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Understanding Legislative Activities in Brazil: Analysis of Open Data from the Chamber of Deputies

Compreensão das Atividades Legislativas no Brasil: Análise dos Dados Abertos da Câmara dos Deputados

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Keywords—Chamber of Deputies, CRISP-DM,
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Palavras-chave — Câmara dos Deputados,
CRISP-DM, Mineração de Dados, K-Means.

Abstract— The growing evolution of technological means as gears of modern life become responsible for the constant generation of data, which in turn imply the most diverse aspects of society. In this sense, data analysis is a powerful device when it comes to predicting and describing information, in order to improve decision-making. Thus, the insertion of open data in the space of public management enables greater transparency with the citizen, making social control and the consolidation of democracy possible. Based on this bias, the present study aims to implement Data Mining techniques on the open data of the Chamber of Deputies, aiming to broaden the understanding of legislative activities and present the knowledge discovered from the relationships and patterns found in the datasets. Therefore, this is an exploratory study, based on the CRISP-DM methodology, covering the steps of understanding the business, understanding and preparing data, modeling, evaluation and implementation, corresponding to post-processing.

Resumo— A crescente evolução dos meios tecnológicos como engrenagens da vida moderna tornam-se responsáveis pela constante geração de dados, que por sua vez implicam os mais diversos aspectos da sociedade. Nesse sentido, a análise de dados é um poderoso dispositivo quando se trata de prever e descrever informações, a fim de aprimorar a tomada de decisão. Assim, a inserção de dados abertos no espaço da gestão pública possibilita maior transparência com o cidadão, tornando possível o controle social e a consolidação da democracia. Com base nesse viés, o presente estudo tem como objetivo implementar técnicas de Mineração de Dados sobre os dados abertos da Câmara dos Deputados, visando ampliar a compreensão das atividades legislativas e apresentar o conhecimento descoberto a partir das relações e padrões encontrados nos conjuntos de dados. Portanto, trata-se de um estudo exploratório, baseado na metodologia CRISP-DM, abrangendo as etapas de compreensão do negócio, compreensão e preparação dos

dados, modelagem, avaliação e implementação, correspondendo ao pós-processamento.

I. INTRODUÇÃO

A evolução tecnológica tem desempenhado um papel crucial na transformação da sociedade moderna, impulsionando a geração contínua de dados que afetam diversos aspectos da vida cotidiana. Neste contexto, a análise de dados emerge como uma ferramenta essencial para a previsão e descrição de informações, aprimorando a tomada de decisões em múltiplos setores [1].

A transparência governamental, facilitada pela disponibilização de dados abertos, é um dos campos que mais se beneficia dessa evolução, promovendo o controle social e fortalecendo a democracia [2].

Este estudo foca na aplicação de técnicas de mineração de dados sobre os dados abertos da Câmara dos Deputados do Brasil. O objetivo central é ampliar a compreensão das atividades legislativas, através da aplicação do algoritmo k-means, revelando padrões e relações que possam informar melhor o público e os tomadores de decisão. A pesquisa adota a metodologia CRISP-DM, um modelo robusto para a análise de dados, guiando o processo desde a compreensão do negócio até a implementação dos resultados [3].

Este estudo parte da hipótese de que os dados abertos da Câmara dos Deputados possibilitam um acompanhamento transparente do exercício parlamentar dos governantes eleitos, sendo este um direito garantido constitucionalmente e que proporciona subsídios ao cidadão a fim de ampliar a participação social com o acesso direto e o reconhecimento da honestidade e integridade, visando alcançar maior visibilidade sobre ações e decisões governamentais. Contudo, ainda que com o aumento da transparência legislativa e a disponibilização de dados em tempo real pela Câmara dos Deputados, há uma carência de maior ênfase na obtenção de informações a partir de análises mais significativas dos dados expostos e melhor apresentação dos resultados, o que interfere diretamente na capacidade de fiscalização, monitoramento e discussão na sociedade [4] e [5].

Ao investigar o uso de dados abertos no contexto da gestão pública, este artigo não apenas contribui para o entendimento das práticas legislativas, mas também destaca a importância da ciência de dados como um catalisador para a transparência e a participação cidadã. A análise dos dados abertos da Câmara dos Deputados serve como um estudo de caso para demonstrar o potencial transformador da tecnologia na governança pública.

II. TRABALHOS RELACIONADOS

Em [3] é investigada as dimensões dos mecanismos digitais de interação e participação política oferecidos pelos parlamentos à sociedade. O estudo foca na compreensão das iniciativas digitais de transparência, com um olhar específico sobre a Câmara dos Deputados do Brasil. A autora analisa como essas ferramentas digitais podem facilitar a participação cidadã e a transparência governamental, destacando a importância de um acesso eficiente e compreensível às informações legislativas. O trabalho também enfatiza a E-Democracia advinda da ascensão de Tecnologias da Informação e Comunicação (TICs), convergindo para a participação política através da relação existente entre política e internet e possibilitada por meio dos portais legislativos e os recursos oferecidos. Nesse viés, compreende-se a história e a motivação dos portais legislativos, além das oportunidades cedidas aos usuários.

Já [6] apresenta como objetivos, desenvolver um diagnóstico sobre a demanda por dados abertos da Câmara dos Deputados e verificar a sua contribuição para a transparência legislativa. A metodologia realizada buscou, inicialmente, analisar através do Google Analytics as cidades brasileiras que mais acessaram o portal de transparência da câmara no ano de 2015, além da quantidade de visualizações em cada serviço, seja na solicitação dos deputados em exercício, das características dos deputados, dos partidos, etc., indicando a porcentagem em relação ao todo. Assim, o intuito dos autores foi demonstrar resultados de diferentes análises quanto ao uso do portal, permitindo verificar as principais em relação à busca de informações pelos usuários, melhorando o desenvolvimento das aplicações sobre os dados disponibilizados.

Por fim, [7] detalha a aplicação da metodologia CRISP-DM (Cross-Industry Standard Process for Data Mining) na análise de dados legislativos. A pesquisa demonstra como cada etapa do CRISP-DM, desde a compreensão do negócio até a implantação, pode ser aplicada para analisar dados abertos da Câmara dos Deputados. O estudo enfatiza a importância de uma abordagem estruturada para a análise de dados, permitindo a descoberta de padrões e relações significativas nos dados legislativos. Além disso, a pesquisa ilustra a utilização de algoritmos de mineração de dados, como o k-means, para modelar e interpretar os dados, oferecendo uma visão aprofundada das atividades legislativas e facilitando a tomada de decisões informadas.

Os trabalhos relacionados contribuíram para a pesquisa atual, oferecem uma base teórica sólida sobre mecanismos digitais de interação e participação política, além de

servirem como guias metodológicos ajudando a refinar as etapas de modelagem e análise de dados no trabalho atual.

III. METODOLOGIA

As etapas de desenvolvimento deste trabalho seguiram o padrão do modelo de processo Crisp-DM. Sua escolha se deu uma vez que ela oferece uma rota completa de etapas a fim de obter melhor entendimento e condução de projetos, sendo idealizado em 1996 por quatro líderes de empresas pioneiras na área: Daimler-Benz, Integral Solutions Ltd, NCR e OHRA [8]. Tal metodologia é composta pelas seguintes etapas:

Compreensão do negócio

Nessa etapa, buscou-se conhecer o domínio da aplicação, sendo este o conjunto de dados públicos sobre a Câmara dos Deputados, incluindo informações sobre legislaturas, deputados, partidos, blocos, órgãos, frentes parlamentares, eventos, proposições, votações, referências e atualizações, totalizando 28 conjuntos distintos de dados. Além disso, se fez necessário a realização de pesquisas e estudos a respeito do processo legislativo brasileiro e todo o âmbito da Câmara dos Deputados.

Compreensão dos dados

A compreensão dos dados abrangeu as etapas de coleta, descrição, exploração e verificação da qualidade dos dados. Foi adotado a legislatura 56 correspondendo ao mandato de 2019 a 2022, com: Conjunto de deputados - 6 atributos e 626 registros; Proposições por ano de apresentação - 11 atributos e 134.337 registros; Proposições por temática - 3 atributos e 59.300 registros e proposição por ano de apresentação - 6 atributos e 303.302 registros. Todos os atributos são descritos na Tab.1.

Análise exploratória

O termo análise exploratória foi criado pelo estatístico John Tukey e consiste na descoberta de fatos e insights, fazendo uso de um determinado procedimento, em que os principais objetivos são visualizar e explorar os dados sob diversos ângulos diferentes. Sendo assim, a forma como a investigação pode ser realizada sob diferentes óticas faz surgir também diferentes conjecturas, de modo que o analista encontre indícios interessantes nos dados coletados [9].

Para o presente trabalho foram selecionadas hipóteses relacionadas às proposições por ano de apresentação, incluindo a classificação temática e os autores.

Hipótese 1: Proposições do tema direitos humanos e minorias são as mais frequentes;

Objetivo: Avaliar a prioridade dada aos temas de direitos humanos e minorias no contexto legislativo,

verificando se esses temas são os mais recorrentes nas proposições apresentadas.

Hipótese 2: O estado de São Paulo é o maior em número de proposições apresentadas;

Objetivo: Investigar se São Paulo, como um dos estados mais populosos e economicamente influentes do Brasil, lidera em termos de número de proposições apresentadas à Câmara dos Deputados.

Hipótese 3: Proposições relacionadas à saúde tiveram um aumento significativo durante a pandemia em 2020 e 2021;

Objetivo: Analisar o impacto da pandemia de COVID-19 nas atividades legislativas, verificando se houve um aumento nas proposições relacionadas à saúde durante os anos críticos da pandemia.

Hipótese 4: Proposições apresentadas por deputados de partidos de oposição são mais propensas a serem rejeitadas do que proposições apresentadas por deputados de partidos da base governista;

Objetivo: Examinar a influência da filiação partidária na aprovação de proposições, explorando se existe um viés político que favorece proposições de partidos da base governista em detrimento das de oposição.

Hipótese 5: O partido com maior número de proposições apresentadas foi o PL;

Objetivo: Identificar qual partido político é mais ativo na apresentação de proposições, especificamente verificando se o partido PL é o mais prolífico.

Hipótese 6: Ano eleitoral detém a maior quantidade de proposições apresentadas;

Objetivo: Explorar se há um aumento na atividade legislativa durante anos eleitorais, possivelmente devido a estratégias de reeleição ou maior engajamento dos deputados.

Hipótese 7: Proposições do tipo PL (projetos de Lei) estão entre as 10 mais apresentadas à Câmara dos Deputados;

Objetivo: Verificar a popularidade e frequência dos projetos de lei em comparação com outros tipos de proposições, confirmando se eles estão entre os mais comuns.

Hipótese 8: A maioria das proposições apresentadas são desenvolvidas por Deputados.

Objetivo: Avaliar o papel dos deputados como principais autores de proposições, em comparação com outros atores como comissões ou órgãos legislativos.

Essas hipóteses, em conjunto, buscam fornecer uma visão mais abrangente sobre o comportamento legislativo, a

dinâmica política e as prioridades temáticas na Câmara dos Deputados, contribuindo para uma compreensão mais profunda do seu funcionamento.

Assim sendo, para realização da análise exploratória, optou-se por utilizar a linguagem Python e as seguintes bibliotecas: Requests, Json, Pandas, Matplotlib, Seaborn, DateTime, Numpy, Scipy e WordCloud. Além disso, foi utilizada a API disponibilizada pelo portal, tendo em vista a facilidade oferecida quanto à seleção de legislaturas. Dessa forma, os dados foram transformados em data frames com a biblioteca Pandas.

Preparação dos dados

Para a aplicação desta etapa, utilizou-se a linguagem de programação Python, juntamente com as bibliotecas Pandas e Scikit-Learn. Portanto, a primeira ação quanto a preparação de dados, consistiu na escolha do conjunto de proposições para a modelagem.

Consoante ao objetivo proposto pela etapa seguinte, referente à modelagem de dados, buscou-se filtrar as colunas com baixa variância e alta correlação, resultando no conjunto de dados apresentados na Tab.1.

Tabela. 1: Elementos do conjunto de proposições. Legislatura 56. Fonte: Elaborado pelo autor(a) (2025)

Coluna	Descrição
id	Identificador único de cada proposição
siglaTipo	sigla que referencia ao tipo da proposição
numero	número da proposição que a identifica na tabela de classificação temática
ano	ano em que a proposição foi apresentada
codTipo	código que referencia ao tipo da proposição
descricaoTipo	Descrição do tipo da proposição
ementa	Representa o resumo da proposição
ementaDetalhada	Detalha a ementa da proposição
keywords	Palavras chaves do que se trata a proposição
dataApresentacao	Data contendo dia, mês e ano em que a proposição foi apresentada à Câmara dos Deputados
ultimoStatusDescricaoTramitacao	Representa o status em que a proposição se encontra, podendo ser aprovada, rejeitada ou arquivada
numero	Número que identifica a proposição

ano	Ano que a proposição foi apresentada
tema	Tema em que a proposição se enquadra
idProposicao	Identificador da proposição
idDeputado	Identificador único de deputado autor da proposição
tipoAutor	Tipo do autor
nomeAutor	Nome do parlamentar
siglaPartidoAutor	Sigla do Partido a qual o parlamentar é afiliado
siglaUfAutor	Unidade Federativa a qual o deputado foi eleito

Modelagem dos dados

Para a etapa de modelagem, a biblioteca Scikit-Learn para linguagem de programação Python foi selecionada, pois conta com inúmeras ferramentas para projetos de aprendizado de máquina. Com isso, a classe K-means do módulo sklearn.cluster foi importada. Dessa classe, criou-se um objeto definido com os seguintes parâmetros:

- `n_clusters` com intervalo [2, 21] - quantidade de clusters em que os dados do conjunto estudado serão agrupados;
- `init = 'k-means++'` - método de inicialização dos centroides de cada cluster. A inicialização do tipo 'k-means++' seleciona os centroides iniciais a partir da utilização de amostragem que se baseia em uma distribuição de probabilidade empírica da contribuição de cada registro para a inércia geral;
- `n_init = 10` - número de vezes que o k-means será executado com diferentes centroides iniciais;
- `max_iter = 300` - quantidade máxima de iterações do k-means em uma única execução, caso a convergência para um agrupamento estável não seja alcançada;
- `random_state = 0` - ao passar um valor inteiro garante que os resultados sejam iguais a cada chamada do K-Means.

Ao final da clusterização, uma nova coluna foi acrescida ao dataset, contendo os labels dos clusters, o que permitiu a identificação de qual grupo cada registro se encontrava.

Avaliação

A partir dos labels resultantes de cada clusterização e utilizando a biblioteca Scikit-Learn, calculou-se o coeficiente de silhueta médio do agrupamento. Assim, para cada clusterização variando de 2 a 21, armazenou-se o coeficiente de silhueta médio das modelagens, sendo

possível definir o melhor número de clusters para o conjunto de dados sendo igual a 3.

Assim, com a modelagem agrupando em 3 clusters distintos, foram realizadas as análises das características dos elementos de cada cluster de forma a validar as hipóteses levantadas anteriormente. Os resultados dessa etapa são expostos na seção de resultados e discussões.

Implantação

A última etapa do CRISP-DM visa apresentar os conhecimentos obtidos e será executada a tarefa de produção do relatório final, através de técnicas de visualização de dados, utilizando a linguagem Python. Nesse sentido, essa etapa busca sintetizar os resultados, possibilitando comparar com o que era esperado, aprender e expandir o conhecimento adquirido. Portanto, compreende-se como a etapa de implantação, o resultado final da escrita deste trabalho.

IV. RESULTADOS E DISCUSSÃO

As análises referem-se ao conjunto de proposições por ano de apresentação, incluindo a classificação temática e os autores, buscando-se validar ou invalidar as hipóteses definidas anteriormente, sendo detalhadas a seguir:

Hipótese 01: Proposições do tema direitos humanos e minorias são as mais frequentes. Essa hipótese é refutada, uma vez que o tema administração pública é o mais frequente, com 935.326 proposições apresentadas à Câmara dos Deputados, seguido por processo legislativo e atuação parlamentar (745.883), finanças públicas e orçamento (722.077), saúde (446.205), direitos humanos e minorias (369.432), entre outros. Assim, podemos concluir que na legislatura 56 (correspondendo ao mandato de 2019 a 2022) os temas de direitos humanos e minorias no contexto legislativo não foram os mais recorrentes nas proposições apresentadas.

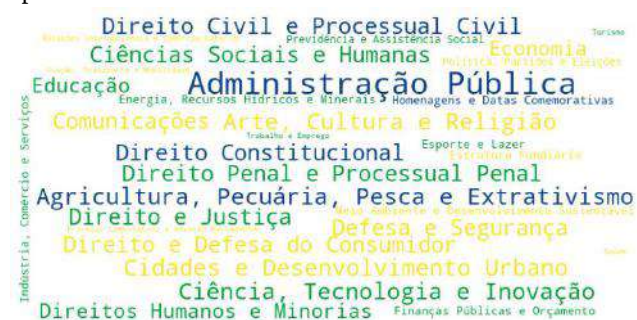


Fig. 1: Temas de proposições apresentados com maior frequência - Legislatura 56. Fonte: Elaborado pelo autor(a) (2025)

Para a validação dessa hipótese, buscou-se desenvolver uma nuvem de palavras conforme a frequência de temas apresentados. Para isso, utilizou-se a biblioteca

WordCloud, sendo o resultado demonstrado na Fig.1, em que as palavras diminuem conforme o número de proposições também diminui.

Hipótese 02: O estado de São Paulo é o maior em número de proposições apresentadas. Utilizando o método groupby para agrupar os dados de acordo com o id da proposição e a sigla federativa do autor, obteve-se como resultado um novo dataframe com os estados e a quantidade de proposições apresentadas. Dessa forma, São Paulo foi o estado líder em proposições apresentadas, somando 426.460 apresentações à câmara, sendo essa hipótese, portanto, verdadeira. Outrossim, a ideia de tal implementação foi a de que o maior estado teria a maior quantidade de deputados, o que foi comprovado pela análise exploratória do conjunto de deputados e, portanto, teria o maior número de proposições apresentadas. Para melhor visualização, o gráfico de barras, Fig.2, demonstra o resultado obtido.

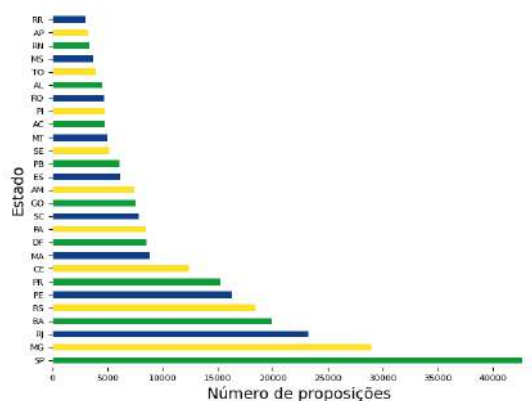


Fig. 2: Estados com maior frequência de proposições apresentadas à Câmara dos Deputados - Legislatura 56.

