Application of Neuro-Fuzzy to the elephant grass production process: A systematic bibliographic review

Aplicação da Neuro-Fuzzy a quantificação química do capim-elefante: Uma revisão bibliográfica sistemática

Aplicación de *Neuro-Fuzzy* al proceso de producción de pasto elefante: Una revisión bibliográfica sistemática

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Abstract

The transition to renewable energy sources can help combat climate change, as they emit fewer greenhouse gas emissions. Biomass is an important source of energy production, being composed of organic materials, such as residues from agricultural and forestry crops, among others, with emphasis on elephant grass. The application of Neuro-Fuzzy in production processes, especially laboratory ones, is of utmost importance, as it allows the creation of more accurate and efficient prediction and control models in the bioenergetic context. Given this context, the objective of this article is to identify how the state of knowledge is configured regarding the application of the use of Neuro-Fuzzy for the chemical quantification process of elephant grass cellulose. A Systematic Bibliographic Review was carried out to search and map published scientific data to identify numerous applications for the use of Neuro-Fuzzy, mainly in renewable energy. By carrying out the research using the Systemic Bibliographic Review, it was possible to identify several opportunities for the application of Neuro-Fuzzy in the chemical quantification of elephant grass. However, it was observed that this article presents a novelty on the application of the use of Neuro-Fuzzy for the process of chemical quantification of cellulose, in addition to the production of bioethanol from this biomass. Of the 22 documents analyzed in this research, 100% were articles in the form of applied research and literature review, demonstrating great relevance in this line of research, which is the application of Artificial Intelligence in field and laboratory production processes using elephant grass. as biomass to produce bioethanol.

Keywords: Rural sustainability; Biomass; Cellulose; *Pennisetum purpureum*.

Resumo

A transição para fontes de energias renováveis podem ajudar a combater as mudanças climáticas, pois emitem menos emissões de gases de efeito estufa. A biomassa é um fonte importante de produção de energia, sendo composta por materiais orgânicos, como restos de culturas agrícolas, florestais dentre outros, com destaque o capim-elefante. A aplicação da Neuro-Fuzzy nos processos produtivos, principalmente laboratoriais é de suma importância, pois permite a criação de modelos de previsão e controle mais precisos e eficientes no context bioenergético. Diante desse contexto, o objetivo desse artigo é identificar como está configurado o estado do conhecimento sobre a aplicação do uso da Neuro-Fuzzy para o processo de quantificação química da celulose do capim-elefante. Foi realizado uma Revisão Bibliográfica Sistemática para busca e mapeamento de dados científicos publicados para identificar inumeras aplicações do uso da Neuro-Fuzzy principalmente nas energias renováveis. Com a realização da pesquisa utilizando a Revisão Bibliográfica Sistêmica, foi possível identificar diversas oportunidades da aplicação da Neuro-Fuzzy na quantificação química do capim-elefante. Entretanto, foi observado que esse artigo apresenta um ineditismo sobre a aplicação do uso da Neuro-Fuzzy para o processo de quantificação química da celulose, além da produção do bioethanol desta biomassa. Dos 22 documentos analisados nesta pesquisa, 100% foram de artigos em forma de pesquisa aplicada e de revisão de literatura, demonstrando uma grande relevância nesta linha de pesquisa que é a

aplicação da Inteligência Artificial em processos produtivos de campo e laboratorial utilizando o capim-elefante como biomassa para a produção de bioetanol.
Palavras-chave: Sustentabilidade rural; Biomassa; Celulose; *Pennisetum purpureum*.

Resumen
La transición a fuentes de energía renovables puede ayudar a combatir el cambio climático, ya que emiten menos emisiones de gases de efecto invernadero. La biomasa es una fuente importante de producción de energía, al estar compuesta por materiales orgánicos, como residuos de cultivos agrícolas y forestales, entre otros, con énfasis en el pasto elefante. La aplicación de Neuro-Fuzzy en procesos productivos, especialmente de laboratorio, es de suma importancia, ya que permite crear modelos de predicción y control más precisos y eficientes en el contexto bioenergético. Dado este contexto, el objetivo de este artículo es identificar cómo se configura el estado del conocimiento respecto de la aplicación del uso de Neuro-Fuzzy para el proceso de cuantificación química de la celulosa de pasto elefante. Se realizó una Revisión Bibliográfica Sistemática para buscar y mapear datos científicos publicados para identificar numerosas aplicaciones del uso de Neuro-Fuzzy, principalmente en energías renovables. Al realizar la investigación utilizando la Revisión Bibliográfica Sistémica, fue posible identificar varias oportunidades para la aplicación de Neuro-Fuzzy en la cuantificación química de la hierba elefante. Sin embargo, se observó que este artículo presenta una novedad sobre la aplicación del uso de Neuro-Fuzzy para el proceso de cuantificación química de celulosa, además de la producción de bioetanol a partir de esta biomasa. De los 22 documentos analizados en esta investigación, el 100% fueron artículos en forma de investigación aplicada y revisión de literatura, demostrando gran relevancia en esta línea de investigación que es la aplicación de la Inteligencia Artificial en procesos productivos de campo y laboratorio utilizando pasto elefante. biomasa para la producción de bioetanol.
Palabras clave: Sostenibilidad rural; Biomasa; Celulosa; *Pennisetum purpureum*.

