST-20C Rev.2 Space product assurance - Quality assurance [13]

The process adopted is based upon the use of the FMEA/FMECA tool [15] to evaluate the possible failures resulting from the eventual non-use of each requirement. That is, a failure in this process is defined as “a restrictive event potentially caused by the absence of the requirement”.

These failures were evaluated in terms of their probability of occurrence, the severity of their effects and their probability of detection. The objective of this process was the assessment of each requirement individually, as well as the associated risks and potential effects.

### 3.1 Process Development

The tailoring process was conducted in two weekly meetings of approximately 2 hours each, over a period of 10 months, with the authors experienced in Product Assurance for space projects in the National Institute for Space Research (INPE). During this period, the specialists interacted in online meetings, exposing their perceptions about each requirement, pointing out the criteria adopted and discussing until common agreement. Further analyses of the requirements were performed to prevent a requirement from being scored differently from another similar requirement.

### 3.2 Process

Among the possible ways to represent processes, the Integration Definition for Function Modeling (IDEFO) diagram has been chosen, as presented in 1993 by the FEDERAL INFORMATION PROCESSING STANDARDS PUBLICATION – FIPS in the Integration Definition for Function Modeling (IDEFO) [23]. This representation defines the function that the process performs, the inputs that will be transformed into outputs, the controls required to produce a correct output, the mechanism by which the inputs are transformed and, finally, the outputs with the output data of the process.

## IV. RESULTS AND DISCUSSION

Figure 5 shows the IDEFO representation of the proposed process “Tailoring”, showing the input (ECSS Space product assurance - Quality assurance [13] the control Aerospace Mission Assurance Guidelines for A-D Mission Risk Classes [18] and ECSS-S-ST-00-02C ECSS System Tailoring DRAFT 1 [11], the mechanism (ECSS Space product assurance - Failure modes, effects (and criticality) analysis (FMEA/FMECA) [15], and the output (“Quality Assurance Requirements for Small Satellite Projects”).

Figure 5 shows that the input had each of its requirements evaluated individually, according to defined criteria. At the end of this assessment, the requirement received one of three possible qualifications: maintained, modified or removed. Those requirements qualified as maintained or modified become part of the subset called “Quality Assurance Requirements for Small Satellite Projects”, shown in Figure 3 as the process output.

During the evaluation of each requirement, those that maintained similarity with the ones from the ESA document Product and Quality Assurance Requirements for In-Orbit Demonstration CubeSat Project [10], used as a reference, were also analyzed.

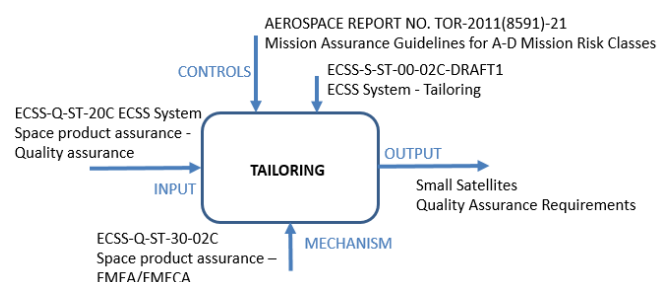


Fig. 3: IDEFO representation for the tailoring process for quality assurance requirements.

Figure 4 shows the process step-by-step. For each input requirement, its related failure (restrictive event potentially caused by the absence of the requirement) and probable consequences for the project are defined. Thus, the characteristics of this failure are defined, that is, are highlighted the effects produced in four dimensions of the project: safety, product, process and programmatic. Subsequently, possible ways of detecting these effects and a possible preventive or compensatory provision to mitigate them are evaluated.

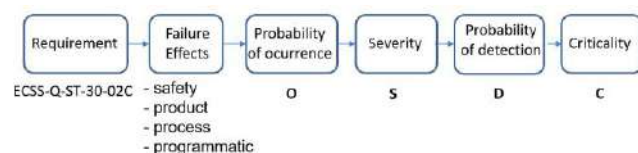


Fig. 4: Obtaining the criticality, or residual risk, associated with the failure.

Table 2 shows an extract of this analysis on each requirement.



Table.2: Extract from the analysis of effects, detection and provision in each assessed requirement.