Fonte: Elaborado pelo autor(a) (2025)

Hipótese 03: Proposições relacionadas à saúde tiveram um aumento significativo durante a pandemia em 2020 e 2021. Apesar do contexto pandêmico, a análise mostra que maiores quantidades de proposições relacionadas à saúde foram apresentadas no ano de 2022, quando a pandemia já estava reduzida. No entanto, podemos notar um aumento de aproximadamente 42% das proposições pós-pandemia. Como o objetivo central dessa hipótese era analisar o impacto da pandemia de COVID-19 nas atividades legislativas, os dados demonstram que a maioria das proposições são relacionadas após o momento mais crítico da pandemia. A Fig.3 auxilia no entendimento dessas dimensões.

tipos de proposições, confirmando se eles estão entre os mais comuns.

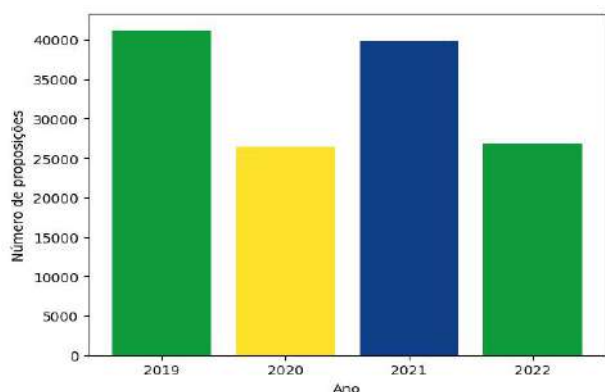


Fig. 7: Porção de proposições por tipo - Legislatura 56.

Fonte: Elaborado pelo autor(a) (2025)

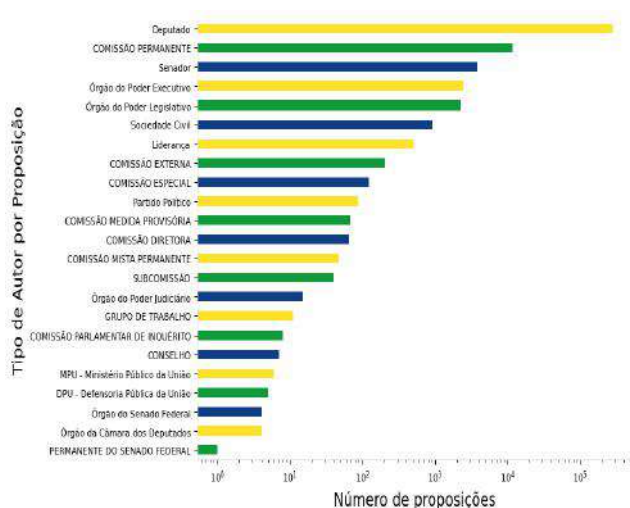


Fig. 8: Porção de proposições por tipo de autor -

Legislatura 56. Fonte: Elaborado pelo autor(a) (2025)

Hipótese 08: A maioria das proposições apresentadas são desenvolvidas por deputados. Para validação dessa hipótese, foi necessário entender o conjunto sobre autores, uma vez que não são apenas deputados, sendo possível a autoria por meio de órgãos legislativos, comissão externa, comissão permanente, senador, sociedade civil, dentre outros. Assim, por se tratar do ambiente da câmara de deputados, assume-se que deputados seriam a maior categoria no que diz respeito à apresentação de proposições, sendo essa uma verdade. Deputados ocupam a maior posição de autorias, contando com 279.829 proposições apresentadas, seguidos por comissão permanente com 11.772, Senador 3.809, dentre outros. A Fig.8 auxilia na visualização dessa hipótese.

Os resultados encontrados revelam as proporções dos dados referentes às proposições em relação aos seus principais atributos, auxiliando no entendimento e

acompanhamento da ocorrência de cada uma das atividades legislativas em âmbitos como federação, partidos, ano, tema, dentre outros. Nesse sentido, o aumento constante de dados em todo o mundo oferece diversas possibilidades de utilização, o que também se aplica ao contexto da Câmara dos Deputados.

Desse modo, o cenário levantado nessa pesquisa aborda a dificuldade encontrada em obter conhecimentos acerca da conjuntura legislativa e foi nesse viés, que os autores buscaram demonstrar, de forma mais acessível e compreensível, as relações entre os dados legislativos, a partir do levantamento de hipóteses, explorando cada um dos registros coletados. Além disso, é perceptível que esse cenário é resultado da carência de informações por parte da população, ainda que com a disponibilidade das informações por meio dos portais de transparência, configurando a necessidade de otimizar a forma como o conhecimento é adquirido, uma vez que é influenciado pela forma como os dados estão sendo representados.

V. CONCLUSÃO

Com base nos resultados apresentados, conclui-se que o objetivo central deste trabalho - ampliar a compreensão das atividades legislativas, revelando padrões e relações que possam informar melhor o público e os tomadores de decisão - foi alcançado.

Através da aplicação do algoritmo k-means e o modelo Crisp-DM, foi possível analisar a veracidade, ou não, de um conjunto de hipóteses relacionadas às proposições apresentadas na Câmara dos Deputados.

Este estudo trouxe contribuições nas áreas tecnológica e social. No âmbito tecnológico, apresenta-se uma metodologia de tratamento de dados, baseada na similaridade dos mesmos, disponíveis no portal de dados abertos da Câmara dos Deputados. Para o âmbito social, a principal contribuição constitui-se em uma maior transparência e entendimento, por parte da população, a respeito das proposições dos parlamentares eleitos, visando confirmar se de fato o seu trabalho está sendo bem desempenhado.

Outrossim, para as pretensões acadêmicas e profissionais, este trabalho representa um passo significativo. Profissionalmente, este estudo proporcionou uma base sólida de análise de dados e compreensão das dinâmicas do poder legislativo no Brasil, oferecendo novas perspectivas e metodologias que podem ser exploradas em pesquisas futuras.

Por fim, o presente estudo consistiu em demonstrar uma das mais variadas possibilidades da análise dos dados legislativos e por isso, é válido direcioná-lo como pontapé

para trabalhos futuros, que possam colaborar ainda mais para a obtenção de resultados voltados à análise de dados da estrutura política brasileira.

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Synthesis optimal guidance law for missile in cruise phases with terminal additional requires

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Keywords—Guidance law, optimal control, objective function.

Abstract— The article analyzes and proposes the synthesis of an optimal guidance method for missiles during the cruise phase in a combined remote-autonomous control system. The objective of the problem to be solved is to guide the missile to a non-fixed point in space according to a predefined rule, meeting specific requirements and criteria. In combined remote-control systems, at the moment of switching to guidance, the missile must satisfy several stringent requirements, such as: ensuring the target is within the seeker's field of view, determining the distance to the target, meeting the initial slip value h_0 at the moment of autonomous guidance, and considering the missile's maneuverability, among others. The article focuses on researching a synthesized optimal guidance law for the missile during the remote control phase while taking into account these requirements at the transition point to autonomous control at the end of the remote control phase.

I. INTRODUCTION

A combined control system is a system capable of utilizing different control principles either in parallel or sequentially, incorporating various guidance methods (GMs). Each GM has its own advantages and limitations [1,3,6]. Combined control is employed to fully exploit the strengths of different GMs while minimizing their drawbacks [3].

The main advantages of a combined control system include the ability to control missiles at long or even very long ranges, expanding measurement range, assessing approach velocity and target line-of-sight angular rate, improving guidance accuracy, enhancing jamming resistance, and increasing control reliability.

The article discusses a form of combined remote-autonomous control for surface-to-air missiles (SAMs), where control is divided into two sequential phases: in the initial phase, the missile (M) is remotely controlled (cruise mode); in the final phase, it transitions to autonomous guidance until it intercepts the target (T) (autonomous mode).

The focus of the article is on analyzing the missile's trajectory and orientation to develop a guidance law during the remote control phase, ensuring that, at the transition point, all conditions for autonomous guidance are fully met. Thus, the objective of the guidance method (GM) in cruise mode is to create favorable conditions for the transition to autonomous guidance. These conditions include [7]:

- Transition timing that aligns with the seeker's detection range, considering autonomous guidance duration and the missile's maneuverability.

- Proper missile orientation angles, ensuring the target remains within the seeker's field of view, facilitating rapid detection, acquisition, and tracking within a limited timeframe.

- Acceptable initial miss distance (h_0) - the distance between the target's center of mass and its projection along the missile-target approach velocity vector [3].

When synthesizing the remote-autonomous combined control system, the following problems must be addressed [7]:

- Trajectory matching between the two control phases (remote and autonomous), ensuring smooth transitions, even if the target maneuvers.

- Seeker orientation towards the target, enabling rapid detection, acquisition, and tracking.

- Reliable transition from remote control to autonomous guidance, avoiding sudden disturbances in the closed-loop control system.

With this problem formulation, the article focuses on synthesizing an optimal missile guidance law for the remote control phase, ensuring it meets all autonomous guidance requirements at the transition point.

II. PROBLEM

2.1. Theoretical foundations

2.1.1 Synthesis of a Remote Guidance Method for Missiles Based on Optimal Control Theory

Modern control theory enables the implementation of various complex information processing and control algorithms [2]. To develop a two-point guidance method for remotely controlled surface-to-air missiles (SAMs), the problem can be formulated and solved based on optimal control theory as follows.

The equation of motion for a SAM is typically expressed as:

$$\begin{aligned} \dot{r}_p &= V_p \\ \dot{V}_p &= u_p \end{aligned} \quad \text{Where:}$$

V_p – Missile velocity vector as the time derivative of range $\dot{r}_p$; u_p – Desired control vector.

With $x_1 = r_p$; $x_2 = V_p$; $u = u_p$, The missile's equation of motion is expressed in the following canonical form:

$$\begin{cases} \dot{x}_1 = x_2 \\ \dot{x}_2 = u \end{cases} \quad t_0 \leq t \leq t_k \quad (1)$$

With initial conditions: $x_1(t_0) = x_{10}$; $x_2(t_0) = x_{20}$

The specific objective of the remote guidance process, without considering the autonomous guidance phase, is that the missile's final trajectory point must coincide with the target's final trajectory point. This means:

$$x_1(t_k) = x_{1k} \quad (2)$$

The cost function of the control process is usually written in the form:

$$I = \frac{1}{2} \int_{t_0}^{t_k} u^T(\tau) u(\tau) d\tau \quad (3)$$

The problem is to find the control $u(t)$ in such a way that the cost function (3) is minimized.

We consider the characteristics of the optimization process in its general form. The control system model is described by a differential equation:

$$\dot{x} = A(t)x + B(t)u \quad t_0 \leq t \leq t_k \quad (4)$$

Initial condition is $x(t_0) = x_0$ with:

x – the state vector of size n ;

u – control vector of size m ;

A, B – The state transition matrix and the control matrix with their corresponding sizes are x_n and u_m .

The requirements for the system's state at the final time point can be set in the form:

$$y(t_k) = Sx(t_k) \quad (5)$$

With $y(t_k)$ – The vector of pre-set requirements at time t_k with size l ($l < n$);

S – size matrix ($l \times n$).

We consider a new phase vector at any given time t :

$$y(t) = S\Phi(t_k, t)x(t) \quad (6)$$

Where $\Phi(t_k, t)$ - The basis matrix of a homogeneous system (4). At time $t=t_k$ (6) convert to (5). At this point $\Phi(t_k, t_k) = E$ (unit matrix).

Vector $y(t)$ follows differential equation:

$$\dot{y}(t) = S\Phi(t_k, t)B(t)u(t) = F(t)u(t) \quad (7)$$

With $F(t) = S\Phi(t_k, t)B(t)$. Equation (7) Obtained when considering in the equation (4) và $\Phi(t_k, t)$ follows equation: $\dot{\Phi}_t = -\Phi(t_k, t)A(t)$.

From (7), we can see that to achieve the final state $y(t_k)$, control must be applied to the vector $y(t)$ and the state forecasts of this vector.

The necessary condition for optimization is that the implicit function has the form: $\frac{dH}{du} = 0$, where H is the Hamiltonian function.

From (3) and (7), we obtain:

$$H(\Psi, u, t) = \frac{1}{2}u^T u + \Psi^T F(t)u \quad (8)$$

Ψ - The constraint vector satisfies the equation: $\dot{\Psi} = -\left(\frac{dH}{du}\right)^T$

By satisfying the necessary condition (8), the optimization problem is transformed into solving the following system of differential equations:

$$\begin{aligned} \dot{y} &= F(t)u \\ \dot{\Psi} &= 0 \\ u &= -F^T(t)\Psi \end{aligned} \quad (9)$$

With $y(t_0) = y_0$; $y(t_k) = y_k$; the initial and boundary conditions for the vector $y(t)y(t)y(t)$ are determined, while the vector $Y(t)Y(t)Y(t)$ remains free.

Thus $\Psi(t) = \Psi_0 = \text{const}$. To determine Ψ_0 we substitute the third equation of (9) into the first equation and integrate over the interval (t_0, t_k) :

$$\begin{aligned} y(t_k) &= y(t_0) - \left[\int_{t_0}^{t_k} F(\tau)F^T(\tau) d\tau \right] \Psi_0 \\ \Psi_0 &= \frac{[y(t_0) - y(t_k)]}{M(t_k, t_0)} \end{aligned} \quad (10)$$

where: $M(t_k, t_0) = \int_{t_0}^{t_k} F(\tau)F^T(\tau) d\tau$

Substituting (10) into the third equation of (9), the optimal control vector is obtained as:

$$u = F^T(t) \frac{[y(t_k) - y(t_0)]}{M(t_k, t_0)} \quad (11)$$

This is the optimal control vector u that we need to determine. This control vector acts on the system and transitions it from the known initial state $y(t_0)$ to the required final state $y(t_k)$ while minimizing the objective function (3).

The initial time t_0 can be chosen as any moment corresponding to a known state $y(t)$. The control law (11) can be interpreted as a feedback control process based on the predicted final state. The transition from t_0 to t using the control law (11) is given by:

$$u[y(t)] = F^T(t) \frac{[y(t_k) - y(t)]}{M(t_k, t_0)} \quad (12)$$

From (12), we observe that the instantaneous control parameter corresponds to the difference between the required final state and its predicted value at the current moment. Expanding M :

$$M(t_k, t) = \int_t^{t_k} S\Phi(t_k, \tau)B(\tau)B^T(\tau)\Phi^T(t_k, \tau)S^T d\tau$$

From this, we can propose a solution to formulate the optimal control law for the missile when the conditions at the interception point are predetermined. Substituting (1) and (2) into the system (3), we obtain:

$$A = \begin{pmatrix} 0 & 1 \\ 0 & 0 \end{pmatrix}; B = \begin{pmatrix} 0 \\ 1 \end{pmatrix}; S = (1, 0)$$

The fundamental matrix of system (1) has the form:

$$\Phi(t_k, t) = \begin{pmatrix} 1 & t_k - t \\ 0 & 1 \end{pmatrix}$$

From (7), we derive:

$$F(t) = (1, 0) \begin{pmatrix} 1 & t_k - t \\ 0 & 1 \end{pmatrix} \begin{pmatrix} 0 \\ 1 \end{pmatrix} = t_k - t = t_*$$

In which t_* - is the remaining time for the missile to reach the target interception point.

Thus, we have:

$$M(t_k, t) = \int_t^{t_k} (t_k - \tau)^2 d\tau = \frac{1}{3} t_*^3$$

If $t_* = 0$, deducing from (2), we have: $y(t_k) = x_1(t_k) = x_y(t_k)$

$$\text{From (6), we have: } y(t) = S\Phi(t_k, t)x(t) = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & t_k - t \\ 0 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

$$y(t) = x_1 + x_2(t_k - t) = x_1 + x_2 t_*$$

From (12), we see that the optimal control vector ultimately takes the form:

$$u(t) = \frac{3}{t_*^2} [x_y(t_k) - \{x_1 + x_2 t_*\}]$$

$$u(t) = \frac{3}{t_*^2} [r_y(t_k) - r_p - V_p t_*] \quad (13)$$

If the control is time-varying in three-dimensional space, then r_p and V_p will be vectors in space.

The motion parameters of the target can be measured by ground-based devices or estimated using modern filtering and extrapolation algorithms. The main issue here is the ability to obtain information about the target's relative position vector

$r_y(t_k)$, the predicted position of the target at time t_k . This information needs to be determined at any given time t , considering various hypotheses about the target's motion.

Typically, during the cruise phase, due to the large distance between the missile (TL) and the target (MT), the assumption of uniform straight-line motion of the target is often used over the interval (t, t_k) ;

This means that:
$$r_y(t_k | t) = r_y(t) + V_y(t) \cdot t_* \quad (14)$$

Substituting (14) into (13), we obtain the control law:

$$u_p = \frac{3}{t_*^2} \left[r_y(t) - r_p(t) + \{V_y(t) - V_p(t)\} t_* \right] \quad (15)$$

Using the control law (15) still depends on the assumption about the target's motion.

Thus, theoretically, the problem of constructing an optimal guidance law entirely from a distance for the missile (TL) has a solution, under the assumption that there is no self-guidance phase.

2.1.2. Synthesizing the optimal long-range guidance law for the missile, taking into account the requirements at the point of transition to autonomous guidance

As analyzed when defining the research problem, the condition for transitioning to self-guidance also requires determining the spatial orientation of the missile (TL) so that the target (MT) is within the field of view of the seeker at the time t_k the end of the long-range guidance phase.

The ability to meet this requirement can be achieved by solving special boundary conditions of the phase vector. The transition time to self-guidance is determined by several factors characteristic of the seeker's operational capabilities. Typically, the factor characteristic of the transition to self-guidance is the self-guidance distance (or the remaining distance to the target (MT) from the long-range guidance). Regarding control, we need to add pre-defined boundary conditions to the optimization problem. This condition is given as:

$$r_p(t_k | t) = r_y(t_k | t) + D_{td} \cdot$$

With D_{td} being the pre-defined self-guidance distance vector, its magnitude depends on the target detection range of the seeker. The direction of the vector D_{td} is opposite to the direction of the target's velocity vector in space.

On the other hand, the missile (TL) and the seeker must be oriented towards the target, such that the initial miss distance h_0 of the missile, at the moment of transition, is smaller than a pre-defined value. The upper limit of the initial miss distance h_0 is determined by the long-range guidance error and the missile's ability to generate force and torque when it transitions to self-guidance

According to the definition of instantaneous miss distance in the literature [3], h_0 primarily depends on the magnitude and direction of the velocity vectors of the missile (TL) and the target (MT), specifically the relative velocity vector ($\vec{V}_{tc} = \vec{V}_p - \vec{V}_y$).

To ensure that the instantaneous miss distance h_0 approaches 0 and that the target (MT) is within the seeker's field of view, the optimal condition is that the direction of the missile's velocity vector must coincide with the direction of the target's velocity vector. In this case, there will be two scenarios that satisfy this assumption:

Trường hợp bắn đuổi:

$$\begin{aligned} \theta_p &= \theta_y \\ \dot{\psi}_p &= \dot{\psi}_y \end{aligned} \quad (16)$$

Chasing case:

$$\begin{aligned} \theta_p &= \theta_y - 180^\circ \\ \dot{\psi}_p &= \dot{\psi}_y - 180^\circ \end{aligned} \quad (17)$$

In both of these cases, the boundary control is presented in the form of:

$$y(t_k) = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \begin{pmatrix} r_p(t_k) \\ V_p(t_k) \end{pmatrix} = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \begin{pmatrix} r_y(t_k) + D_{ld} \\ V_p^* \end{pmatrix} \quad (18)$$

In which V_p^* is the velocity vector of the missile at the end of the long-range guidance phase, and its magnitude and direction must satisfy the self-guidance condition. V_p^* has a magnitude within the limits that the missile's propulsion system can ensure, with a direction that satisfies the conditions of the equations (16), (17).