1. Introduction

Biomass is, in fact, an important source of energy production, and it is composed of organic materials, such as harvest residues in agriculture, forest residues, wood residues and other organic materials (Milward-Hopkins & Purnell, 2019). When these materials are burned, the thermic energy generated can be used to generate electricity or heat. Furthermore, biomass is considered a renewable energy source as it can be produced continuously through agriculture and forestry (Tenorio et al., 2015).

An emphasis biomass is the elephant grass, one of the most used plants in energy production in Brazil (kullavanijaya & Chavalparit, 2020). This is due to the fact that it is an evergreen grass, with a high productivity and resistance to adverse weather conditions (Doknua et al., 2020).

Above the matter of using this biomass as a source of energy for electrical production, it stands out in the production of fuel, fermenting the biomass, resulting in a "second generation ethanol[1]", in other words, briefly, elephant grass is an important source of renewable energy in Brazil, that possesses diverse applications in generating electricity and replacing fossil fuels.

Knowing the production process of the elephant grass is important for several reasons. First, it allows producers to obtain better income, by ensuring that production is more efficient and profitable (Macêdo et. al, 2019). Besides, it allows producers to identify and correct that may arise during the production, and so, ensuring the quality of the final product.

The application of Neuro-Fuzzy in production processes is important because it allows the creation of more accurate and businesslike prediction and control models (Yadav et al, 2022). Neuro-Fuzzy is a technique that combines the advantages of fuzzy logic and neural networks, allowing the use of inaccurate or incomplete data for decision making (Singh & Bharadvaja, 2021). Therefore makes it possible to obtain more reliable results and reduce prodoction cost, and also improving the quality of products and services offered to customers (Godoy et al., 2020). The applience of neuro-fuzzy has been increasingly common in various sectors, such automobile, food and pharmaceutical industries (Olatunji et al., 2022).

[1] The second Generation etanol, also known as cellulosic etanol, is produced from non-food raw materials such as agriculture croop residues, wood and Other biomass sources. Unlike the first-generation etanol, which is produced from food raw materials such as corn and sugar cane, the second-generation etanol is a more sustainable and environmentally friendly alternative. Furthermore, the cellulosic etanol production process is more complex and requires more advanced Technologies than the conventional etanol production process.

Given this context, the goal of this article is to identify how the state of knowledge is configured regarding the application of the neuro-fuzzy technique for the chemical quantification process of elephant grass cellulose.

2. Material and Methods

Considering the presented problem of the research about “application of the use of Neuro-fuzzy for the chemical quantification process of the elephant grass cellulose”, which, as indicated by (Olatunji et al., 2022) this interrogative enunciation argues about the importance of the artificial intelligence application of Neuro-Fuzzy in the production process of an important biomass for the renewable energy sector. There for, according to guidelines from the same authors, it was constructed an hypothesis that is possible to optimize the production process from planting to chemical quantification of the biomass using the existent data in a bibliographical review form as being the true “productive factor” of the research.

The adopted research technique for this article, which according to (Bandeira et al., 2019), was the one of prospecting documents based on scientific papers. The technique described in his research seems to be related to critical data analysis; this approach involves the author’s ability to separate relevant information from trivial data, using organized notes and rigorous methods to validate his observations. The critical data analysis is an important ability in various areas, including academic research, journalism and business analysis. It is a technique that demands attention to detail and critical thinking to ensure that the conclusions are accurate and reliable (Fernandes et al., 2016).

Thereby, due to these authors’ considerations (Conforto et al., 2011), it was adopted the Systematic Bibliographic Review (SBR) as the methodological basis for carrying out the present study. RBS is an important technique for scientific research, as it allows the studies already carried out on a given topic identification and critical analysis, making possible a gap identification in the knowledge and formulation knew research hypotheses (Godinho et al., 2021).