ECSS Quality Assurance ECSS-Q-ST-20C		Effects A – safety B – product C – process D - programmatic	Detection (in effect)	Provision P – preventive C - compensatory
<b>5.5.9</b>	<b>Specific requirements for assembly and integration</b>			
<b>5.5.9.1</b>	<b>Control of temporary installations and removals</b>			
<b>a</b>	The supplier shall ensure the control of flight items which are temporarily removed or non-flight items which are temporarily installed to facilitate assembly, integration, testing, handling or preservation of the end item.	A – worker injury B – product damage C – unfeasible activities D – increase in cost and time	A – perception B – inspection and tests C – perception D – schedule and budget analysis	C – activities logbook
<b>b</b>	The control shall be initiated upon installation or removal of the first temporarily installed or removed item and be maintained through delivery and use of the end item.	A - Not Applicable B - Not Applicable C - Not Applicable D - Not Applicable	A - Not Applicable B - Not Applicable C - Not Applicable D - Not Applicable	-
<b>c</b>	The supplier shall establish and maintain records of temporary installations and removals.	A - worker injury B - product damage C - unfeasible activities D - increase in cost and time	A - Not Applicable B - Not Applicable C – perception D - schedule and budget analysis	-
<b>d</b>	Temporarily installed items shall be accounted for to prevent their being incorporated in the final flight configuration.  NOTE Temporary installations and removals are also called respectively, red tag items and green tag items.	A - Not Applicable B - Not Applicable C - Not Applicable D - Not Applicable	A - Not Applicable B - Not Applicable C - Not Applicable D - Not Applicable	-

Table.3: Extract of the Quality Assurance requirements assessment matrix.

ECSS Quality Assurance  ECSS-Q-ST-20C	(O) Class C	(O) Class D	(S) Class C	(S) Class D	(D) Class C	(D) Class D	(C) Class C	(C) Class D
		Q-ST-30-02C page 36 Table 8.2		Q-ST-30-02C page 36 Table 8.1		Q-ST-30-02C page 36 Table 8.3		critical (O) = 4; (D) = 4; (S) ≥ 3; (C) ≥ 12
<b>5.5.9</b>	<b>Specific requirements for assembly and integration</b>							
<b>5.5.9.1</b>	<b>Control of temporary installations and removals</b>							

<b>a</b>	The supplier shall ensure the control of flight items which are temporarily removed or non-flight items which are temporarily installed to facilitate assembly, integration, testing, handling or preservation of the end item.	4	3	4	3	3	3	<b>48</b>	<b>27</b>
<b>b</b>	The control shall be initiated upon installation or removal of the first temporarily installed or removed item and be maintained through delivery and use of the end item.	1	1	2	2	3	3	<b>6</b>	<b>6</b>
<b>c</b>	The supplier shall establish and maintain records of temporary installations and removals.	1	1	3	2	3	3	<b>9</b>	<b>6</b>
<b>d</b>	Temporarily installed items shall be accounted for to prevent their being incorporated in the final flight configuration.  NOTE Temporary installations and removals are also called respectively, red tag items and green tag items.	1	1	2	2	3	3	<b>6</b>	<b>6</b>

Then, the three factors related to the failure are scored, based on the ECSS Space product assurance - Failure modes, effects (and criticality) analysis (FMEA/FMECA) [15]. Initially, the probability of occurrence (O) of the failure in the project is evaluated, that is, in the perception of the specialists on what is the probability of that failure to occur. Then, the severity (S) of the possible consequences of the failure occurrence is analyzed and, finally, its probability of detection (D). These 3 factors are analyzed based on the description of the criteria in ECSS standard (ECSS-Q-ST-30-02C [15] Tables 8.1, 8.2 and 8.3.

The parameter probability of Occurrence (O) of the failure can be graded from 1 (very unlikely), 2 (unlikely), 3 (likely) or 4 (very likely).

The parameter Severity (S) of the failure is associated with the effects of the possible failure in four dimensions: safety, product, process and programmatic. In this case, the standard ECSS-Q-ST-30-02C [15] recommends the adoption of four values, from 1 to 4, being 1 for minor losses and 4 for damages of greater impact.