The necessary calculations according to the requirements of the optimal control method are provided correspondingly for system (1). We have:

$$F(t) = \begin{pmatrix} 1 & t_* \\ 0 & 1 \end{pmatrix} \begin{pmatrix} 0 \\ 1 \end{pmatrix} = \begin{pmatrix} t_* \\ 1 \end{pmatrix} \quad (19)$$

$$M(t) = \int_t^{t_k} \begin{pmatrix} t_k - \tau \\ 1 \end{pmatrix} (t_k - \tau, 1) d\tau = \begin{pmatrix} \frac{1}{3} t_*^3 & \frac{1}{2} t_*^2 \\ \frac{1}{2} t_*^2 & t_* \end{pmatrix} \quad (20)$$

Note that M^{-1} exists when $t_* \neq 0$, meaning that:

$$\det M(t) = |ad - bc| = \frac{1}{12} t_*^4 \neq 0$$

This is evident because $t_* \neq 0$. In this case:

$$F^T(t) M^{-1}(t) = (t_*, 1) \frac{12}{t_*^4} \begin{pmatrix} t_* & -\frac{1}{2} t_*^2 \\ -\frac{1}{2} t_*^2 & \frac{1}{3} t_*^3 \end{pmatrix} = \frac{1}{t_*^2} (6 - 2t_*) \quad (21)$$

Finally:

$$u_p = \frac{(6 - 2t_*)}{t_*^2} \left[\begin{pmatrix} r_y(t_k) + D_{ld} \\ V_p^* \end{pmatrix} - \begin{pmatrix} 1 & t_* \\ 0 & 1 \end{pmatrix} \begin{pmatrix} r_p(t) \\ V_p(t) \end{pmatrix} \right] \quad (22)$$

$$u_p = \frac{1}{t_*^2} \left[6[r_y(t_k) + D_{ld} - \{r_p + V_p(t)t_*\}] - 2t_* \{V_p^* - V_p(t)\} \right]$$

Equation (22) describes the control law equation, taking into account the boundary condition (18). Using the assumption about the target's motion, as presented in section 2, substituting (14) into (22), we get:

$$u_p = \frac{6}{t_*^2} \left[r_y(t) - r_p(t) + D_{ld} + \{V_y(t) - V_p(t)\} t_* \right] - \frac{2}{t_*} \{V_p^* - V_p(t)\} \quad (23)$$

$$\text{Let: } r_y^*(t) = r_y(t) + D_{ld} \quad (24)$$

From equation (23), we obtain

$$u_p = \frac{6}{t_*^2} \left[r_y^*(t) - r_p(t) + \{V_y(t) - V_p(t)\} t_* \right] - \frac{2}{t_*} \{V_p^* - V_p(t)\} \quad (25)$$

Equation (25) is the optimal guidance law to be determined based on the transition conditions, as analyzed. It can be seen that the guidance law (25) allows the missile (TL) to lead to a predicted point Π^* (the assumed target) at time t_{tt} , which is not fixed and has a correlation with the target's motion, as expressed in equation (24).

To obtain complete control information, we need to find the value of t^* . This is an unmeasurable quantity and can only be estimated using certain methods. The accuracy of these estimates affects the quality of the control process. Below is one of these methods.

From [3,8], we have the concept of instantaneous miss distance when guiding towards the point Π^* :

$$h = r_y^*(t) - r_p(t) + \{V_y(t) - V_p(t)\}t_* \quad (26)$$

Write in another form: $h = D_{td}(t) + V_{tc}(t)t_*$ với $D_{td}(t)$ is the relative distance vector TL - Π^* . Thus, we have the value of the vector that exists in the control equation $u(t)$.

Taking the dot product of both sides of the equation of the instantaneous miss vector with the relative velocity vector, we get:

$$(h \cdot V_{tc}) = 0 = V_{tc} \cdot D_{td} + V_{tc}^2 t_*.$$

It follows that:

$$t_* = -\frac{(V_{tc} \cdot D_{td})}{V_{tc}^2} = -\frac{D_{td} \dot{D}_{td}}{V_{tc}^2} = \frac{D_{td} |\dot{D}_{td}|}{V_{tc}^2}$$

Here $\dot{D}_{td}$ is the projection of the relative velocity vector V_{tc} onto the line of sight. TL- Π^* và $\dot{D}_{td} < 0$. According to the initial conditions of the self-guidance phase $h \ll D_{td}$, we can consider $|V_{tc}| \cong |\dot{D}_{td}|$, in this case:

$$t_* = \frac{D_{td}}{|\dot{D}_{td}|} \quad (27)$$

On the other hand, from the geometric dynamics relation, we have:

$$h = \frac{D_{td}^2}{|\dot{D}_{td}|} \omega_L \quad (28)$$

With ω_L being the angular velocity of the missile-target line of sight TL- Π^* .

Substitute (27) and (28) into (25), taking (26) into account, we get:

$$\begin{aligned} u_p &= 6|\dot{D}_{td}|\omega_L - 2\frac{|\dot{D}_{td}|}{D_{td}}\{V_p^* - V_p(t)\} \\ u_p &= 6V_{tc}\omega_L - 2\frac{V_{tc}}{D_{td}}(V_p^* - V_p) \end{aligned} \quad (29)$$

Thus, (29) is the equation of the optimal far-field guidance law constructed for system (1) with the objective function (3), taking into account the transition condition to autonomous guidance (18). This guidance law allows the missile to be directed to a predefined point, relative to the target, and at that point, the missile's velocity vector has the desired value and direction.

2.2. Experiment preparation

2.2.1. Instrumentation and Experimental materials

The examination of the new guidance law using the simulation method allows us to analyze and evaluate its effectiveness. The assumed survey conditions are as follows:

The target flies in a straight $\theta_y = 0^0$; and uniform motion, heading toward the control station, with a speed of 600 m/s and an initial distance of 60 km. The missile is launched from the control station with an average speed of 900 m/s. The relative distance at which the transition to autonomous guidance occurs is $D_{td}=10\text{km}$.

2.2.2. Target scenarios:

Scenario 1: Altitude of the target $H_t=8\text{km}$, with the flight direction: $\psi_u = 40^\circ$;

Scenario 2: Altitude of the target $H_t=10\text{km}$, with the flight direction: $\psi_u = 20^\circ$;

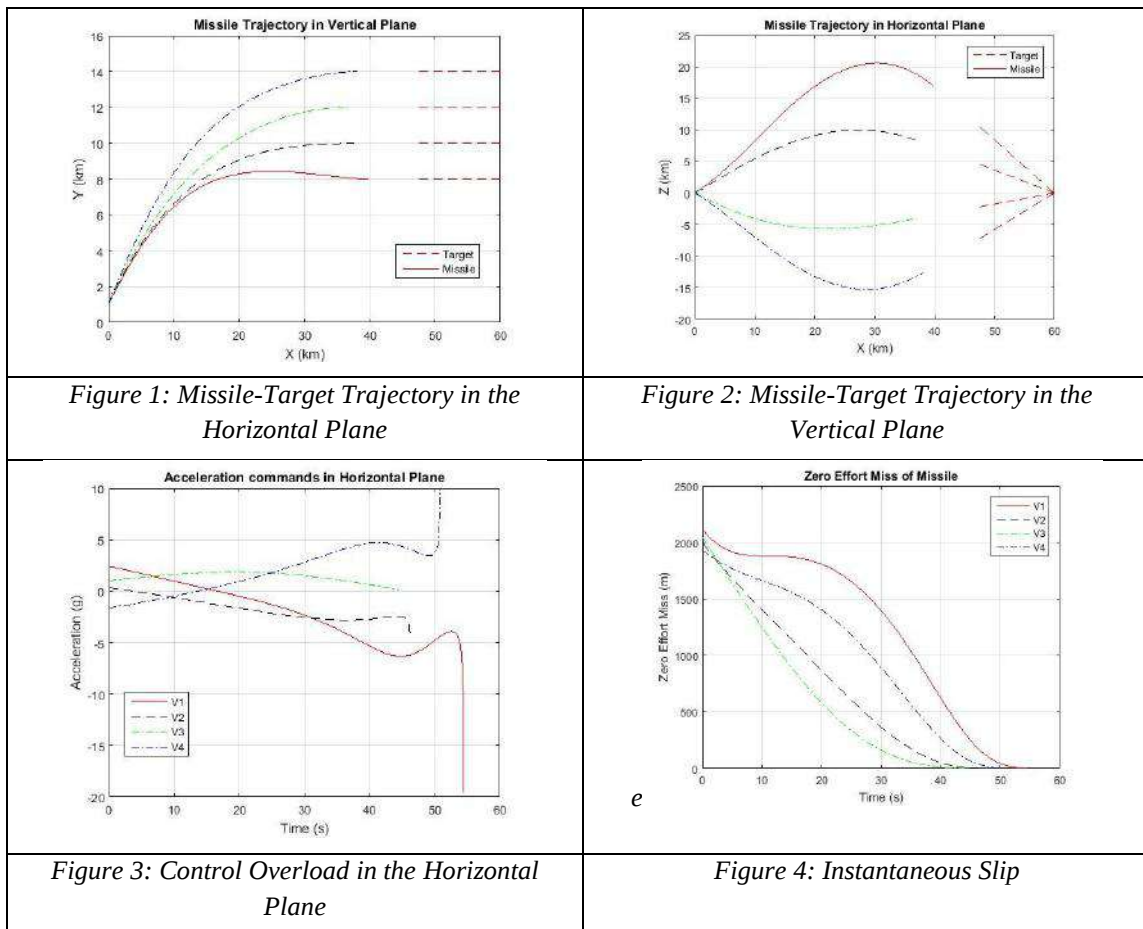
Scenario 3: Altitude of the target $H_t=12\text{km}$, with the flight direction: $\psi_u = -10^\circ$;

Scenario 4: Altitude of the target $H_t=14\text{km}$, with the flight direction: $\psi_u = -30^\circ$;

III. RESULTS AND DISCUSSION

3.1. Simulation results and comments

The survey results for the four cases are reflected in a single graph, as shown in Figures 1, 2, 3 and 4 below:



We draw the following observations:

- The missile-target trajectory in the vertical plane has a rainbow-like shape, which is energy-optimal (Figure 1). Guidance law (29) directs the missile to the final point of the cruise phase with its trajectory aligned with the target's motion direction, approximately 10 km from the target, ensuring the required distance and orientation for the transition to autonomous guidance. Even when engaging low-altitude targets, the missile's trajectory follows a top-down approach (Case 1).

- The missile-target trajectory in the horizontal plane has a parabolic shape, corresponding to the different

approach directions of the target at the end of the cruise phase. The velocity vectors of the missile and the target lie on the same straight line (Figure 2). Simulation results also show that the constructed guidance law ensures the required distance D_{td} as specified.

- The control overload in the horizontal plane is smooth and uniform in the initial phase, then changes direction and increases significantly in the final phase due to the need to maneuver the missile's trajectory to achieve the desired approach angle (Figure 3).

- In all four cases studied, the instantaneous slip parameter approaches 0 before reaching the guidance point.

This ensures accuracy when directing the missile to a predefined point and also demonstrates the precision of the synthesized guidance method (Figure 4).

Thus, the simulation results have shown that the newly synthesized guidance law (29) can control the missile during the cruise phase to reach the predicted point, ensuring the required autonomous guidance distance and trajectory orientation. The simulation results also confirm the effectiveness of the synthesized guidance law, validating the analyses as accurate.

IV. CONCLUSIONS

From the approach of considering the guidance law as a state-space function and selecting the quality criterion function, we can see that if the control vector $u(t)$ is proportional to the control overload, the quality criterion represents the energy required throughout the entire control process. Therefore, the trajectory executed by guidance law will be energy-optimal when the optimization criterion is applied. By constructing the guidance law as described, we can definitively determine the transition point to autonomous guidance by incorporating the required condition for the target distance vector at the final time into the guidance law. This is particularly important when transitioning from the cruise phase to autonomous guidance.

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The impact and psychological consequences of post covid on healthcare professionals

O impacto e as consequências psicológicas pós covid em profissionais de saúde

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Abstract— The COVID-19 pandemic has thrown the entire world into economic and mental turmoil, changed our lifestyles and changed the way we interact in care in what is a very challenging and rapidly

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Keywords— *Pandemic, Anxiety, Depression, Disorders.*

Palavras chave— *Pandemia, Ansiedade, Depressão, Transtornos.*

evolving circumstance. The methodology: this is a bibliographical research of a documentary, descriptive and qualitative nature, the information was obtained from the analysis of scientific data published on online platforms. Results and Discussion: Healthcare professionals face additional pandemic stressors. They are known to include an increased risk of infection, of becoming ill or dying, of inadvertently transmitting the disease to others, and overwhelming and serious cases of illness. These professionals will also likely face a large number of deaths at the same time, will be frustrated with themselves for not being able to save many lives, and will be subjected to threats and attacks by people seeking dependent care when resources are limited. Conclusion: Anxiety and depression are the most common mental disorders among healthcare professionals, especially among those working on the front lines against COVID-19. Improvement strategies must be implemented that focus not only on the physical health of employees, but especially on mental health, as it is often overlooked and dismissed in its importance.

Resumo—A pandemia da COVID-19 lançou o mundo inteiro em turbulência econômica e mental, mudou nosso estilo de vida e mudou a forma como interagimos na assistência, no que é uma circunstância muito desafiadora e de rápida evolução. A metodologia: trata-se de uma pesquisa bibliográfica de caráter do tipo, documental, descritivo e qualitativo, as informações foram obtidas a partir da análise de dados científicos publicados nas plataformas online. Resultados e Discussões: Os profissionais de saúde enfrentam estressores pandêmicos adicionais. Sabe-se que eles incluem um risco maior de infecção, de adoecer ou morrer, de transmitir inadvertidamente a doença a outras pessoas e casos avassaladores e graves de doença. Esses profissionais provavelmente também enfrentarão um grande número de mortes ao mesmo tempo, ficarão frustrados consigo mesmos por não conseguirem salvar muitas vidas e serão submetidos a ameaças e ataques por pessoas que buscam cuidados dependentes quando os recursos são limitados. Conclusão: Ansiedade e depressão são os transtornos mentais mais comuns entre os profissionais de saúde, principalmente entre aqueles que trabalham na linha de frente contra a COVID-19. Estratégias de melhoria devem ser implementadas que se concentrem não apenas na saúde física dos funcionários, mas especialmente na saúde mental, pois muitas vezes é negligenciada e recebida com desprezo em sua importância.

I. INTRODUCTION

The COVID-19 pandemic has thrown the entire world into economic and mental turmoil, with Brazil alone having documented around 664,000 Coronavirus-related deaths. COVID-19 has changed our lifestyle and changed the way we interact in healthcare in what is a very challenging and rapidly evolving circumstance. The increase in the disease due to infection in several countries and the indication of community transmission led to social containment measures being recommended throughout the world; as was done in Brazil (WERNECK et al., 2020).

In the absence of effective treatments, the WHO recommends isolating suspected cases and maintaining social distancing, fundamental strategies to contain the exponential increase in cases and the overload of the health service. As isolation measures were put in place to reduce contamination, schools and colleges were closed, non-essential government and private services were shut down, companies began doing their employees' work online from home, and millions of families were asked to stay at home (SÁ et al., 2021).

Thus, children and the entire world population were kept at home with what appeared to be the beginning of a long period of restricted mobility and social contact, without any organized physical activity (PA) or opportunity to play outdoors, which could make them more vulnerable to harmful behaviors, for example, excessive sedentary lifestyle and possible psychological harm, due to social distancing (SÁ et al., 2021).

The psychological impact of the COVID-19 pandemic has attracted a lot of attention, particularly on frontline healthcare workers such as nurses. This research project will focus on identifying the specific psychological outcomes that were experienced by these professionals following the global health emergency. Understanding the psychological implications, such as post-traumatic stress, anxiety and burnout, is crucial not only to provide the support these professionals need, but to inform policies and practices that can mitigate such impacts in the future and ensure the mental health and well-being of these essential professionals (SCHMIDT et al., 2020).

This emotional and physical burden that the pandemic brings to nursing professionals can be very healing, as it contributes not only to their own mental health problems, but also to the quality of patient care. According to the research results, the state of well-being of healthcare professionals plays an important role in the quality of care received, which further increases the need for attention and consideration to be given to the problems described (RAMOS et al., 2020).

Another relevant point is that many nursing and healthcare professionals did not receive adequate support and resources during the pandemic. For example, the lack of sufficient personal protective equipment, work overload and constant exposure to the risk of infection have increased stress and anxiety. The present research serves to highlight these adverse working conditions and their effects as a prodrome for better conditions and resources in the future (MIRANDA et al., 2021).

Furthermore, the effect of the pandemic on the mental health of healthcare staff is not experienced uniformly across all demographic factors, which include age, gender and years of professional practice. Being able to understand how these specific factors influence psychosocial outcomes is fundamental because in this way personalized interventions can be created to meet the personal needs of different groups within this collective (TEIXEIRA et al., 2020).

How the virus impacted people's lives, especially healthcare professionals, what were the effects of social isolation, multiple losses and the atypical change in the overload of the work routine. The methodology of the

approach adopted in this course conclusion work was the descriptive method, as it served as a means of constructing a scientific analysis between the objective pursued and facts and ideas from other authors. In which the main objective needs to present reasoned arguments and diverse sources of information in an exposed manner.

The work will be a bibliographical review, based on the qualitative method, which demands an in-depth study of the objective of the research — appreciating the context in which it is inserted and the characteristics of the society to which it belongs. Descriptive theoretical foundations that contributed to the construction of this work will be exposed. The work demands immense reference because its construction is based on a current theme that demands immense theoretical reference to contribute to its development. The construction will be based on the ideas and assumptions of theorists who have significant importance in defining the contexts discussed in this work: health professionals, care, psychological disorders.

Finally, the research also aims to explore the coping strategies used by healthcare professionals to deal with stress and anxiety during the pandemic.

II. LITERATURE REVIEW

If we consider from a systemic perspective both acting and not acting as possible selection communications and constitute a specific environment of certain systems, since the beginning of the pandemic we have been witnesses of certain health systems collapsing. Precisely because they were not prepared for the violent irritation/disturbance they suffered. Generated by the need for intensive treatment of a huge contingent of organic and psychic systems – human beings – affected by the coronavirus. We must also keep in mind the fact that since the health system is codependent on economic subsystems, especially those focused on the production of PPE, viral tests, technologies for intensive care beds, among others, these subsystems also ended up overloaded by the violent irritation/disturbance caused by the spread of the coronavirus. In turn, there is also a systemic irritation on the health system, which, faced with the high number of patients infected by the virus and the lack of not only material but also human resources, was unable to operate properly (leading to the collapse that also generated numerous disruptions in the functioning of other social systems) (MARTINI, 2015).

The sudden increase in the number of deaths, for example — in Luhmann's words, annihilation of organic systems and corresponding psychic systems — caused by the new coronavirus has drastically disrupted the funerary subsystem, as well as the religious system, considering the

different religions and communicative beliefs that sustain it. Italy, New York and, later, Brazil, with hundreds of bodies piled inside them. In Brazil, cities like Manaus and São Paulo were at the forefront of burying victims in mass graves, collective ceremonies that last 10 or 15 minutes. In Ecuador, Covid-19 resulted in a lack of coffins and the collapse of cemeteries and funeral homes, forcing many families to leave the bodies of their dead relatives on the streets of Guayaquil until they were collected by health authorities (RODRIGUES et al., 2021).