To accord the objective of this article, an SBR was used, adopting the method developed by (Conforto et al., 2011), which is composed of three phases: Input, processing, and output.

The input phase of a research accomplished due to SBR is defined by the problem to be investigated, where objectives, criteria for inclusion and exclusion of documents in the study and, mainly the creation of search strings are established. In the processing phase, searches and initial selection of documents are achieved through reading and analysis. Finally, in the output phase, documents are registered and downloaded to facilitate analysis and processing, allowing the elaboration of a synthesis of the results obtained.

2.1 Input

The problem that this research seeks to answer is: how is the state of knowledge configured regarding the application of the use of neuro-fuzzy for the chemical quantification process of elephant grass cellulose?

Therefore, the present objective of the SBR is the identification of the state of knowledge of the tools for applying Neuro – fuzzy in a chemical quantification process of cellulose in elephant grass.

The databases were chosen according to their relevance in the study area, being: *ScienceDirect, Web of Science, Scielo and SpringerLink.*

After an initial uplift of keywords and, the creation of search Strings, a total of 11 Strings were confined for the first exploratory search, presented in Chart 1, research carried out on August 15, 2023.

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Chart 1 - Definitions tests for Search Strings.

Id	*Strings*	ScienceDirect	Scielo	SpringerLink
1	(Agriculture)	1.230.000	6.816	563.335
2	(Elephant grass)	6.822	377	3.083
3	(*Pennisetum purpureum*)	2.110	625	1.395
5	(Biofuels)	102.959	424	32.269
6	(Pretreatments)	604.687	981	174.730
7	(Sodium hidroxide)	80	244	19
9	(Cellulose)	546.226	727	20.222
10	(Lignocellulosic biomass)	47.290	3.369	253.633
11	(*Neuro-Fuzzy*)	19.780	79	9.243
	Total	**2.559.954**	**13.642**	**1.057.929**

Source: Authors.

The search Strings were elaborated in terms of interest, where were performed initial testes for the best qualifying string witch would better attend the search goals, as can be seen in Chart 1, being the elected strings: (Agriculture) AND ((elephant grass) OR (*Pennisetum purpureum*)) AND (second generation ethanol); (Agriculture) AND ((elephant grass) OR (*Pennisetum purpureum*)) AND ((biofuels) OR (pretreatments) OR (Sodium hidroxide)); (Agriculture) AND ((elephant grass) OR (*Pennisetum purpureum*)) AND ((Cellulose) OR (Lignocellulosic biomass)) e (Agriculture) AND ((elephant grass) OR (*Pennisetum purpureum*)) AND (*Neuro-Fuzzy*), presented in Chart 2, research carried out on August 15, 2023.

Chart 2 - Definitions tests for Search Strings.

Search Strings	ScienceDirect	Scielo	SpringerLink
(Agriculture) AND ((elephant grass) OR (*Pennisetum purpureum*)) AND ((biofuels) OR (pretreatments) OR (Sodium hidroxide))	958	0	208
(Agriculture) AND ((elephant grass) OR (*Pennisetum purpureum*)) AND ((Cellulose) OR (Lignocellulosic biomass))	1268	0	271
(Agriculture) AND ((elephant grass) OR (*Pennisetum purpureum*)) AND (biofuels) AND (*Neuro-Fuzzy*)	7	0	0
(Agriculture) AND ((elephant grass) OR (*Pennisetum purpureum*)) AND ((biofuels) OR (pretreatments) OR (Sodium hidroxide)) AND ((Cellulose) OR (Lignocellulosic biomass))	748	0	132
(Agriculture) AND ((elephant grass) OR (*Pennisetum purpureum*)) AND ((biofuels) OR (pretreatments) OR (Sodium hidroxide)) AND (*Neuro-Fuzzy*)	8	0	1
(Agriculture) AND ((elephant grass) OR (*Pennisetum purpureum*)) AND ((Cellulosic) OR (Lignocellulosic biomass)) AND (*Neuro-Fuzzy*)	8	0	1
Total	2997	0	613

Source: Authors.

This Chart 2, displays the Strings that were listed for the search and the formation of filter phrases with the appropriate connectors so that the software can scan the network and the respective databases of scientific bases, presenting the results obtained from each of the filters.