The parameter Detectability (D) of the failure is associated with the probability that the effects of the failure will be detected, and considers four values, from 1

to 4, being 1 (very likely), 2 (likely), 3 (unlikely) and 4 (very unlikely).

With these three parameters (O, S and D) in hand, the value of the Criticality (C) of the failure, also known as Residual Risk (RR) is defined as their product, that is:  $C = O \times S \times D$

Finally, the ECSS-Q-ST-30-02C [15] provides the steps to identify the critical processes (requirements), that for this study means “a requirement that cannot be eliminated”. In other words, the “C” metric will be used to identify requirements that must be maintained (or eventually modified), in opposition to those that can be eliminated.

Thus, a requirement will be considered critical if the score associated with its potential failure is:

- Occurrence  $A = 4$ , or
- Severity  $S \geq 3$ , or
- Detectability  $D = 4$ , or
- Criticality (Residual Risk)  $C \geq 12$

The applied process is shown in Table 3, which shows a clipping of the ECSS requirements assessment matrix, for the Quality Assurance discipline [13], object of this study.

In this matrix, the requirements of the ECSS standard [13] are allocated on the left, that in this example are the requirements belonging to section 5.5.9.1 – Control of Temporary Installation. In this section four requirements are allocated, respectively 5.5.9.1a to 5.5.9.1d, which were evaluated with the proposed process.

The effects of the failure in the safety, product, process and programmatic dimensions; the means of detecting these effects; and eventual preventive or compensatory provisions to minimize them; were evaluated. These evaluations served as a benchmark for the analysis of the parameters of Probability of Occurrence (O), Severity (S), Detectability (D) and Criticality (C). Table 2 shows pairs of columns associated with these parameters, respectively for satellites classes C and D [18].

Taking the requirements of family 5.5.9.1 as example, it can be seen in Table 2 that the parameter (O) for requirement 5.5.9.1a was considered to have a high probability of occurrence for class C satellites, grade 4 (very likely), while for Class D it received grade 3 (probable). The failures referring to the other requirements of this same family, 5.5.9.1b to 5.5.9.1d, received grade 1, with a very low probability of occurrence for both classes of satellites. The Severity parameter (S) received grades 4 and 3 for classes C and D, while the Detectability parameter (D) received 3 for both classes. With these three parameters (O, S and D) for requirement 5.5.9.1a, the Criticality (C) value of the potential failure was obtained as 48 for Class C and 27 for Class D.

According to the criteria for inclusion or exclusion of requirements described above, the potential failure regarding requirement 5.5.9.1a was considered critical, therefore the requirement must be maintained for both classes of satellites. However, requirements 5.5.9.1b and 5.5.9.1d did not have their potential failures considered critical, and therefore were excluded from the set of requirements for both classes. Moreover, the potential failure referring to requirement 5.5.9.1c received a grade 3 in severity for class C (critical) and 2 for class D (non-critical), and thus the requirement was maintained for class C and eliminated for the class D.

Following this analysis process, all 193 requirements present in the standard ECSS Space product assurance - Quality assurance [13] were evaluated, and the resulted requirements (maintained or modified) are shown in Table 4.

Table.4: Results from the tailoring process.

Document		Requirements	
		Qty	%
ESA - ECSS standard	ECSS-Q-ST-20C [8]	193	100
ESA - IOD project	PA and QA for IOD CubeSat [5]	125	65
This work	Tailored ECSS-Q-ST-20C for Class C	145	75
	Tailored ECSS-Q-ST-20C for Class D	102	53

It is observed that the proposed tailoring process resulted in a reduction in the amount of requirements to be used in projects with low responsibility. This reduction was on the order of 50% of the requirements originally present in the ECSS-Q-ST-20C [13]. In comparison to the number of requirements presented in the document Product and Quality Assurance Requirements for In-Orbit Demonstration CubeSat Project [10] it is observed that there is also a reduction of the same order of magnitude in the amount of requirements. In spite of the arrangement requirements in IOD Project does not follow the same text and arrangement as provided for in the ECSS-Q-ST-20C [13], a direct comparison between their results is possible but limited, Figure 5.