More than the general population, healthcare workers face additional pandemic stressors. They are known to include a greater risk of infection, of becoming ill or dying, of inadvertently transmitting the disease to others, and overwhelming and serious cases of illness (BAO et al., 2020). These professionals will also likely face a large number of deaths at the same time, will be frustrated with themselves for not being able to save many lives, and will be subjected to threats and attacks by people seeking dependent care when resources are limited (TAYLOR, 2019). In particular for COVID-19, the very challenges that healthcare professionals face can act as a precipitating factor for the onset or exacerbation of symptoms of anxiety, depressive and stress disorders, primarily in employees working on the "front line" — in short-term contact with infected people LI et al., 2020a).

Generally, these professionals were discouraged from getting close to other people, which tends to increase isolation; they have had to deal with frequent changes in care protocols because so much is being learned every day about COVID-19; and a lot of time is often spent putting on and taking off personal protective equipment, which leaves them fatigued from work (ZHANG et al., 2020a). In this sense, in China, mental health teams began to notice signs of psychological distress, increased irritability and refusal to rest on the part of frontline health professionals (CHEN et al., 2020).

As one of the strategies to face the new coronavirus pandemic event, the population's general recommendation is to stay at home, aiming to reduce transmission while the trend increases working hours and/or the existing workforce among health professionals (BARROS-DELBEN et al., 2020). Frontline health professionals, exposed daily to the virus for several months, were infected in several countries. In Italy, this number reached 20% at the end of March 2020. Therefore, access points to personal protective equipment are an issue of great concern for such countries (THE LANCET, 2020).

In addition to the lack of personal protective equipment, the Brazilian press reported the increase in rates of absence from work among health professionals,

which appears to be the situation of municipal employees in São Paulo during the second half of March compared to the first half (RODRIGUES, 2020).

Probably, even if they are not working on the front line or do not need to leave this work for a short period, health professionals can develop psychological distress in the context of health emergencies (BROOKS et al., 2020; LI et al., 2020). Therefore, the phenomenon of "vicarious traumatization" is of interest, also known as "secondary traumatization", where people who have not personally experienced trauma begin to show psychological symptoms resulting from empathy for those who have experienced it (LI et al., 2020).

Thus, even when they need to take time off from work and when quarantine is necessary, healthcare professionals tend to report guilt, anger, frustration and sadness (BROOKS et al., 2020), which suggests the importance of psychological care for this population in the context of pandemics.

The coronavirus pandemic has woven its threads throughout the social fabric, affecting practically every collective area and individual life, with repercussions on mental health. The usual effect of an epidemic is that the number of people affected psychologically is greater than those actually infected by the infection. It is estimated that up to a third to half of the population will suffer or may at least suffer psychological/psychiatric sequelae if they do not have adequate preventive care (MARQUES et al., 2020; ORNELL et al., 2020). This article reported that studies of people who survived quarantines showed high levels of terrible psychological effects, including low mood, irritability with outbursts of anger and fear, and fear and insomnia, often extending over long periods (LIMA, 2020). However, the very fact that this pandemic is simultaneously shaped by social distancing measures and isolation of millions is unprecedented and therefore its effects are likely much more extensive. It is a hypothesis of a "pandemic of fear and stress" (ORNELL et al., 2020). Some of the first articles and reports are starting to come out (available for consultation on pages such as The Lancet's COVID-19 Resource Center), but there are still some of them in a methodologically appropriate way evaluating their psychosocial effects in different countries and social groups.

This recommendation aims to humanize, both on the street and within institutions, the homeless population in case of need or purpose of quarantine and isolation. Target: avoid compulsory hospitalization, treat mental health aspects and, as a priority, deal with alcohol and other drugs in high demand national strategies. For the distribution of material for crack smoking or wound

reduction are included, respectively, in the Federal Government Guidelines on users of alcohol and other drugs under the policy that supported both compulsory and involuntary hospitalization and financed closed devices, such as therapeutic communities.

Publications warn the community that, in conditions of distance and isolation, some feelings of discomfort are to be expected, such as helplessness, boredom, loneliness, irritability and sadness and a series of fears (of falling ill with the disease, dying, losing one's economic life, infecting other people), which can result in loss of appetite and sleep, disturbances in family relationships and increased consumption of alcohol or illicit drugs. Verbal or non-verbal children, with or without associated pathologies, such as autism, may re-present outdated behaviors, such as enuresis (MARQUES et al., 2020; WHO, 2015).

They also state that specialized health/mental health care should be sought when distress is very intense or persistent, when it is associated with suicidal thoughts or behavior, psychotic symptoms, or recurrent substance abuse. On the one hand, the immediate ones can range from depression to transient acute stress reactions; Later disorders may comprise post-traumatic stress disorder and adjustment disorders, in addition to depression and harmful substance use, along with psychosomatic conditions. On the other hand, this also becomes a question of the medicalization of discomfort and care, which has incapacitated people arguing that a pathologization, an over-professionalization of their pain prevents the reevaluation of social policies to promote a context that improves their quality of life (MARQUES et al., 2020). Here we are located in the gray zone between normality and pathology, between individual and social suffering.

It is especially important to highlight the difference between sociocultural trauma and individual trauma. The word trauma itself is elusive in itself, as it is used to denote both the injury itself and its consequences, incorporating within its scope manifestations — both acute and long-term. For this article, trauma will be used as a process, not an event. It is a trauma like a tumor that spreads throughout the psychic apparatus, breaking ties and tending to constellate new malignant links between deformed feelings (they are the equivalent of metastases) throughout the various layers of the mind (BARROS et al., 2020).

The effects of the pandemic, grief, illness, suffering, fear, economic destabilization, disruption of social relationships, created a specific state of stress, making mental health a strategic position of care. This is the theme

focused on by Joel Birman in the book “Trauma in the Coronavirus Pandemic: Its Political, Social, Economic, Ecological, Cultural, Ethical and Scientific Dimensions”, which was released in December 2020 and now reaches its third edition in 2021 (GOUGET, 2023).

Given the assumption that the pandemic created sociocultural trauma, this article will focus mainly on the dimensions that trigger individual traumatic processes. A situation, without a doubt, can be catastrophic, but it does not automatically transform into trauma for all individuals in the same intensity and in the same way. We have to start, then, being very attentive to the specificity with which each of our patients is reacting to this moment. All patients were shocked by the events, but not traumatized by the pandemic. Some of those who were not traumatized by it may be traumatized later by its consequences (BARROS et al., 2020).

We seek to contribute to nursing by making health professionals aware of the relevance of mental health for nursing teams in the face of a pandemic. So that more means of prevention can be sought by identifying and recognizing stressors, preventing these professionals from acquiring mental illnesses and aiming for a better quality of life in the work environment; in addition to expanding the number of scientific studies that look at nursing performance, relating the work and psychological aspects of the nursing team inserted in the pandemic environment (SOUZA et al., 2022).

Post-Covid psychological consequences in nursing professionals represent an area of significant concern today, given the challenging and stressful nature of these professionals' work during the pandemic. In the midst of directly confronting the disease and providing intensive care to patients, nursing professionals were exposed to a variety of physical, emotional and psychological stressors that can leave lasting consequences on their mental health (SILVA; NASCIMENTO; BOTELHO, 2023).

One of the main psychological consequences faced by these professionals is post-traumatic stress (PTSD), resulting from exposure to extremely stressful or traumatic situations. Paes, Cruz and Oliveira (2022) emphasize that constant exposure to the disease, work overload, lack of adequate resources and fear of infection can trigger symptoms of PTSD, such as flashbacks, nightmares, hypervigilance and avoidance of trauma-related situations. PTSD can have a significant impact on nurses' quality of life and job performance, compromising their ability to effectively deal with stress and provide quality care to patients.

In addition to PTSD, nursing professionals are also at risk for developing other mental health conditions, such as anxiety and depression. Uncertainty regarding one's own

safety, mourning the loss of colleagues or patients, and the physical and emotional fatigue associated with exhausting work can contribute to the development of these disorders. Anxiety and depression can interfere with nurses' ability to perform their duties effectively, impairing their concentration, decision-making and communication skills, and increasing the risk of medical errors and professional burnout (BARBOSA et al., 2020).

In addition to individual consequences, the post-COVID psychological repercussions on nursing professionals also have implications for the healthcare system as a whole. Increased staff turnover, work absenteeism and reduced job satisfaction can compromise the health system's ability to provide quality care and respond effectively to future public health emergencies (SILVA; NASCIMENTO; BOTELHO, 2023). Furthermore, stigma and lack of social support can make it difficult for nursing professionals to seek help, perpetuating the cycle of suffering and isolation.

Given these considerations, it is crucial that effective measures are implemented to prevent and mitigate post-covid psychological consequences in nursing professionals (BARBOSA et al., 2020). This includes providing psychological support and accessible mental health resources, implementing self-care and stress management strategies, and promoting an organizational culture that values the well-being of healthcare professionals. Furthermore, it is important that additional research is conducted to better understand the risk factors and mechanisms underlying post-Covid psychological consequences in nursing professionals in order to inform policies and practices that promote the mental health and well-being of these essential professionals.

It was observed in the present study that the prevalence of symptoms of Anxiety and Depression is higher in professionals who work in private services, who have Burnout Syndrome and who work in services with no structure to face the COVID-19 pandemic. As long as talking to friends and family proves to be a habit that reduces the prevalence of Anxiety and Depression symptoms in nursing professionals during the COVID-19 pandemic. Nursing professionals are more vulnerable to psychological distress, with depression being one of the three diseases that most affect them. This vulnerability is explained not only by the nature of the activity they perform, which is directly linked to the physical and emotional suffering of those to whom care is provided, but also by the working conditions and lack of professional recognition (SILVA et al., 2015).

Another impact of the current pandemic was the formulation of social distancing, which brought changes in human interrelationships (HUMEREZ et al., 2020).

Because people are, by nature, social creatures, with needs that are fed by interrelationships — needs that, in fact, underlie interrelationships and that interrelationships sustain in a similar way, intuitive distancing puts at risk the commitment to psychological restoration (RIBEIRO et al., 2020).

The impact of these factors does not only occur among professionals who are actively working, as professionals who reported being on vacation or having their job changed due to the COVID-19 pandemic had a 35% higher prevalence of severe symptoms of depression than individuals who are working normally. We must highlight that these same professionals may have been away due to being suspected or confirmed cases of COVID-19, which adds an impact to be considered on the mental health condition (FARO et al., 2020).

It is no surprise to consider that multidisciplinary health professionals who are already on the front line of the fight against the new coronavirus disease 2019 (COVID-19) caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) encounter a little more difficulty because in addition to these difficulties related to the fear of becoming infected and concerns about their family and friends, they have to provide direct care for a disease with a high degree of uncertainty regarding its symptoms and consequences, in addition to increasing working hours — and in a hostile environment (TEIXEIRA et al., 2020). The distance from the family, the pressure of the disease from being a beginner to still unknown in the scientific world, the fear of becoming infected while providing care, long working hours, professional devaluation, among other challenges faced by frontline professionals, are facts that lead to a high risk of developing mental illnesses in the medium and long term; Among them, the ones with the highest incidence are anxiety and depression (DAL'BOSCO et al., 2020).

According to Santos et al. (2021, p. 9), “[...] professionals who work in private services, who present symptoms of Burnout Syndrome, and who work in services with no structure to deal with the COVID-19 pandemic [...] have a higher prevalence of symptoms of anxiety and depression”. This fact demonstrates that, although all nurses, technicians and nursing assistants suffer significantly when facing the pandemic, those who work in institutions with a lack of resources and precarious conditions face a greater challenge and suffer a greater mental impact, which generates more fragility and effects on their mental health.

According to Cai et al. (2020) present the condition of nursing professionals working on the front line in China, where, in addition to depression and anxiety, there was a

considerable incidence of post-traumatic stress disorder and insomnia, not very different from the cases presented in studies in Brazil. Here stress peaks also lead to results similar to the Chinese study (SAMPAIO et al., 2020; BARROS et al., 2020).

This scenario served to ensure that the research findings corresponded to the results presented in the literature, as other studies carried out with nurses in other work contexts found a significant prevalence of depression in the professionals studied (Vargas & Dias, 2011). For professionals working in the Family Health Strategy (ESF), for example, depressive symptoms were present in more than half of the participants, even though they did not consider themselves ill. In these studies, the main factors of work-related psychological distress were related to poor working conditions (FERNANDES & MARCOLAN, 2017).

III. CONCLUSION

Anxiety and depression are the most common mental disorders among nursing professionals, especially among those working on the front lines against COVID-19. Although mental disorders have a high prevalence in Brazil, as well as in other countries, in Brazilian professionals they reach an alarmingly high frequency due to recent years and the historical devaluation of work in the country. In Brazil, studies on the prevalence of mental disorders in professionals are recent. The results for the two pathologies in this research showed higher prevalence rates of symptoms indicative of depression than those indicative of anxiety; changes such as panic syndrome and insomnia occur. When both pathologies are considered, symptoms indicative of depression were prevalent compared to those of anxiety.

This study is so relevant to the future environment in academia for those who will become nursing professionals because it shows the reality within hospital units and portrays the situation that nurses, technicians and nursing assistants face, which is complex and challenging. It intensifies the need for improvements in the health of hospital workers, given the new global health situation. Improvement strategies must be implemented that focus not only on the physical health of employees, but especially on mental health, as it is often overlooked and dismissed in its importance. Mental health has as much effect on the quality of care and service as any other issue. When psychological complaints are valued within the work environment, this shows appreciation not only for the employee, but also guarantees quality in the work process.

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Applications of Design of Experiments (DOES) in Engineering – State of the Art

Aplicações de Planejamentos de Experimentos (DOES) na Engenharia – Estado da Arte

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Palavras chave— DOE, Engenharia,
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Experimentos, Taguchi

Abstract— Design of Experiments (DOE) is an essential statistical methodology for engineering, allowing the systematic analysis of processes and the optimization of products. Its use allows the controlled manipulation of variables to maximize efficiency and quality in several areas, such as chemical, mechanical and materials engineering. However, despite its effectiveness, there are still challenges in the practical implementation of DOE, especially due to the methodological complexity and the lack of training in some industries. The study includes a review of practical cases between 2009 and 2024, selected from the academic database ScienceDirect, which illustrate the applications of DOE in industrial and scientific contexts, with emphasis on the factorial and Taguchi methods. Through DOE, it is possible to identify the most influential variables in a process and determine the ideal conditions to maximize system performance. Methodologies such as the Taguchi method, analysis of variance (ANOVA) and response surfaces allow engineers to explore the simultaneous impact of multiple factors, enabling a robust approach to decision-making in a controlled and efficient manner, with significantly lower costs and efforts. The research results demonstrate applications of DOE in areas such as optimization of machining processes in mechanical engineering, improvement of the thermal efficiency of heat exchangers in chemical engineering, and the development of high-strength metal alloys in materials engineering. In addition, there was an increase in the adoption of DOE in emerging sectors, such as genetic engineering and optimization of advanced materials. It is concluded that DOE is an indispensable tool for innovation and industrial competitiveness, promoting greater efficiency and reliability in processes. However, there is still room for its evolution, mainly in the development of more accessible approaches and in professional training for its effective implementation. This study contributes to the dissemination of knowledge about DOE, encouraging

its wider adoption in engineering and driving technological advances in the most diverse areas.

Resumo— O Planejamento de Experimentos (DOE) é uma metodologia estatística essencial para a engenharia, permitindo a análise sistemática de processos e a otimização de produtos. Seu uso possibilita a manipulação controlada de variáveis para maximizar eficiência e qualidade em diversas áreas, como engenharia química, mecânica e de materiais. No entanto, apesar de sua eficácia, ainda há desafios na implementação prática do DOE, especialmente devido à complexidade metodológica e à falta de capacitação em algumas indústrias. O estudo inclui uma revisão de casos práticos entre 2009 e 2024, selecionados da base de dados acadêmica ScienceDirect, que ilustram as aplicações do DOE em contextos industriais e científicos, com ênfase nos métodos fatorial e Taguchi. Por meio do DOE, é possível identificar as variáveis mais influentes em um processo e determinar as condições ideais para maximizar o desempenho do sistema. Metodologias como o método Taguchi, análise de variância (ANOVA) e superfícies de resposta permitem que os engenheiros explorem o impacto simultâneo de múltiplos fatores possibilitando uma abordagem robusta para a tomada de decisões de maneira controlada e eficiente, com custos e esforços significativamente menores. Os resultados da pesquisa demonstram aplicações do DOE em áreas como otimização de processos de usinagem na engenharia mecânica, o aprimoramento da eficiência térmica de trocadores de calor na engenharia química e o desenvolvimento de ligas metálicas de alta resistência na engenharia de materiais. Além disso, observou-se um crescimento na adoção do DOE em setores emergentes, como engenharia genética e otimização de materiais avançados. Conclui-se que o DOE é uma ferramenta indispensável para a inovação e a competitividade industrial, promovendo maior eficiência e confiabilidade nos processos. No entanto, ainda há espaço para sua evolução, principalmente no desenvolvimento de abordagens mais acessíveis e na capacitação profissional para sua implementação eficaz. Este estudo contribui para a disseminação do conhecimento sobre DOE, incentivando sua adoção mais ampla na engenharia e impulsionando avanços tecnológicos nas mais diversas áreas.

I. INTRODUÇÃO

O Planejamento de Experimentos (*Design of Experiments* – DOE) é uma metodologia estatística utilizada para o planejamento, execução e análise de experimentos, sendo amplamente empregada no teste e otimização de processos, sistemas e produtos em diversas áreas da engenharia. Sua aplicação permite estimar o impacto de múltiplos fatores simultaneamente, possibilitando a identificação das relações entre variáveis independentes e dependentes em sistemas complexos (Durakovic, 2017). O princípio fundamental do DOE reside na organização sistemática dos experimentos, visando maximizar a obtenção de informações com o menor custo e esforço experimental. Para isso, empregam-se métodos estatísticos rigorosos, como a análise de variância

(ANOVA) e a regressão linear, garantindo a robustez e a confiabilidade dos resultados (Smucker et al., 2023).

Historicamente, os métodos experimentais eram limitados e, frequentemente, utilizavam a abordagem *One Factor At a Time* (OFAT), na qual apenas um fator era alterado por vez, enquanto os demais permaneciam constantes. Apesar de sua simplicidade, essa técnica apresentava limitações significativas, como a impossibilidade de identificar interações entre variáveis e a necessidade de um grande número de experimentos para obter conclusões robustas. A evolução do planejamento experimental ocorreu na década de 1920, com as contribuições de R. A. Fisher, que, ao atuar na Estação Experimental Rothamsted, na Inglaterra, desenvolveu os fundamentos do planejamento experimental moderno

(Fisher, 1925). Fisher introduziu conceitos essenciais, como a aleatorização, a replicação e os experimentos fatoriais, permitindo a análise simultânea de múltiplos fatores com maior precisão e eficiência (Ilzarbe et al., 2008). Essas inovações deram origem a metodologias mais avançadas, como os experimentos fatoriais completos e fracionados, que se tornaram referência na pesquisa científica e industrial, consolidando o DOE como uma ferramenta essencial na engenharia e em outras áreas aplicadas.