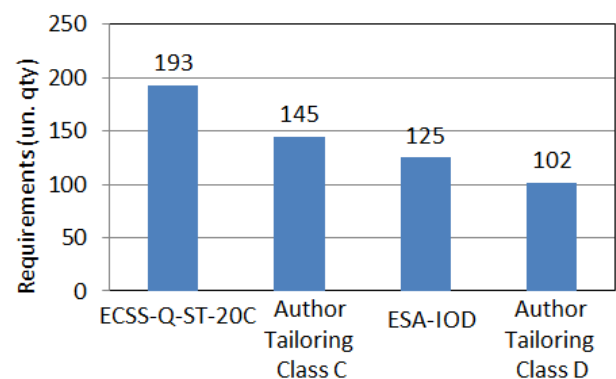


Fig. 5: Comparison between author results, IOD Project and ECSS-Q-ST-20C requirements.

However, even though the method used is based on risk analysis and counting on experts with experience in Product Assurance in INPE satellites, notably in the CBERS and AMAZONIA1 satellites, the results still lack validation in a small satellite project.

The complete results of the application of this methodology are available in the Appendix A to this work and an extract can be seen in Table 5.

Table.4: Extract of the final result.

ECSS-Q-ST-20C Rev.	Class C	Class D
5.1	QA management requirements	
5.1.1	Quality assurance plan	
	a	x
	b	x
5.1.2	Personal training and certification	
	a	x
	b	x
	c	x
	d	
5.2	QA general requirements	
5.2.1	Critical items control	
	a	x
5.2.2	Nonconformance control system	
	a	x
5.2.3	Managements of alerts	
	a	x
5.2.4	Acceptance authority media	
	a	x
	b	x
	c	x
	d	x
	e	x
	f	x
5.2.5	Traceability	
	a	x
	b	x
	c	x
	d	x
	e	x

## V. CONCLUSION

In the proposed process, the Quality Assurance requirements presented in the standard ECSS-Q-ST-20C [13] could be individually evaluated by specialists from the perspective of a risk analysis based on the FMECA tool. In this process, the potential failures associated with the requirements received grades that, when combined, became reference for choosing the requirements to be maintained, modified or eliminated for use in projects of low responsibility satellites. This process and its resulting set of requirements must be validated in a satellite project that meets these characteristics.

## ACKNOWLEDGEMENTS

The author thanks INPE to provide the structure to carry out the analysis from this work.

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**Appendix A**

Requirements from ECSS Quality Assurance (ECSS-Q-ST-20C [2020])			
5.1	QA management	Class C	Class D
5.1.1	Quality assurance plan		
	a	x	x
	b	x	x
5.1.2	Personnel training and		
	a	x	x
	b	x	x
	c	x	x
	d		
5.2	QA general requirements		
5.2.1	Critical-items control		
	a	x	x
5.2.2	Nonconformance control		
	a	x	x
5.2.3	Management of alerts		
	a	x	x
5.2.4	Acceptance authority media		
	a	x	x
	b	x	x
	c	x	
	d	x	
	e	x	
	f	x	
5.2.5	Traceability		
	a	x	x
	b	x	x
	c	x	
	d	x	
	e	x	
5.2.6	Metrology and Calibration		
	a	x	x
	b	x	x
	c	x	
	d	x	
	e	x	
	f	x	x
	g	x	
	h	x	
	i	x	