Atualmente, o DOE desempenha um papel estratégico na engenharia, especialmente nos setores de manufatura, engenharia química e engenharia de materiais, sendo amplamente utilizado para a otimização de processos e a melhoria da qualidade de produtos e sistemas. O arcabouço teórico estabelecido por Fisher foi posteriormente expandido por pesquisadores como Genichi Taguchi, que desenvolveu abordagens voltadas para o aprimoramento da robustez dos processos industriais (Taguchi, 1986). Os *Taguchi Methods* enfatizam a minimização da variabilidade e a redução da influência de perturbações externas, garantindo maior estabilidade e qualidade dos produtos. Essas técnicas foram rapidamente incorporadas a metodologias de gestão da qualidade, como o *Six Sigma*, devido à sua eficácia na identificação de fatores críticos e na otimização de processos, resultando na redução de custos e no aumento da confiabilidade dos sistemas (Durakovic, 2017; Milosavljević et al., 2024).

Com os avanços tecnológicos, ferramentas computacionais passaram a ampliar as aplicações do DOE, facilitando o planejamento e a análise de experimentos complexos. Softwares estatísticos, como R e Minitab, oferecem recursos avançados para modelagem experimental, tornando o DOE mais acessível a pesquisadores e profissionais (Tanaka & Amaliah, 2022). Essa evolução contribuiu para a popularização da metodologia, viabilizando sua aplicação em diferentes contextos, incluindo setores emergentes e pesquisas de menor escala.

Assim, o planejamento experimental possibilita a identificação de variáveis-chave e a definição de condições operacionais ideais para a otimização de sistemas (Box et al., 2005). O desenvolvimento contínuo do DOE tem expandido suas aplicações para novos domínios, consolidando-o como uma ferramenta indispensável na engenharia moderna.

Apesar da ampla aceitação do DOE, desafios persistem, como a capacitação de profissionais sem formação estatística e a adaptação à crescente complexidade dos sistemas. A integração de inteligência artificial e algoritmos avançados oferece novas oportunidades para melhorar a análise experimental, mas exige investimentos em

treinamento e ferramentas especializadas (Khan et al., 2023).

Além disso, torna-se essencial avaliar a aplicabilidade do DOE em contextos que demandam soluções sustentáveis e otimizadas, como a transição para indústrias de baixo carbono e o desenvolvimento de tecnologias limpas. Essas lacunas na literatura indicam a necessidade de estudos que investiguem a evolução do DOE nas últimas décadas e suas tendências futuras (Durakovic, 2017).

Diante desse cenário, este estudo busca preencher essa lacuna ao apresentar uma revisão sistemática das aplicações do DOE na engenharia entre 2009 e 2024. O objetivo é identificar padrões e inovações no uso dessa metodologia, destacando suas contribuições para a otimização de processos industriais e o avanço tecnológico. Espera-se, assim, fornecer aos engenheiros e pesquisadores um referencial consolidado que favoreça a aplicação eficiente do DOE em diferentes contextos industriais e acadêmicos. Além disso, pretende-se aprofundar a compreensão das interconexões entre os avanços teóricos e as aplicações práticas do DOE, contribuindo para a formulação de diretrizes que orientem futuras pesquisas e implementações.

II. METODOLOGIA

Objetivo De Estudo

Este estudo busca compilar e analisar casos práticos publicados em periódicos técnicos entre 2009 e 2024, demonstrando a aplicação do Planejamento de Experimentos (DOE) em diversas áreas da engenharia. Esse intervalo foi selecionado devido ao aumento significativo no número de publicações relacionadas ao tema a partir de 2009, além da existência de revisões bibliográficas abrangentes até 2008.

Os estudos selecionados abrangem uma ampla variedade de periódicos científicos e oferecem uma fonte valiosa para acadêmicos, consultores e profissionais interessados em identificar aplicações específicas do DOE em suas áreas de atuação. Além disso, essa compilação representa um recurso prático que facilita a transferência de conhecimento para futuras aplicações industriais.

Para a seleção dos casos práticos, foram utilizadas as bases de dados Web of Science e ScienceDirect, resultando na identificação de trinta estudos relevantes dentro do período analisado. Esses casos foram organizados e classificados conforme seu campo de aplicação, permitindo uma análise descritiva que contempla os objetivos dos estudos, os modelos de planejamento experimental adotados, os setores de aplicação e a evolução das práticas ao longo do tempo.

Origem Do Banco De Dados

O processo de seleção dos casos práticos seguiu as etapas descritas a seguir:

1. **Busca inicial:** Foi realizada uma pesquisa na base de dados ScienceDirect utilizando o termo “Design of Experiments”, abrangendo o período de 2009 a 2024. Essa consulta resultou em um total de 126.165 artigos, incluindo tanto estudos teóricos quanto aplicações práticas do DOE.
2. **Filtragem por área:** Para restringir a busca ao campo da engenharia, aplicaram-se filtros específicos, reduzindo o conjunto de artigos para 45.535 publicações.
3. **Triagem manual:** Foi realizada uma análise dos resumos de uma amostra representativa desses artigos. O critério de seleção considerou exclusivamente estudos que apresentavam casos de aplicação prática do DOE em contextos reais da engenharia, focados na otimização de processos e na solução de problemas industriais.
4. **Construção do banco de dados:** Após essa triagem criteriosa, foi constituído um banco de dados contendo trinta artigos que atendiam aos objetivos do estudo.

III. ANÁLISE DE APLICAÇÕES PRÁTICAS

Evolução Das Publicações Ao Longo Do Tempo

A aplicação do Design de Experimentos (DOE) tem se expandido significativamente nas últimas décadas, consolidando-se como uma metodologia essencial para a melhoria e otimização de processos em diversos setores industriais. Segundo Montgomery (2017), o DOE permite uma análise robusta das variáveis que influenciam um processo, proporcionando um entendimento detalhado das interações e facilitando a tomada de decisões para melhorias contínuas.

Na Figura 1 está apresentada a evolução do número de publicações sobre DOE nos últimos 10 anos, evidenciando uma tendência crescente de interesse e adoção dessa metodologia. Esse aumento reflete o reconhecimento do DOE como uma ferramenta fundamental para a otimização e inovação em diversas áreas da engenharia. O crescimento das publicações também indica o aprimoramento contínuo das técnicas associadas ao DOE, tornando-o cada vez mais indispensável para pesquisas e avanços tecnológicos.

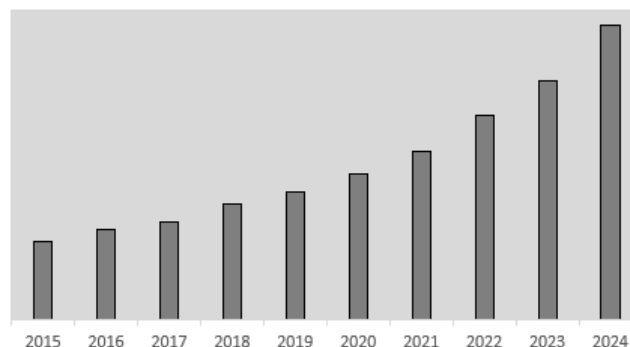


Fig.1: Evolução das publicações sobre DOE ao longo do tempo.

Fonte: Feito pelo autor

Area De Aplicação

O DOE é amplamente valorizado em setores que exigem alto rigor técnico, como engenharia química e engenharia mecânica. Na engenharia química, por exemplo, o DOE é frequentemente utilizado para otimizar processos de síntese e reações químicas, representando 33,33% das aplicações analisadas (Bisgaard, 2016).

Na engenharia mecânica, que corresponde a 30% dos casos estudados, o DOE auxilia na determinação de parâmetros operacionais ideais e na redução da variabilidade dos processos, sendo essencial para a fabricação e o controle de qualidade (Taguchi, 1986).

Outras áreas também fazem uso significativo do DOE:

- **Engenharia de Materiais (10%):** emprega o DOE para estudar propriedades de novos materiais e suas respostas sob diferentes condições experimentais.
- **Engenharia Genética e Bioquímica (10%):** utiliza o DOE para otimizar processos de bioprocessamento e experimentos em genética aplicada (Gunst & Mason, 2009).

Esses dados reforçam o DOE como um instrumento essencial para inovação, eficiência e competitividade industrial. Na Figura 2 ilustra-se a distribuição das aplicações do DOE em diferentes áreas da engenharia.

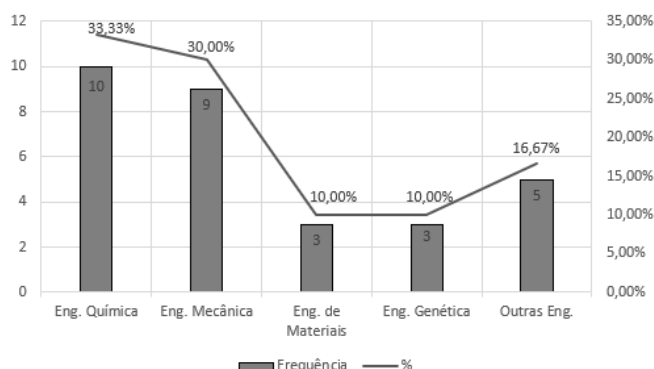


Fig.2: Distribuição das aplicações do DOE por área da engenharia.

Fonte: Feito pelo autor

Tipo De Design Utilizado

Os métodos mais empregados no Design de Experimentos (DOE) incluem o planejamento fatorial e a metodologia de Taguchi, ambos amplamente utilizados devido à sua eficácia em contextos industriais diversos.

De acordo com Myers et al. (2009), o planejamento fatorial é amplamente utilizado para analisar múltiplas variáveis e suas interações, sendo ideal para otimizações complexas que exigem uma visão abrangente dos efeitos combinados dos fatores. Essa abordagem permite uma análise sistemática dos experimentos, contribuindo significativamente para a melhoria contínua dos processos.

Por outro lado, a metodologia de Taguchi é amplamente reconhecida por sua abordagem robusta de controle de qualidade. Taguchi (1986) introduziu o conceito de matrizes ortogonais, permitindo a otimização de múltiplos fatores com um número reduzido de experimentos, tornando o método altamente eficiente. Essa abordagem é particularmente útil em ambientes industriais onde a redução da variabilidade é essencial para garantir produtos mais confiáveis e processos mais estáveis (Roy, 2001).

A escolha entre esses métodos reflete a busca por estratégias que maximizem a qualidade e otimizem os recursos disponíveis. Ambos desempenham um papel fundamental no aprimoramento da eficiência operacional e na inovação tecnológica, consolidando o DOE como uma metodologia indispensável na engenharia e manufatura.

IV. APLICAÇÕES PRÁTICAS

As aplicações práticas do Planejamento de Experimentos (DOE) abrangem diversas áreas da engenharia, sendo uma ferramenta essencial para otimização de processos, melhoria da qualidade de produtos e redução de custos. A seguir, estão listadas algumas dessas aplicações conforme suas respectivas áreas.

Engenharia Química

O uso do Planejamento de Experimentos (DOE) na Engenharia Química tem se consolidado como uma ferramenta essencial para a otimização de processos, melhoria da qualidade de produtos e redução de custos operacionais. Sua aplicação abrange áreas como bioprocessos, produção de energia e síntese de novos materiais. A versatilidade do DOE, com sua capacidade de identificar interações entre variáveis e otimizar condições experimentais, tem sido fundamental para diversas inovações tecnológicas e científicas neste campo. metodologia de Taguchi, ambos amplamente utilizados devido à sua eficácia em contextos industriais diversos.

Um exemplo relevante é a aplicação do DOE na ampliação de processos cromatográficos. Shekhawat et al. (2018) utilizaram o DOE para otimizar processos cromatográficos em bioprocessos. O uso do Split Design permitiu ajustar as condições experimentais e aprimorar a compreensão das interações entre os parâmetros do processo, contribuindo para o aumento da eficiência na separação de componentes em sistemas biotecnológicos. Essa abordagem não só minimizou o número de experimentos necessários, mas também garantiu o controle de uma variável crítica, resultando em um processo mais eficaz e economicamente viável.

De maneira semelhante, Biondo et al. (2024) aplicaram o DOE para otimizar a produção de hidrogênio a partir da decomposição de metano, com foco na redução de emissões de COx. Através do DOE, os pesquisadores conseguiram identificar os parâmetros mais influentes na eficiência do processo, permitindo uma produção mais sustentável e com menor impacto ambiental. Esta aplicação ilustra claramente como o DOE pode ser utilizado para resolver questões tecnológicas e ambientais de grande relevância, como a transição para fontes de energia mais limpas.

O DOE também tem sido amplamente utilizado na engenharia de processos térmicos e de admissão. Korkerd et al. (2024) integraram o DOE com simulações CFD-DEM para analisar a transmissão de calor e a admissão de biomassa e sílica em leitos fluidizados. A combinação das simulações computacionais com o DOE permitiu uma análise detalhada das diferentes configurações de tubos imersos, proporcionando insights cruciais para otimizar a eficiência dos sistemas de troca térmica e os processos de material.

Na área de síntese química, o DOE tem demonstrado grande relevância. Hernández-Rivera et al. (2023) utilizaram o DOE para otimizar a síntese do epóxido de diosgenina, com o objetivo de melhorar o rendimento diastereoseletivo e as propriedades antimicrobianas,

antioxidantes e antiproliferativas do composto. A aplicação do DOE não apenas ajudou a determinar as melhores condições para a síntese, mas também contribuiu para a descoberta de novos compostos com propriedades farmacológicas promissoras, ampliando as possibilidades de desenvolvimento de tratamentos inovadores.

Outras áreas, como o desenvolvimento de curcumina encapsulada em nanopartículas de sílica, também se beneficiam amplamente do DOE. Saputra et al. (2022) aplicaram o método Taguchi para otimizar o processo de agregação de curcumina em nanopartículas, melhorando a estabilidade do composto. O uso do DOE permitiu definir as condições experimentais ideais para maximizar a eficácia do processo, com implicações para a ampliação de sistemas de liberação controlada, com aplicações tanto na indústria farmacêutica quanto alimentícia.

Além disso, o DOE é amplamente utilizado em processos de análise e instrumentação. Lanot et al. (2023) empregaram o DOE para otimizar a padronização interna no ICP-MS, uma técnica analítica essencial para a quantificação de elementos-traço. A utilização do DOE neste contexto contribuiu para a melhoria da precisão e confiabilidade dos resultados analíticos, uma consideração crucial em análises químicas de alta precisão.

Pesquisas adicionais, como a de Nagy et al. (2024), que otimizaram a síntese de N,N,N-trimetilquitossano, demonstram a aplicabilidade do DOE no desenvolvimento de novos materiais com propriedades específicas. A revisão de Ranc et al. (2016) sobre a seleção de doses de oxidantes para a oxidação química in situ de solos contaminados por hidrocarbonetos aromáticos policíclicos destaca ainda a versatilidade do DOE em processos ambientais.

Engenharia Mecânica

Estudos recentes demonstram a versatilidade e a eficácia do DOE na engenharia mecânica, especialmente na otimização de componentes e processos. Ghalandari et al. (2019) utilizaram uma abordagem híbrida que combina aprendizado de máquina com o DOE para otimizar as lâminas do compressor da primeira fila em um test stand aeromecânico. A integração de algoritmos genéticos, redes neurais artificiais e DOE possibilitou uma análise detalhada dos parâmetros envolvidos, resultando em melhorias significativas no desempenho aerodinâmico e mecânico das lâminas. Esse estudo destaca o potencial do DOE em processos de otimização complexos que envolvem múltiplos fatores interdependentes.

Outro exemplo relevante é o estudo de Senthilkumar et al. (2014), que investigou o desempenho de insertos de carboneto cementado de diferentes geometrias, utilizando o DOE com base na análise de relações cinzas (grey relational analysis) e no método Taguchi. A pesquisa demonstrou

como o DOE pode ser aplicado para identificar e otimizar variáveis que afetam o desempenho de ferramentas de corte, como geometria, velocidade de corte e outros parâmetros de processo. Isso resulta em uma produção mais eficiente e uma maior vida útil das ferramentas, facilitando a escolha das melhores condições operacionais e, conseqüentemente, reduzindo os custos de operação e melhorando a qualidade do processo de usinagem.

A impressão 3D também se beneficia da aplicação do DOE, como evidenciado pelos estudos de Zaman et al. (2019) e Alafaghani e Qattawi (2018). Ambos os estudos utilizaram o método Taguchi para investigar os parâmetros do processo de modelagem por deposição fundida (FDM), como temperatura de extrusão e velocidade de impressão, com o objetivo de otimizar a resistência e a precisão das peças produzidas. Esses trabalhos demonstram como o DOE pode ser empregado para melhorar a qualidade dos produtos fabricados aditivamente, um campo em rápido crescimento na engenharia mecânica. A aplicação do DOE permitiu identificar os parâmetros críticos que afetam as propriedades mecânicas das peças impressas e contribuiu para a melhoria dos processos de fabricação aditiva, minimizando falhas e defeitos no produto final.

No campo da otimização de compósitos e materiais avançados, o trabalho de Sidharthan et al. (2023) utilizou o método Taguchi para analisar e otimizar as propriedades mecânicas e tribológicas de compósitos híbridos de alumínio funcionalmente graduados, reforçados com SiC e MoS₂. A pesquisa demonstrou como o DOE pode ser aplicado para otimizar as propriedades materiais e o desempenho tribológico em processos de fabricação, contribuindo para o desenvolvimento de novos materiais com características superiores para aplicações mecânicas exigentes.

Além disso, a pesquisa de Ma e Qu (2015) exemplifica o uso do DOE na otimização de motores de relutância comutados, utilizando o método de otimização por enxame de partículas (particle swarm optimization) em conjunto com o DOE. A combinação dessas duas abordagens permitiu uma análise detalhada dos parâmetros de design, resultando em melhorias no desempenho e na redução de custos de produção de motores elétricos, componentes essenciais em sistemas mecânicos de controle de energia. A integração dessas metodologias possibilitou otimizações multiobjetivo, essenciais em projetos de alta performance.

Esses exemplos destacam a importância do DOE como uma ferramenta poderosa na engenharia mecânica, especialmente em contextos de alta complexidade e múltiplas variáveis. O DOE oferece uma abordagem científica rigorosa e eficiente para a análise e otimização de processos, garantindo resultados precisos e o

desenvolvimento de soluções inovadoras. Além disso, a integração do DOE com outras técnicas de otimização, como algoritmos evolutivos e análise de dados, tem ampliado as fronteiras da engenharia mecânica, permitindo o avanço para novos paradigmas de fabricação e design.

Engenharia De Materiais

No setor de agregados para a construção, o trabalho de Bhadani et al. (2024) ilustra como o Design de Experimentos (DoE) foi empregado para avaliar e otimizar o desempenho dos processos de britagem e peneiramento de agregados. Esses processos são fundamentais na produção de materiais para a construção civil, e a aplicação do DoE permitiu identificar combinações ideais de parâmetros operacionais, maximizando a eficiência do processo, reduzindo perdas e melhorando a qualidade dos agregados. Por meio do planejamento experimental, foi possível isolar os efeitos das variáveis-chave, possibilitando uma compreensão mais aprofundada de como as mudanças em um fator poderiam influenciar os resultados, como a distribuição de tamanhos de partículas e a eficiência do processo de separação. Essa abordagem não só resultou em ganhos de desempenho operacional, mas também contribuiu para a sustentabilidade da indústria, ao reduzir desperdícios e melhorar o uso de recursos.