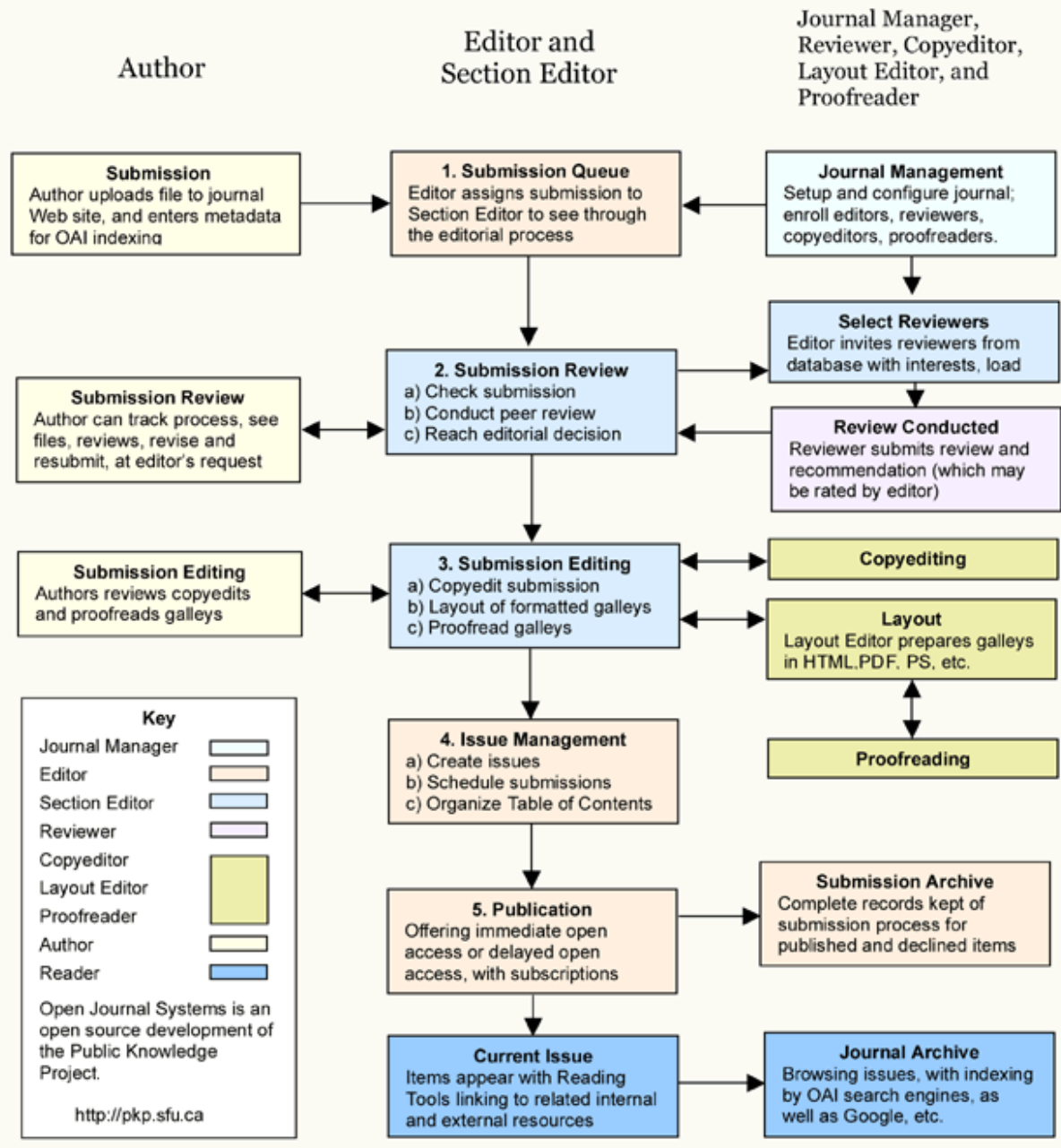
	j	x	
	k	x	
	l	x	
	m	x	x
	n	x	x
	o	x	
	p	x	
	q	x	
5.2.7	5.2.7 Handling, storage,		
5.2.7.	Handling, storage and		
	a	x	x
5.2.7.	Storage (deleted)		
5.2.7.	Preservation		
	a	x	x
5.2.8	Statistical quality control and		
5.2.8.	General		
	a		
	b		
	c		
	d		
	e		
	f		
5.2.8.	Sampling plans		
	a		
	b		
5.3	QA requirements for design		
5.3.1	Design rules		
5.3.1.	Producibility		
	a	x	x
5.3.1.	Repeatability		
	a	x	x
5.3.1.	Inspectability and testability		
	a	x	x
5.3.1.	Operability		
	a	x	x
5.3.2	Verification		
5.3.2.			
	a	x	
	b	x	
	c	x	
	d	x	
	e	x	
5.3.2.	Design verification analysis		
	a	x	x
	b	x	x
5.3.2.	Design reviews		
	a	x	x
5.3.2.	Qualification process		
5.3.2.	Qualification		
	a	x	x
	b	x	
	c	x	
	d		
	e	x	
5.3.2.	Qualification by similarity		
	a	x	x
	b	x	
	c	x	
	d	x	
5.3.2.	Qualification testing		
	a	x	