Outro exemplo significativo do uso do DoE na engenharia de materiais é o estudo de Román-Ramírez e Marco (2022), que revisa a aplicação dessa metodologia no desenvolvimento de baterias de lítio-íon, um componente crítico para a indústria de energia e mobilidade elétrica. O desenvolvimento de baterias mais eficientes e duráveis exige a investigação de várias variáveis, como a composição química dos materiais, a estrutura das células e os parâmetros de fabricação. O uso do DoE neste contexto possibilitou a otimização do design das baterias, permitindo aos pesquisadores explorar diferentes configurações de materiais e processos, como a composição dos eletrodos e o tratamento térmico das células, para obter o melhor desempenho em termos de capacidade de carga, tempo de vida útil e segurança. Além disso, a aplicação do DoE tem permitido não só aprimorar as propriedades das baterias, mas também reduzir custos de produção e melhorar a sustentabilidade do processo, fatores essenciais para a viabilidade comercial em larga escala dessas tecnologias.

No campo dos elastômeros e compostos poliméricos, a pesquisa de Nunez Carrero et al. (2022) exemplifica como o DOE pode ser aplicado no desenvolvimento de compostos de borracha auto-regenerativa, utilizando aditivos reforçadores derivados de pneus reciclados. A aplicação do DOE nesse estudo foi crucial para definir as proporções ideais entre os materiais, como borracha estireno-butadieno e pó de pneus reciclados, de modo a otimizar tanto as

propriedades mecânicas quanto as de auto-cura do composto. Com a análise experimental, foi possível determinar quais variáveis mais influenciavam as características do material, como resistência à tração, elasticidade e capacidade de regeneração após danos. O uso do DoE permitiu, assim, o desenvolvimento de compostos mais eficientes e com menor impacto ambiental, ao mesmo tempo em que atendiam às exigências de desempenho para aplicações nas indústrias automotiva e de construção.

Esses exemplos demonstram a ampla gama de aplicações do DoE na engenharia de materiais, destacando sua importância na melhoria de processos e no desenvolvimento de novos produtos. Ao permitir uma análise precisa das interações entre diferentes variáveis, o DoE oferece um meio eficaz de otimizar tanto a qualidade quanto o desempenho dos materiais, além de contribuir para a inovação tecnológica e a sustentabilidade. Com seu caráter sistemático e rigoroso, a aplicação do DoE tem se consolidado como uma ferramenta indispensável na busca por soluções cada vez mais eficientes e avançadas na engenharia de materiais.

Engenharia Genética

Um exemplo notável da aplicação do Design de Experimentos (DOE) na engenharia genética é o estudo de Moazami Goodarzi et al. (2024), que utilizou o DOE para otimizar o processo de purificação do antígeno de superfície da hepatite B recombinante a partir de *Pichia pastoris*. A pesquisa envolveu a análise de diferentes condições de purificação utilizando a resina Capto adhere, com o objetivo de maximizar a eficiência e a pureza do produto final. Por meio de um planejamento experimental rigoroso, os pesquisadores conseguiram identificar as condições ideais para o processo de purificação, resultando em uma melhoria significativa na recuperação do antígeno e na redução de custos operacionais. Esse exemplo ilustra como o DOE pode ser uma ferramenta poderosa para otimizar processos biotecnológicos, diminuindo o número de experimentos necessários e aumentando a precisão dos resultados.

Outro exemplo relevante é o estudo de Hernández et al. (2023), que aplicaram o DOE para otimizar o ensaio imunológico ELISA quantitativo. A pesquisa utilizou um design fatorial completo para ajustar as variáveis envolvidas na reação imunológica, com o objetivo de melhorar a sensibilidade e a precisão do teste. O uso do DOE permitiu que os pesquisadores identificassem de forma eficiente os fatores que mais influenciavam o desempenho do ensaio, como as concentrações dos reagentes e as condições de incubação. A otimização do processo resultou em um protocolo de ELISA mais eficiente, que pode ser amplamente utilizado na quantificação de biomarcadores em pesquisas biomédicas e diagnósticas. Este estudo

ressalta o papel crucial do DOE em áreas da Engenharia Genética que envolvem testes diagnósticos e ensaios laboratoriais, onde a precisão e a repetibilidade são essenciais.

Ademais, Moon et al. (2024) exploraram a aplicação do DOE para otimizar vias metabólicas em organismos geneticamente modificados. Utilizando engenharia metabólica, os pesquisadores aplicaram o DOE para identificar os parâmetros chave que influenciam a produção de compostos desejados em microrganismos modificados. Através de experimentos planejados, foi possível guiar a otimização genética desses organismos para aumentar a produção de metabólitos de interesse industrial, como ácidos orgânicos e biocombustíveis. O DOE desempenhou um papel essencial na identificação das interações entre os fatores que afetam a expressão genética e a produção metabólica, oferecendo uma base sólida para o desenvolvimento de cepas microbianas mais eficientes.

Outras

O uso de Planejamentos de Experimentos (DOE) na engenharia tem se expandido consideravelmente nas últimas décadas, abrangendo uma gama crescente de áreas e tecnologias. Atualmente, métodos como o Taguchi, a metodologia de superfícies de resposta e experimentos fatoriais têm sido fundamentais para a otimização e o ajuste fino de sistemas complexos. Um exemplo marcante dessa aplicação é o estudo de Kapsalis et al. (2021), que utilizou a técnica Taguchi para otimizar um tipo de aeronave não tripulada (UAV) com a arquitetura Blended-Wing-Body (BWB). Neste trabalho, as simulações numéricas de Dinâmica dos Fluidos Computacional (CFD) permitiram uma análise simultânea e eficiente de múltiplos fatores aerodinâmicos, como o formato da asa e o desempenho do motor. A metodologia DOE, combinada com o Taguchi, não só possibilitou a otimização de parâmetros-chave, mas também reduziu os custos experimentais e a necessidade de experimentos físicos, diminuindo o tempo de simulação.

Outro exemplo interessante é o estudo de Lujan-Moreno et al. (2018), que integrou o DOE com a metodologia de superfícies de resposta para otimizar os hiperparâmetros de um modelo de aprendizado de máquina baseado em floresta aleatória. A pesquisa demonstrou como o DOE pode ser aplicado em áreas não tradicionais, como o aprendizado de máquina, facilitando a otimização eficiente dos parâmetros do modelo. Essa abordagem é crucial para melhorar a precisão e a eficiência de algoritmos em grandes volumes de dados, contribuindo para o desempenho superior em tarefas complexas, como a previsão de comportamentos em sistemas dinâmicos.

O uso do DOE também tem se mostrado promissor no campo da educação e do aprendizado prático, como

evidenciado por Unzueta e Eguren (2023). Os pesquisadores implementaram o aprendizado baseado em projetos (PBL) para o ensino de técnicas de design de experimentos, utilizando a impressão 3D como ferramenta didática. Essa abordagem inovadora permite que os alunos construam protótipos físicos enquanto desenvolvem a capacidade de analisar dados e otimizar processos, integrando teoria e prática de maneira eficaz. Além de facilitar a aprendizagem de conceitos complexos de engenharia, essa metodologia prepara os estudantes para enfrentar desafios do mundo real com uma abordagem analítica e prática.

Na engenharia civil, o DOE tem demonstrado sua eficácia, como exemplificado por Mohan e Mini (2018), que investigaram a resistência e a durabilidade de concreto autoadensável (SCC) com a incorporação de sílica ativa e escória de alto forno ultrafina. O uso do DOE, neste caso, possibilitou uma análise detalhada dos efeitos de diferentes aditivos no desempenho do concreto, permitindo a otimização de suas propriedades sem a necessidade de um grande número de ensaios. Essa aplicação contribuiu significativamente para o desenvolvimento de materiais mais eficientes e duráveis, com implicações diretas para a sustentabilidade na construção civil.

V. CONCLUSÃO

Esta pesquisa demonstrou que o Design of Experiments (DOE) é uma ferramenta essencial para a engenharia moderna, destacando-se por sua versatilidade e capacidade de promover avanços significativos na otimização de processos, redução de custos e aprimoramento da qualidade de produtos e serviços. Com sua aplicação interdisciplinar, o DOE tem se mostrado crucial para engenheiros que enfrentam desafios complexos em áreas como engenharia química, mecânica, de materiais e bioquímica. Essa flexibilidade permite que o DOE seja ajustado para atender às especificidades de cada setor, otimizando recursos e promovendo a eficiência em ambientes cada vez mais competitivos e tecnológicos.

Além de facilitar a inovação, o DOE oferece uma estrutura metodológica rigorosa para a experimentação, permitindo que os profissionais obtenham insights valiosos de maneira mais eficiente e controlada. Em um cenário de rápidas mudanças tecnológicas e crescente demanda por processos sustentáveis e precisos, o DOE se consolida como um método indispensável para a engenharia orientada à melhoria contínua. Ao possibilitar o controle detalhado sobre variáveis e suas interações, o DOE não apenas contribui para o avanço da engenharia, mas também serve como um pilar para práticas inovadoras, promovendo

soluções robustas e eficazes para os desafios da indústria atual e futura.

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The Determination of Phytochemical Properties and Antimicrobial Effect of *Salvia verticillata* L. subsp. *amasiaca*

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Keywords— *S. verticillata*, **antioxidant**,
antimicrobial, **phenolic compound**, **essential**
oil.

Abstract— People are constantly interested in tasting, smelling and consuming flavors and aromas obtained from natural sources. At the same time, their health benefits in addition to their flavors and smells increase this interest even more. *Salvia verticillata* L. is one of these sources known for centuries. *Salvia verticillata* L. is a species belonging to the Lamiaceae family, *Salvia* (Lamiaceae) genus. It is widely used in the Mediterranean region not only as an ornamental plant but also in traditional medicine. In this study, the antioxidant activity, essential oil composition and antimicrobial activity of *Salvia verticillata* L. subsp. *amasiaca* were determined. While the phenolic substance concentration equivalent to gallic acid was found to be 431.70 mg, the phenolic substance concentration equivalent to ascorbic acid was found to be 351.97 mg. Copper reducing capacity was determined as 112 mmol/g and Carotene-linoleic acid emulsion as 16.35 percent, the major volatile oil ratio was found to be trans-trans-caryophyllene with 35%. It was found to be significantly effective against *E. fecalis*, *S. aureus*, *P. aeruginosa* among the studied microorganisms, but not against *E. Coli*.

I. INTRODUCTION

The genus *Salvia* L. (Lamiaceae), comprising 900 to 1,000 species, ranks as the seventh largest genus in its family. It is part of the subfamily Nepetoideae and the Chloanthi clade. This diverse group is broadly distributed across regions including Asia, Europe, Africa, Central America, and North America. Numerous species within the genus possess pharmacological properties and are widely utilized in industries such as scent, flavoring, natural ingredients, pharmaceuticals, and cosmetics industries [1-4]. *Salvia verticillata* L. is native to southeastern Europe and is particularly prevalent in regions like Turkey, Albania, and Greece, where it disperses and undergoes evolutionary adaptation and in Turkey, the rate of endemism in genus

Salvia is 50%. The genus *Salvia* L. is highly diverse, encompassing a range of growth forms including annuals, biennials, short-lived perennials, shrubs, subshrubs, chamaephytes, and even trees, allowing it to thrive in varied ecological and geographic conditions [5-9]. Species of *Salvia* L. have traditionally been valued as medicinal plants across various cultures. They have been used to treat a range of conditions, including infections, inflammation, fever, peptic ulcers, cough, diarrhea, vomiting, liver disorders, arthritis, and rheumatoid pain. Additionally, *Salvia* leaves have served as hair treatments, natural sweeteners, spices, and condiments. The genus has also been used to enhance the flavor of medications, improving their acceptance among patients. *Salvia verticillata* L., in particular, is

widely cultivated in gardens for its striking tubular flowers, aromatic leaves with mild essential oils, a delicate scent, a slightly bitter note, and its extended flowering period [10-12]. In this study; the antioxidant activities, antimicrobial effects, phenolic composition and essential oil composition of *Salvia verticillata* L. subsp. *amasiaca* grown in Hatay were determined. Specimens of *Salvia verticillata* L. subsp. *amasiaca* were obtained and identified by Dr. Yelda Güzel, a faculty member of the Biology Department of Mustafa Kemal University, from the Yayladağı region of Hatay. The antioxidant capacities were evaluated by using phosphomolybdenum method, cupric reducing antioxidant capacity (CUPRAC) and β -carotene-linoleic acid emulsion method. Results were compared against reference synthetic antioxidants (BHA, BHT).

II. MATERIAL AND METHODS

2.1. Preparation of Plant Extracts

After the plants provided in dry form were cut into small pieces with scissors, they were crushed and turned into powder. In order to perform antioxidant analyses, methanol extraction was performed on 30 g of powdered plant samples. For this, the samples were subjected to extraction in 70% methanol at 40°C for 3 hours at first. This process was repeated 3 times by filtering each time. The filtrates were combined and removed under vacuum in the evaporator at 40°C. After this process, the remaining light methanol part was taken into petri dishes in small volumes and subjected to lyophilization. Thus, the remaining methanol was completely removed at low atmospheric pressure and low temperature. The extract, which was completely dried by lyophilization, was stored at +4°C until analyzed [1].

2.2. Antioxidant Activity

2.2.1. Determination of Total Phenolic Substance Content Phosphomolybdenum Method

In addition to the Folin method, the total antioxidant capacity of the sample was also determined by the phosphomolybdenum method according to the method of Prieto et al. (1999) [13]. For this purpose, sulfuric acid, sodium phosphate, ammonium molybdate, ascorbic acid, methanol, Hitachi U.V. U1900 spectrophotometer, water bath are the chemicals and devices used. Reagent solution containing 0.6 M H_2SO_4 , 28 mM Na_3PO_4 and 4 mM $(\text{NH}_4)_6\text{Mo}_7\text{O}_{24}$ (ammonium molybdate) was prepared and 3 ml of reagent solution was added to 0.3 ml of sample at a concentration of 0.4 mg/mL. After the tubes were closed, they were incubated at 95°C for 90 minutes. The samples were cooled to room temperature and read against the control sample (0.3 ml methanol, 3 mL indicator solution)

at a wavelength of 695nm. Results are given as mg ascorbic acid equivalent/gram extract.

2.2.2. CUPRAC Method

Neocuproine (2,9-dimethyl-1,10-phenanthroline), BHT, BHA, Trolox, (SigmaAldrich), $\text{CuCl}_2 \cdot 2\text{H}_2\text{O}$, methanol, ethanol, ammonium acetate (Merck) were the chemicals used and Hitachi U.V. U-1900 spectrophotometer was used for measurements. The method was applied by making some changes in the method of Apak et al. (2006) [14]. 0.5 mL of plant extracts with a concentration of 0.0025 mg/mL were added to the tubes that were shaken and 1 mL of 10^{-2} M CuCl_2 , 1 mL of 7.5×10^{-3} M Neocuproine solution and 1 mL of 1M (pH=7) NH_4Ac buffer were added, and 0.6 mL of deionized water+trolox was added to make the total volume 4.1 mL. After the tubes were kept at room temperature for 30 minutes with their lids closed, absorbance values were measured at 450 nm. The solution prepared in the same way for all procedures but without the sample was used as a blank. Trolox solution was used as a standard at a concentration of 1.0×10^{-3} M. After a 1:1 dilution process was performed at five different concentrations, a standard curve was created. The dry matter antioxidant capacities of each plant in terms of trolox equivalent were calculated using the calculation method given below. Since the % moisture content is different in each plant, % dry matter values were taken into account in the calculation of capacity values.

$$\text{TEAC}_{(\text{mmol/g})} = \frac{\text{Absorbance} \times 4.1 \times 100 \times 100 \times 1}{1.67 \times 10^4 \times 0.5 \times 10 \times \text{Drog Weight (g)} \times \text{Dry Matter \%}}$$

2.2.3. β -Carotene-Lineolic Acid Emulsion Method

The method was performed according to the β -carotene linoleic acid emulsion system method of Kaur and Kapoor (2002) [15]. Chloroform (CHCl_3), β -carotene, linoleic acid, tween 40 (SigmaAldrich), evaporator (Buchi), water bath (JSR, Korea), Hitachi U.V. U-1900 spectrophotometer are the devices and chemical materials used in the method. First, β -carotene linoleic acid emulsion solution was prepared. For this process, 0.2 mg β -carotene was dissolved in 1 ml chloroform. 0.02 ml of 60% linoleic acid solution and 200 mg Tween 40 were added. Chloroform was completely removed in the evaporator under vacuum at 40°C. 100 ml oxygenated and dissolved in deionized water stirred vigorously. The concentration of the sample and the synthetic antioxidants BHA and BHT prepared for comparison was prepared in 70% methanol to be 1 mg/mL. 0.2 ml of each BHA and BHT solution was taken into the test tubes and 5 ml of the prepared emulsion solution was added to them. Methanol was used as the control sample. 5 ml of β -carotene linoleic acid emulsion solution was added to the tube into which 0.2 ml of methanol was taken. The absorbance of the samples in the test tubes and the control

solution was read at 470 nm (A_0). Immediately afterwards, it was left for incubation in a water bath at 50°C from this moment on, the absorbance of the solutions in the incubation was read every 15 minutes for a total of 120 minutes. Based on these absorbances, the absorbance change rate (AR) and, accordingly, the oxidation inhibition coefficients were calculated.

$$\text{Rate of absorbance change (AR)} = \frac{\ln(A_0 / A_t)}{t} \quad t = 120 \text{ minute}$$

$$\text{Oxidation prevention \%} = \frac{\text{AR}_{\text{Control}} - \text{AR}_{\text{Sample}}}{\text{AR}_{\text{Control}}} \times 100$$

2.3. Essential Oil Composition

The oil in the plant was obtained with the cleaver apparatus to be used in essential oil analysis. For this purpose, approximately 50 g of the substance was taken into a one liter flask and subjected to water vapor distillation with half the volume of water in the flask for 6 hours. The essential oil obtained at the end of distillation was taken into a vial and stored at +4°C until the analysis time. The sample was analyzed with the Thermo Scientific Focus (ISQ Single Quadrupole) brand GS-MS device. Helium gas with 99.9% purity, 1 ml/min flow range and 70 eV ionization energy was used as the carrier gas. MS transfer temperature was set as 250°C and injection temperature as 220°C. The sample was injected in 1 µl volume at 250 split range. The oven temperature was increased from 50°C to 220°C with an increase of 3°C/min. The structure of each compound was determined by comparing the mass spectra of these compounds with the data obtained using the Xcalibur software program [16].

2.4. Antimicrobial Activity

The antimicrobial activity of *Salvia verticillata* L. subsp. *amasiaca* species was determined by disk diffusion method (CLSI). In this method, the sample was increased at a concentration of 100 mg/mL and the analysis was carried out in triplicate. DMSO (dimethylsulfoxide, Merck) was used as solvent and amikacin (Oxoid, 30 µg) was used as standard antibiotic. In the analysis, four bacterial species, two Gram positive (*Staphylococcus aureus* (ATCC 29213), *Enterococcus faecalis* (ATCC 29212)), two Gram negative (*Escherichia coli* (ATCC 35218), *Pseudomonas aeruginosa* (ATCC 27853)) and one yeast (*Candida albicans* ATCC 14053)) were recorded. For

Staphylococcus aureus, *Enterococcus faecalis* Bloody medium (Biomerieux), for *Escherichia coli*, *Pseudomonas aeruginosa* EMB (Eosin-Methylene blue) medium (Biomerieux), for *Candida albicans* SDA (Sabouraud Dextrose Agar) medium (Merck) album. For antimicrobial activity studies, firstly, bacterial stocks were cultured on suitable media. After culture, plants were incubated at 37°C

for 24 hours. Then, bacterial potential was prepared according to McFarland 0.5 capacity standard and cultured on Müller Hinton medium. Three media were prepared for bacteria and 40 µl, 80 µl and 120 µl sample impregnated disks were placed on the medium. Inhibition zones formed around healthy discs against the characteristics of the sample were determined in mm. In addition, discs containing only DMSO were recorded as negative controls.

III. RESULTS AND DISCUSSION

3.1. Determination of Total Phenolic Substance Content

3.1.1. Phosphomolybdenum Method

The total phenolic substance amount of the sample was determined by the phosphomolybdenum method with both gallic acid and ascorbic acid standards. For this purpose, ascorbic acid calibration curve was drawn and the total phenolic substance amount was calculated in terms of ascorbic acid and gallic acid from these calibration graphs (Table 1).

Table.1: Total phenolic substance amount of *Salvia verticillata* L. subsp. *amasiaca*

Total Phenolic Substance Content			
Gallic acid equivalent		Ascorbic acid equivalent	
431.70 mg GAE/g extract		351.97 mg	AAE/g extract

3.2. CUPRAC Method

Trolox was used as a standard for copper ion reducing activity. Calibration graph of Trolox was drawn.

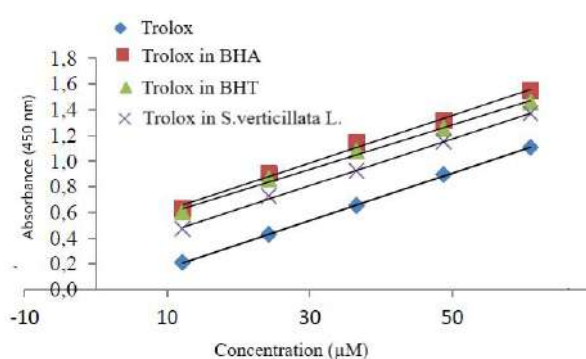


Fig.1: Comparison of antioxidant capacities of *S. verticillata* L. subsp. *amasiaca* and synthetic antioxidants.

Table.2: TEAC values of *Salvia verticillata* L. subsp. *amasiaca* and synthetic antioxidants.

Sample	TEAC (mmol/g)
BHA	0.760
BHT	0.717
<i>Salvia verticillata</i> L. subsp. <i>amasiaca</i>	0.112

High TEAC value indicates high antioxidant capacity. The values found are given in Table 2 and these values show that the synthetic antioxidant BHA has the highest reducing power.

3.3. β - Carotene-Lineolic Acid Emulsion Method

In the study, absorbance change rates and inhibition rates were determined at each time interval from the time-dependent absorbance values measured. Antioxidant activities against air and heat oxidation were determined according to the color fading in the mixtures. The higher the % inhibition values, the higher the oxidation inhibition activity. In other words, it is a strong antioxidant. At the end of this experiment, it was seen that the highest antioxidant capacity belonged to BHA, BHT and *S.verticillata* L. subsp. *amasiaca*, respectively.

Tablo.3: Absorbance change rates and % inhibition values of *Salvia verticillata* L. subsp. *amasiaca* and synthetic antioxidants

Sample	Absorbance change rate	Inhibition %
BHA	0.001252	93.35
BHT	0.001988	89.43
<i>S. verticillata</i> L. subsp. <i>amasiaca</i>	0.015744	16.35

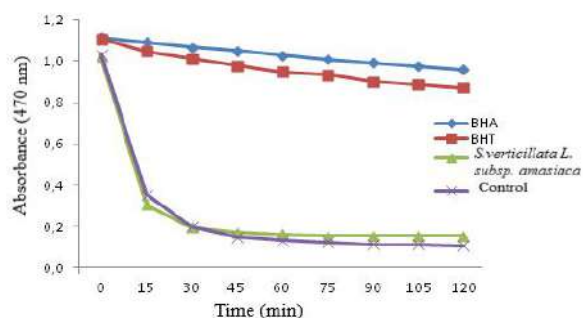


Fig.2: Change in linoleic acid peroxidation of samples with time

3.4. Analysis of Essential Oil Composition

The essential oil composition of the sample was determined by GS-MS and the chromatogram obtained for this purpose is given in Figure 3. The results of the essential oil components determined by the data obtained from this chromatogram according to retention times are given in Table 4.

Table 4: Essential oil composition of *Salvia verticillata* L. subsp. *amasiaca* species

Retention Time (min)	Retention index	Area %	Component
3.71	1033	0.54	delta-3-carene
5.24	1117	3.38	beta-pinene
5.55	1131	0.08	alpha-phellandrene
6.2	1159	0.31	sabinene
6.61	1174	0.11	alpha-myrcene
7.53	1205	0.68	dl-limonene
7.8	1216	0.18	gamma-terpinene
16.41	1460	0.89	alpha-copaene
17.64	1490	0.98	alpha-cubebene
18.64	1517	2.55	beta-bourbone
19.04	1528	7.89	alpha-gurjunene
20.7	1572	1.59	alpha-ylangene
21.36	1588	4.74	germacrene-d
21.56	1593	35.07	trans-caryophyllene
23.72	1652	0.03	junipene
24.23	1665	7.07	alpha-humulene
24.33	1668	0.86	epi-bicyclosquiphellanderene
25.02	1686	1.46	alpha-amorphene
25.7	1703	10.98	germacrene-d
25.87	1708	0.14	aromadendrene
26.61	1730	0.09	bicyclogermacrene
27.53	1756	1.75	delta-cadinene
30.18	1830	0.03	cis-calamenene
32.03	1883	0.06	cubenol
33.17	1917	0.1	butyl hydroxy
34.98	1972	5.81	caryophyllene oxide
35.86	1997	0.48	ethylchrysanthemu
36.82	2029	0.58	huuladenone
42.89	2246	0.46	beta-cadinol

46.44	2350	1.06	spathulenol
55.78	2693	5.4	myristic acid

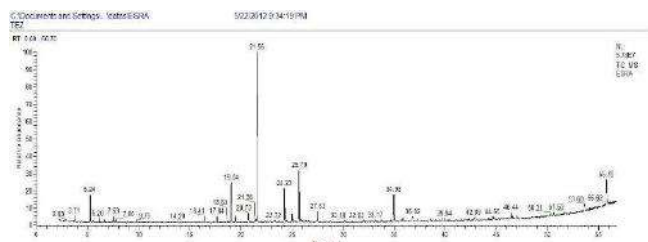


Fig.3: GS-MS chromatogram showing the essential oil composition of the sample

GS-MS analysis of *Salvia verticillata* L. subsp. *amasiaca* revealed that it had 31 different oil components and the main components were trans-caryophyllene (35.07%), germacrene-d (10.98%) and caryophyllene oxide (5.81%). Chromatograms of the components are given in Figure 3 and retention times of the components are given in Table 4 in detail.

3.5. Antimicrobial Activity Determination Method

Antimicrobial activity results The diameters of the inhibition zones formed by *Salvia verticillata* L. subsp. *amasiaca* against each microorganism were determined in Table 6: Inhibition zone diameters of the sample against microorganisms (mm).

<i>Staphylococcus aureus</i>	disk vol(μ l)	40	80	120
	Zone(mm)	24.7 $\pm$ 1.7	30.4 $\pm$ 1.5	32.6 $\pm$ 1.9
<i>Enterococcus faecalis</i>	Disk vol(μ l)	40	80	120
	Zone(mm)	21.2 $\pm$ 0.9	20.6 $\pm$ 1.3	23.6 $\pm$ 0.9
<i>Escherichia coli</i>	disk vol(μ l)	40	80	120
	Zone(mm)	-	-	-
<i>Pseudomonas aeruginosa</i>	disk vol(μ l)	40	80	120
	Zone(mm)	23.1 $\pm$ 1.1	26.4 $\pm$ 0.9	31.5 $\pm$ 2.6
<i>Candida albicans</i>	disk vol(μ l)	40	80	120
	Zone(mm)	-	-	-

(- : no zone observed)

As seen in the Table 6, *Salvia verticillata* L. subsp. *amasiaca* is seen to be effective against each bacteria at different levels. In addition, as the amount of sample impregnated on the discs increased, the diameter of the formed inhibition zone also increased. It was determined that the amount of sample and the inhibition zone diameter were directly proportional. However, it was determined that *Salvia verticillata* L. subsp. *amasiaca* was not effective against *Escherichia coli* and *Candida albicans*.

mm. The lengths of the inhibition zone diameters formed by the standard antibiotic (Amikacin 30 μ g) used in the tests against the microorganisms were also determined and are given in Table 5. It was determined in the study that DMSO did not form an inhibition zone.

Table 5: Effect of amikacin against the microorganisms used.

Microorganism	Zone Diameter (mm)
<i>Staphylococcus aureus</i>	23
<i>Enterococcus faecalis</i>	28
<i>Escherichia coli</i> (ATCC	20
<i>Pseudomonas</i>	21
<i>Candida albicans</i>	0

The inhibition zones created by the sample against bacteria in the analysis and the lengths of these zones (mm) are given in Table 6.

As a result of the analyses, the antioxidant, antimicrobial capacity, phenolic substance composition and essential oil components of *Salvia verticillata* L. subsp. *amasiaca* species, a member of the sage family, were determined. As a result of the study, it was determined that the antioxidant and antimicrobial effects of the sample were considerably strong and that it had a rich component content in terms of phenolic content and essential oil. According to the total phenolic compound method which is intended to determine

the total phenolic substance amount in the sample, the total phenolic substance amount contained in *Salvia verticillata* L. subsp. *amasiaca* species was found to be 351.94 mg AAE/g extract and 431.7 mg GAE/g extract according to the phosphomolybdenum method. Along with all other species of the *Salvia* family, it is considered a promising source of polyphenols with remarkable diversity in both chemical structure and biological activity. In previous studies on *Salvia* species, spectrophotometric determination of total phenols, phenolic acids and/or flavonoids has been frequently performed and a direct relationship has been established with antioxidant activity. The results of total phenolic substance content in terms of gallic acid and ascorbic acid also explain this [17-20]. High TEAC value obtained in the CUPRAC method indicates high reduction. Copper ion reducing capacity is higher than the sample in synthetic antioxidants. These values were found as 0.760; 0.717; 0.112 for BHA, BHT and *Salvia verticillata* L. subsp. *amasiaca*, respectively. Therefore, copper ion reducing capacity is BHA>BHT>*Salvia verticillata* L. subsp. *amasiaca*. The results obtained in β -carotene Linoleic acid emulsion system were consistent with the results of the analyses and the % inhibition value was found as BHA>BHT>*Salvia verticillata* L. subsp. *amasiaca*. Considering these data, it has been determined that *Salvia verticillata* L. subsp. *amasiaca* species can prevent the formation of damaged cells caused by free radicals and therefore can be used as an alternative to synthetic antioxidants that have carcinogenic effects in the protection of human health. The *Salvia* genus is a species rich in essential oil content. Therefore, the use of this species is widespread in cosmetics, perfumery and food industry. In this study, it was determined that *Salvia verticillata* L. subsp. *amasiaca* species had 31 different essential oil components as a result of GS-MS analysis and therefore it was concluded that it is one of the species that can be widely used in the mentioned areas. According to the data obtained as a result of the essential oil analysis of the sample, its main components were determined to be trans-caryophyllene (% 35.07), germacrene-d (% 10.98) and caryophyllene oxide (% 5.81). Antimicrobial activity analysis of *Salvia verticillata* L. subsp. *amasiaca* was studied by disk diffusion method and its effect against four bacteria and one yeast species was tested. Multiple previous studies have shown antibacterial activity of *Salvia* spp. Predominantly against Gram-positive strains, generally attributed to the rich content of polyphenolic active compounds, which supposedly mechanism of action consists in damaging the structure of the cellular membrane and its functions, consequently. A possible explanation for the poor susceptibility of the Gram-negative bacteria to various extracts and antibiotics would be the barrier formed against

lipophilic compounds, due to the lipopolysaccharides and lipoproteins present in their cellular walls [21-25]. In this study, it was understood that *Salvia verticillata* L. subsp. *amasiaca* was ineffective against the gram-negative bacteria *E. Coli*. When the results were taken into consideration, it was seen that it showed significant effect against *E. fecalis*, *S. aureus*, *P. aeruginosa* from the studied microorganisms, but it was not effective against *C. albicans* and *E. Coli*. When the analysis results were evaluated, it could be concluded that *Salvia verticillata* L. subsp. *amasiaca* could be evaluated as an alternative in the development of drugs that can be used in the treatment of diseases caused by *E. fecalis*, *S. aureus* and *P. aeruginosa*. Members of the plant genus *Salvia* have a long and rich history of use as both culinary and medicinal herbs [26-27]. *Salvia* species, perhaps one of the most well-known members of the medicinal aromatic plant family, can be used both in the kitchen and as a medicinal plant. It is clear that similar studies will be useful in revealing the medicinal aromatic properties of *Salvia* species.

Statistical Analysis

All the above-mentioned experiments were carried out in triplicates and the results are expressed as mean $\pm$ standard deviation. The differences between the obtained results were determined by the ordinary one-way ANOVA and post hoc Tukey's multiple comparisons test. Pearson's correlation coefficient was calculated to find the degree of association between the two variables. All statistical analyses were accomplished by the GraphPad Prism software (version 8.4.3) as well as Microsoft Excel. All values with $p < 0.05$ were considered statistically significant.

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Territorial management plan of Quilombo Água Fria in Calha Norte as a tool for dialogue in public policies

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Abstract— The Territorial Management Plan (PGT) of Quilombo Água Fria, located in Calha Norte, is a fundamental tool for strengthening the autonomy and territorial preservation of the quilombola community. This study investigated the implementation of the PGT as a means of dialogue in public policies, with the aim of integrating local demands into government actions. The research revealed that, although the PGT has contributed significantly to the recognition and strengthening of the community, it faces challenges, such as the lack of financial resources, inadequate infrastructure and lack of coordination between the different levels of government. The research found that the PGT is fundamental to promoting sustainability and cultural resistance, but that its effectiveness depends on active community participation and inter-institutional partnerships. The main recommendations include strengthening local governance, training leaders, access to financial resources and the integration of public policies at the local, state and federal levels. In terms of results, the implementation of the plan has brought benefits to the community in areas such as sustainable agriculture and environmental preservation, but it has also faced difficulties in implementing some actions due to the lack of financial support and institutional disarticulation. This paper proposes that the creation of monitoring committees and the strengthening of ongoing dialogue between the community and public managers are key elements in ensuring the long-term success of the PGT, making it an effective territorial management model, both for Quilombo Água Fria and for other quilombola communities in Brazil.

I. INTRODUCTION

Quilombola communities, the result of historical processes of resistance to slavery and social exclusion, have a deep connection with their territory. The territorial management of these communities has been recognized as a strategic tool to guarantee the preservation of their territorial, cultural and social rights, and is essential for strengthening their autonomy. Quilombo Água Fria, located in the Calha Norte region of Pará, is a significant example of this struggle for recognition and management of the territory, and is a paradigmatic case of how a Territorial Management Plan (PGT) can become an instrument of dialogue and the construction of public policies aimed at promoting equality and social justice.

The research problem that arises is to understand how the Territorial Management Plan of Quilombo Água Fria has functioned as a tool for dialogue between quilombola communities and the government, and what impact this process has had on the public policies implemented for the protection and sustainable development of these communities. Previous studies have shown that the lack of effective dialogue between traditional communities and the State has led to the marginalization of these populations, making it difficult to implement public policies that meet their real needs (Gomes, 2017; Almeida, 2019). In this context, the creation and implementation of a PGT can represent a significant step forward in the construction of a shared governance model, in which public policies can be more assertive and focused on local needs.

The justification for this study is the growing importance of territorial management as a tool for social inclusion and for addressing the historical inequalities experienced by quilombola communities. Quilombo Água Fria, like many other traditional communities, faces challenges related to the recognition of its territory, the preservation of its cultural practices, and the inclusion of public policies that meet its specificities. The literature indicates that the implementation of a PGT can not only guarantee the protection of the territory, but also create a space for continuous dialogue between the parties involved, favoring the construction of more appropriate and effective public policies (Lima, 2020). Thus, this study aims to contribute to the understanding of how a PGT can be used as an instrument to strengthen quilombola communities and expand social participation in political decisions.

The objectives of this article are to analyze the Quilombo Água Fria Territorial Management Plan as a tool for dialogue in public policies, identify the challenges and opportunities for its effective implementation, and evaluate the impact of this plan on strengthening local governance and preserving quilombola cultures and traditions. This

study aims to offer a contribution to the improvement of public policies aimed at quilombola communities, based on a detailed analysis of the Quilombo Água Fria PGT and its role in the process of dialogue between these communities and the State.

II. LITERATURE REVIEW

2.1 Contextualization of Quilombo Água Fria and its Importance

Quilombo Água Fria, located in the Calha Norte region of Pará, represents a significant example of traditional Brazilian communities, especially in the context of preserving cultural and territorial heritage. With a population composed of descendants of enslaved Africans, this community faces historical, social and political challenges related to the recognition of its territory and its inclusion in the State's public policies.

In terms of territorial recognition, quilombos were officially recognized by the Brazilian Constitution of 1988, which guaranteed the right to land for these communities (Brasil, 1988). The fight for this land continues to be one of the greatest battles faced by quilombolas. Territorial management therefore becomes an essential process, not only for the protection of the land, but also for strengthening the autonomy of these communities, allowing them to formulate and implement actions that meet their needs and interests.

2.2 The Concept of the Territorial Management Plan (TMP)

The Territorial Management Plan (TMP) is a tool that seeks to articulate and plan the use of the territory in a sustainable manner, respecting the cultural and environmental specificities of local communities. In the case of quilombos, the TMP is not only a matter of environmental planning, but also a strategy for community empowerment, since it promotes dialogue between traditional communities and government public policies.

The TMP of Quilombo Água Fria, as described in several studies (Silva, 2018), seeks to guarantee the permanence of the community in its traditional territory, promoting sustainable development, the protection of natural resources and cultural preservation. This planning involves both the use of environmental management techniques and the construction of public policies that favor the education, health and well-being of the community.

2.3 The Importance of Dialogue in Public Policies for Quilombola Communities

Dialogue between the government and quilombola communities is a fundamental aspect for the formulation of

inclusive and effective public policies. The participatory management model, in which communities have an active voice in defining their own needs, is considered one of the best practices for implementing public policies in quilombola territories (Almeida, 2019).

The literature on governance and public policies for traditional communities shows that the implementation of a PGT can be an effective means of establishing this dialogue, promoting the active participation of quilombolas in the construction of public policies aimed at education, health, security and sustainable development (Lima, 2020). The involvement of communities in the territorial management process not only strengthens their autonomy, but also ensures that public policies are more appropriate to the local reality.

2.4 Challenges in Implementing Territorial Management Plans in Quilombola Communities

Despite advances in public policies aimed at quilombola communities, the implementation of PGTs still faces a series of challenges. The lack of financial resources, the absence of adequate training for management, and resistance from government and private interests continue to be obstacles to the effective implementation of these plans (Gomes, 2017).