	b	x	x
5.3.2.	Qualification status		
	a		
5.3.2.	Maintenance of qualification		
	a	x	
	b	x	x
	c	x	x
5.3.2.	Design changes		
	a	x	x
5.4	QA requirements for		
5.4.1	Selection of procurement		
5.4.1.	General		
	a	x	
5.4.1.	Selection criteria		
	a	x	x
	b	x	x
5.4.1.	Record and list of		
	a	x	x
	b	x	x
5.4.2	Procurement documents		
	a	x	x
	b	x	x
	c	x	x
	d		
5.4.3	Surveillance of procurement		
	a	x	x
	b	x	x
	c	x	x
	d	x	x
	e	x	x
5.4.4	Receiving inspection		
5.4.4.	General		
	a	x	x
	b	x	x
	c	x	x
5.4.4.	Receiving inspection		
	a	x	x
5.4.4.	Customer furnished items		
	a	x	x
5.4.4.	Receiving inspection records		
	a	x	x
5.5	QA requirements for		
5.5.1	Planning of manufacturing,		
	a	x	x
	b		
	c		
	d	x	x
	e	x	x
	f		
	g		
5.5.2	Manufacturing readiness		
	a	x	x
	b	x	x
5.5.3	Control of processes		
5.5.3.	General		
	a		
	b	x	x
	c	x	x
	d	x	x
5.5.3.	Special processes		
	a	x	x

5.5.3.	Statistical process control		
	a		
5.5.4	Workmanship standards		
	a	x	x
	b	x	
	c	x	
5.5.5			
	a	x	x
	b	x	x
	c	x	
5.5.6	Equipment control		
5.5.6.	Tooling		
	a		
	b	x	x
	c		
	d		
	e		
	f		
	g		
	h	x	x
	i		
5.5.6.	Equipment for computer-		
	a	x	x
	b	x	
5.5.7	Cleanliness and		
5.5.7.	General		
	a	x	x
5.5.7.	Cleanliness levels		
	a	x	x
	b	x	x
5.5.7.	Cleaning materials and		
	a	x	x
5.5.7.	Contamination control		
	a	x	
	b	x	
	c	x	x
5.5.7.	Cleanliness of facilities		
	a	x	x
5.5.8	Inspection		
	a	x	x
	b	x	x
	c	x	x
	d	x	x
	e	x	x
	f	x	x
	g		
	h		
	i	x	
	j		
	k		
5.5.9	Specific requirements for assembly and integration		
5.5.9.	Control of temporary installations and removals		
	a	x	x
	b		
	c	x	
	d		
5.5.9.	Logbooks		
	a	x	x
	b		
	c		

	d		
	e		
5.5.1	Manufacturing, assembly		
	a	x	x
5.5.1	Electrostatic discharge		
	a		
	b	x	x
5.6	QA requirements for testing		
5.6.1	Test facilities		
	a		
5.6.2	Test equipment		
	a	x	
	b		
	c	x	x
5.6.3	Test documentation		
5.6.3.	Test procedures		
	a	x	x
	b		
5.6.3.	Test reports		
	a		
	b		
5.6.4	Test performance monitoring		
	a		
	b		
	c		
	d	x	x
	e		
	f	x	x
	g	x	x
	h		
5.6.5	Test reviews		
	a	x	x
	b		
5.7	QA requirements for		
5.7.1	Acceptance and delivery		
	a	x	x
	b		
5.7.2	End item data package		
	a	x	x
	b	x	x
	c	x	
5.7.3	Acceptance review board		
	a	x	x
	b	x	x
	c	x	x
	d	x	x
	e	x	x
	f	x	x
	g	x	x
5.7.4	Preparation for delivery		
5.7.4.	Packaging		
	a	x	x
5.7.4.	Marking and labelling		
	a	x	x
5.7.5	Delivery		
5.7.5.	Shipping control		
	a	x	x
	b	x	x
5.7.5.	Transportation		
	a	x	x

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