In addition, bureaucracy itself and the complexity of legal and administrative processes often hinder the recognition and effective implementation of territorial management plans (Costa, 2018). In the case of Quilombo Água Fria, these challenges manifest themselves in the difficulty of obtaining the institutional support necessary for the implementation of the PGT, as well as in the pressure from external groups on the territory, which seek to exploit the region's natural resources in an unsustainable manner.

2.5 The Impact of Land Management Plans on Quilombola Communities

Studies indicate that the implementation of PGTs has brought significant benefits to quilombola communities, especially with regard to the preservation of their lands and the improvement of the quality of life of the members of these communities. The preservation of the environment and the promotion of sustainable land use practices are essential components of these initiatives, and have allowed the recovery of degraded areas and the protection of local biodiversity (Souza, 2020).

In addition, the PGT has also contributed to the strengthening of community institutions, promoting greater social cohesion and autonomy in decisions about land use. The participation of communities in the planning processes has been a decisive factor in the success of these initiatives,

as it ensures that the solutions adopted are truly suited to local needs.

2.6 Examples of Land Management Plans in Other Quilombola Communities

Several PGT studies and projects have been successfully implemented in other quilombola communities in Brazil. The PGT of the Quilombo do Rio dos Macacos, in Bahia, for example, was one of the first to be recognized by the government, and brought significant benefits to the preservation of its lands and the strengthening of cultural practices (Santos, 2018). Similarly, the PGT of the Quilombo de Ivaoporunduva, in São Paulo, demonstrated how territorial management can improve the quality of life of the community, providing sustainable management of natural resources and guaranteeing land rights.

These examples serve as a reference for Quilombo Água Fria, which seeks to adapt the successful practices of these projects to its local reality, promoting dialogue and collaboration between the community and different levels of government.

III. METHODOLOGY

3.1 Type of Research

The research is qualitative and exploratory in nature, with the objective of understanding the social, political and territorial aspects of Quilombo Água Fria. Qualitative research allows for a more in-depth analysis of the relationships and processes involving quilombola communities, their experiences and the impact of the Territorial Management Plan on the daily life of the community and on the dialogue with public policies.

According to Gil (2017), qualitative research is characterized by the search for a deeper understanding of the phenomena studied, without initially worrying about quantifying the data. This approach is ideal for investigating social processes, such as the implementation of a territorial management plan in traditional communities.

3.2 Methodological Approach

The methodological approach adopted for this research is a case study, with a specific focus on Quilombo Água Fria. The case study is a methodological strategy that allows for a detailed analysis of a phenomenon within its real context, as pointed out by Yin (2015). In this case, the case study is used to understand the dynamics of territorial management and its interface with public policies, allowing us to identify the unique characteristics of Quilombo Água Fria, its challenges and opportunities for integration into public policies.

3.4 Data Collection Strategies

The following strategies were used to collect data:

Documentary Research: Documentary research is one of the main sources of data for this research. It consists of analyzing documents related to the Quilombo Água Fria Territorial Management Plan, including reports, meeting minutes, action plans and other official publications. These documents provide important information about the decisions taken, the negotiation processes and the impacts of the plan on the community.

Documentary research is recommended by Marconi and Lakatos (2017), as it offers an effective way to access historical and contextual information about the object of study.

Qualitative Interviews: To complement the documentary research, semi-structured interviews were conducted with members of the Quilombola community, representatives of the government, non-governmental organizations (NGOs) and other actors involved in the territorial management process. The interviews allow for a more in-depth view of the perceptions and experiences of those directly involved in the implementation and negotiations of the plan.

The interviews were conducted based on a flexible script, allowing participants to express their opinions and experiences freely. According to Minayo (2014), the semi-structured interview offers the necessary flexibility to explore emerging themes and better understand the meanings attributed by participants to their experiences.

Participant Observation: Participant observation was conducted during meetings and events related to the territorial management plan in Quilombo Água Fria. The researcher had the opportunity to directly observe the interactions between the community and different stakeholders, such as government representatives and external organizations.

Participant observation is a technique widely used in qualitative research, according to Bogdan and Biklen (1994), allowing the researcher to immerse themselves in the context and obtain data in real time, in addition to observing aspects that are often not expressed verbally.

3.4 Population and Sample

The target population of this research consists of members of the Água Fria quilombola community, as well as governmental and non-governmental institutions involved in public policies aimed at quilombos in the Calha Norte region. The sample was selected based on criteria of representativeness and relevance to the topic, aiming to ensure that different perspectives were considered.

The sample of interviewees was defined intentionally, focusing on individuals directly involved in decisions about

territorial management, including community leaders, representatives of social organizations, environmental technicians and public managers. According to Sampieri et al. (2013), intentional sampling is appropriate when one wants to obtain specific and in-depth information about a particular phenomenon or group.

3.5 Data Analysis Techniques

Data analysis was performed using content analysis. Content analysis allows qualitative data to be interpreted systematically and rigorously, identifying recurring categories and themes in interviews, documents, and observation records. The technique is well-established in qualitative research, according to Bardin (2011), and was applied to extract meanings and patterns from the information collected.

The analysis was divided into three stages:

Pre-analysis: In this stage, the collected material was organized and categorized, with a cursory reading of documents and interview transcripts.

Exploring the Material: A more detailed reading of the content was carried out, identifying keywords, expressions, and key concepts related to territorial management and dialogue with public policies.

Processing the Results: In the last stage, the identified categories were analyzed in light of the existing literature on territorial management in quilombola communities and the impact of public policies on these communities.

3.6 Ethical Considerations

The research complied with the ethical principles defined by Resolution No. 466/12 of the National Health Council (CNS), which regulates research involving human beings in Brazil. All participants were informed about the objectives of the research, the procedures adopted, and their rights, including the right to confidentiality and anonymity.

In addition, free and informed consent was granted to all participants in the interviews and participant observation. The personal data of the interviewees were kept confidential and used exclusively for the purposes of this research.

3.7 Limitations of the Study

This study is subject to some limitations, which should be taken into account when interpreting the results. The main limitation is related to the difficulty in accessing some documents and information due to the lack of complete records on the process of implementing the PGT in Quilombo Água Fria. In addition, the geographic limitation of the research may restrict the generalization of the results to other quilombola communities in different contexts.

IV. RESULTS AND DISCUSSION

The analysis of data collected through interviews, observations and document analysis on the Territorial Management Plan (PGT) of Quilombo Água Fria reveals important information about the community's perception of the plan, its effectiveness as a tool for dialogue in public policies and the challenges that arise in the implementation of its actions. The objective of this section is to present and discuss the results obtained, relating them to the theoretical framework presented in the previous chapters.

The interviews conducted with members of the quilombola community, together with the analysis of documents and field observations, allowed us to identify central elements that characterize the interactions between the PGT and public policies aimed at traditional communities. Below, we present the detailed analysis of the results.

4.1 Characteristics of the Territorial Management Plan of Quilombo Água Fria

The documents analyzed on the Territorial Management Plan (PGT) indicate a clear intention to integrate Quilombo Água Fria into public policies, while preserving and strengthening local culture and practices. However, the implementation of the plan presents challenges related to the lack of infrastructure, financial difficulties and a lack of ongoing commitment from the local and federal governments. Below, we highlight the main findings of this analysis.

Planning Documents: The PGT of Quilombo Água Fria is based on an accurate diagnosis of the region, highlighting the importance of sustainability and environmental preservation as pillars of the plan. The main actions foreseen in the plan include sustainable agriculture, the preservation of areas of collective use, such as rivers and forests, and the appreciation of the cultural heritage of the quilombola community.

According to Santos et al. (2018), territorial management plans must reflect the interests of local communities, but also ensure their integration with national public policies. This aspect is important, since public policies often do not consider the cultural and social specificities of quilombola communities, making it difficult to implement the PGT proposals.

4.2 Community Perceptions of the PGT

The analysis of the interviews revealed two main perspectives on the PGT: a positive one, which sees the plan as an opportunity for strengthening and providing visibility for the community, and a more skeptical one, which questions the effectiveness of the actions due to the lack of government monitoring.

Positive View: Many community members highlighted the participatory process in the elaboration of the PGT as a positive factor. The presence of the community in the diagnosis and in the construction of the plan increased the feeling of belonging and autonomy. In the words of one of the interviewees: "The plan gave us a voice to talk about our needs and desires, which never happened before" (Interviewee 4, 2021). In addition, they highlighted that the plan would help preserve the territory, combating external pressures for the exploitation of natural resources and defending the self-sustainability of the community.

Skeptical View: On the other hand, other interviewees expressed concerns about the lack of financial resources and the absence of concrete actions. One of the interviewees stated: "The plan is there, but we have not seen any significant changes so far. We continue to depend on the government's promises" (Interviewee 7, 2021). This distrust is fueled by the lack of ongoing commitment from public agents, which compromises the effectiveness of the plan.

4.3 Challenges in Implementing the PGT

The main challenges reported by community members, local managers and other stakeholders involve issues related to the lack of financial resources, lack of structure to implement actions and the fragmentation of public policies. Below, we will detail some of these challenges:

Financial resources: The implementation of a plan like that of Quilombo Água Fria requires significant investments in infrastructure, training and monitoring of actions. However, financing the plan depends on public and private partnerships, which have not yet been effectively implemented. According to Silva and Almeida (2020), the main limitation to the implementation of territorial plans in quilombola communities is the scarcity of financial resources and the complexity of the bureaucracy involved.

Disconnection between different levels of government: The lack of coordination between federal, state and municipal governments hinders the implementation of integrated and effective public policies. Several community members and managers expressed that support from local government, although positive, is sporadic and poorly structured. As stated by Pereira (2019), the effectiveness of public policies depends on effective coordination between government spheres, which does not always occur in quilombola communities.

4.4 Dialogue with Public Policies: Challenges and Opportunities

Although the PGT was developed with community participation, it still faces obstacles to being effectively integrated into public policies for environmental management and traditional territories. However, there are

also opportunities for improvement, especially through strengthening ongoing dialogue between public managers and the quilombola community.

Strengthening dialogue: The research revealed that communication between the different actors involved in implementing the PGT needs to be improved. Although there are channels for dialogue, such as regular meetings and meetings with local managers, many community members indicated that these spaces are still insufficient and do not guarantee effective monitoring of the proposed actions.

Opportunities for more integrated public policies: The PGT of Quilombo Água Fria has the potential to be an effective tool for dialogue with public policies if permanent structures for dialogue are created and if governments invest more in training and monitoring of actions. As argued by Costa and Souza (2018), the key to the success of territorial plans such as that of Quilombo Água Fria lies in strengthening partnerships and creating support networks to ensure the continuity of actions.

4.5 Implications for Public Policies and Conclusions

The research showed that the Territorial Management Plan can be a powerful tool for strengthening the autonomy of quilombola communities and integrating local and national public policies. However, its effective implementation depends on the guarantee of resources, coordination between levels of government and the creation of permanent dialogue structures.

In addition, the plan has the potential to be a tool for resistance against external pressures and for promoting sustainability. However, the effectiveness of the plan will be directly related to the commitment of the government and the ability of the community to organize itself and demand the implementation of the planned actions.

V. CONCLUSION

The development and implementation of a Territorial Management Plan (TMP) in Quilombo Água Fria has proven to be an important strategy for preserving the territory and strengthening the autonomy of the quilombola community. This study investigated the role of the TMP as a tool for dialogue in public policies aimed at traditional communities, with the aim of analyzing how it can contribute to greater integration between local needs and government actions.

Based on the interviews conducted, documentary analysis and field observations, it was possible to verify both the progress and the challenges associated with the implementation of the plan. The main conclusions of this research will be presented below, followed by proposals,

recommendations and suggestions for strengthening the TMP as an instrument for ongoing dialogue and effectiveness in public policies.

The research revealed that the TMP of Quilombo Água Fria is a significant step towards the recognition and strengthening of the community, but faces fundamental challenges that prevent its full implementation and effectiveness.

Community Engagement: The active participation of the quilombola community in the development of the PGT was essential for the actions to be developed in a manner aligned with their needs. However, the continuity of this participation in the implementation and monitoring phases is a critical point, which needs to be guaranteed through participatory governance mechanisms.

Implementation Challenges: The main obstacle encountered to the effectiveness of the PGT was the lack of financial resources and inadequate infrastructure to support the planned actions. The difficulty in accessing public and private resources is also a significant barrier. In addition, the lack of coordination between the different levels of government weakened the implementation of integrated policies and the implementation of the plan's actions.

The Importance of Interinstitutional Dialogue: The PGT, although it has the potential to integrate public policies and local practices, still lacks a more robust structure to ensure continuous dialogue between public managers and the quilombola community. Strengthening interinstitutional partnerships between governments, NGOs, and other social entities is essential to overcome financial and operational limitations.

Potential and Opportunities: Despite the challenges, the PGT has also proven to be a valuable tool for promoting sustainability and cultural resilience in the community. Actions aimed at sustainable agriculture, environmental preservation and strengthening cultural heritage have great potential to ensure the self-sufficiency of the community and its social and economic well-being.

Based on the above conclusions, some proposals and recommendations are presented with the aim of strengthening the implementation of the PGT and ensuring its sustainability as a tool for dialogue in public policies:

Strengthening Local Governance: It is essential that the quilombola community continues to actively participate in the management of the plan. To this end, it is recommended that monitoring committees be created, made up of community members and government representatives. These committees should be responsible for monitoring the actions of the PGT and for the continuous evaluation of the results, in a transparent and participatory manner.

Access to Public and Private Resources: To ensure the effectiveness of the PGT, it is essential that the federal, state and municipal governments provide specific financial resources for the implementation of projects linked to the plan. In addition, partnerships with the private sector and non-governmental organizations (NGOs) should be encouraged, aiming to increase the capacity to execute the planned actions.

Training and Education of Local Leaders: Training community members for territorial management is one of the most important actions. Training programs in environmental management, sustainability and public policies should be implemented, with the aim of strengthening the autonomy and technical capacity of local leaders.

Integration of Public Policies: The PGT should be integrated with broader public policies on territorial management, the environment and sustainable development. This implies creating inter-institutional support structures that promote effective coordination between the various government agencies and ensure compliance with the goals established in the plan.

Monitoring and Evaluation of Results: For the PGT to be successful, it is essential to implement a system for monitoring and evaluating results that allows for continuous adjustments to the plan in response to challenges and changes in local conditions and public policies. The use of impact indicators related to environmental, social and economic sustainability should be a priority.

Although this research has provided valuable insights into the Quilombo Água Fria Territorial Management Plan, further studies are needed to further analyze the following:

Long-Term Impacts: Studies that assess the long-term impacts of the PGT on improving the living conditions of the quilombola community, strengthening its cultural identity, and sustaining natural resources are essential.

Territorial Management Models in Other Quilombos: Comparing the territorial management model of Quilombo Água Fria with other quilombos in the region and elsewhere in Brazil can provide insights into best practices and the most effective implementation strategies.

Relationship with Federal and State Public Policies: Research on the relationship of the PGT with broader public policies on environmental management and traditional territories is also recommended, with the aim of improving integration between local and national public policies.

The Quilombo Água Fria Territorial Management Plan is a strategic tool for strengthening the quilombola community, promoting environmental sustainability, cultural strengthening and territorial autonomy. However,

its implementation depends on ongoing collaboration between the community, public administrators and external entities. By overcoming financial and infrastructure barriers, and by promoting ongoing and constructive dialogue, the PGT can become a successful model for other traditional communities in Brazil.

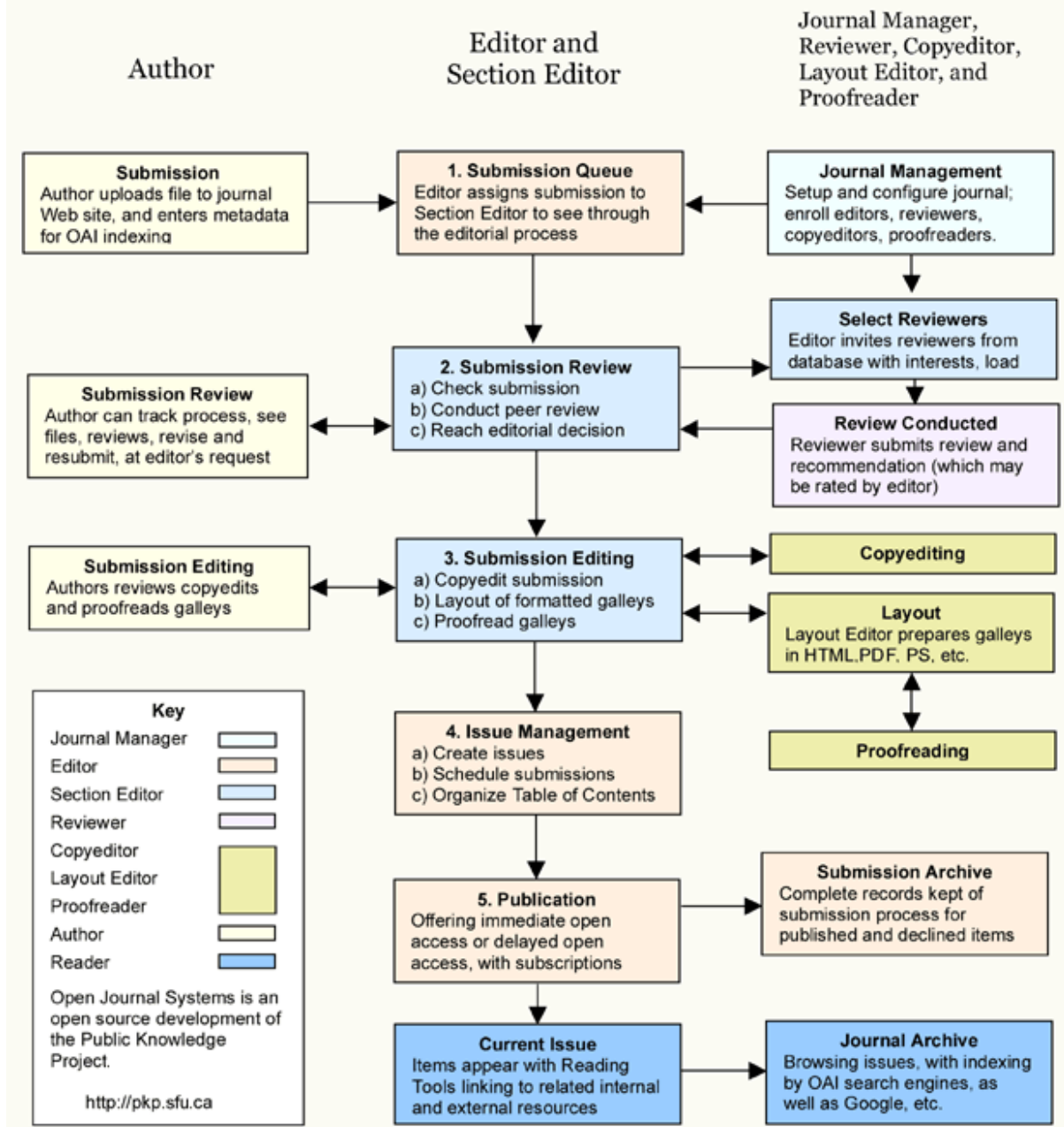
Inter-institutional dialogue and government commitment are essential to ensure that the Territorial Management Plan is not just a project, but a continuous and effective practice, capable of transforming the living conditions of Quilombo Água Fria and strengthening public policies aimed at the quilombola population and other traditional communities.

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