Initioally, it was decided to delimit the Search into three filters: Filter 1 – Reject all types of documents, except completed articles and reviewed articles, both published in scientific journals; Filter 2 – Reject all documents that were not in the language of interest (Portuguese or English) and, Filter 3 – Delimited time period (2000 – 2020 – twenty Years).

Chart 3 shows the number of articles including the mentioned filters.

Chart 3 - Definitions tests for Search Strings.

Search Strings	**ScienceDirect**	**Scielo**	**SpringerLink**
(Agriculture) AND ((elephant grass) OR (*Pennisetum purpureum*)) AND ((biofuels) OR (pretreatments) OR (Sodium hidroxide))	336	0	109
(Agriculture) AND ((elephant grass) OR (*Pennisetum purpureum*)) AND ((Cellulose) OR (Lignocellulosic biomass))	416	0	143
(Agriculture) AND ((elephant grass) OR (*Pennisetum purpureum*)) AND (biofuels) AND (*Neuro-Fuzzy*)	1	0	0
(Agriculture) AND ((elephant grass) OR (*Pennisetum purpureum*)) AND ((biofuels) OR (pretreatments) OR (Sodium hidroxide)) AND ((Cellulose) OR (Lignocellulosic biomass))	282	0	86
(Agriculture) AND ((elephant grass) OR (*Pennisetum purpureum*)) AND ((biofuels) OR (pretreatments) OR (Sodium hidroxide)) AND (*Neuro-Fuzzy*)	2	0	0
(Agriculture) AND ((elephant grass) OR (*Pennisetum purpureum*)) AND ((Cellulosic) OR (Lignocellulosic biomass)) AND (*Neuro-Fuzzy*)	2	0	0
Total	1039	0	338

Source: Authors.

As it can be seen in Chart 3, the number of articles in the Science Direct and Springer Link databases were higher than expected. Therewith, a three-dimensional correlation of main keywords originating from the theme was created again, being agriculture, Elephant grass and Pennisetum purpureum with the other Strings, as shown in Chart 4.

Chart 4 - Definitions tests for Search Strings.

Search Strings	**ScienceDirect**	**Scielo**	**SpringerLink**
(Agriculture) AND ((elephant grass) OR (*Pennisetum purpureum*)) AND ((biofuels) OR (pretreatments) OR (Sodium hidroxide)) AND ((Cellulose) OR (Lignocellulosic biomass))	286	0	86
(Agriculture) AND ((elephant grass) OR (*Pennisetum purpureum*)) AND ((biofuels) OR (pretreatments) OR (Sodium hidroxide)) AND ((Cellulose) OR (Lignocellulosic biomass)) AND (*Neuro-Fuzzy*)	2	0	1
Total	288	0	87

Source: Authors.

3. Results and Discussion

3.1 Processing

With the documents previously selected, and based on initial phasel criteria (Input), the processing stage began, in which 375 documents were exported from the databases and imported into the Mendeley® management software, being: 288 documents from Science Direct, 0 from Scielo and 87 from SpringerLink.

In sequence, 5 more filters were applied: filter 1 – duplicates indentified by Mendeley®, filter 2 – duplicates identified manually, filter 3 – the ones rejected in the simple textual analysis, filter 4 – unavailable for full access and filter 5 – rejected in the detailed textual analysis, as shown in Chart 5.

At last, after all the analyzes carried out and with the applications of the established filters, the scientific basses (ScienceDirect, Scielo and SpringerLink) resulted in 11; 0 and 11 articles would be respectively analyzed for the research.

Chart 5 - Definitions tests for Search Strings.

Search Strings	**ScienceDirect**	**Scielo**	**SpringerLink**
(Agriculture) AND ((elephant grass) OR (*Pennisetum purpureum*)) AND ((biofuels) OR (pretreatments) OR (Sodium hidroxide)) AND ((Cellulose) OR (Lignocellulosic biomass)) AND (*Neuro-Fuzzy*)	11	0	11
Total	11	0	11

Source: Authors.

3.2 Output

The 22 documents were then dowloaded as listed in Chart 6, all of witch were read in full and charted in order to present the results obtained.

Chart 6 - Definitions tests for search Strings.

id	Author	Title	Contribution
1	(Saleem et al., 2021)	*Adaptive recurrent NeuroFuzzy control for power system stability in smart cities*	The article proposes an adaptive Neuro-Fuzzy recurrent wavelet control for smart cities that uses the recurrent Gaussian membership function and the recurrent wavelet neural network in the antecedent and consequent parts, respectively.
2	(Heddam et al., 2012)	*ANFIS-based modelling for coagulant dosage in drinking water treatment plant: a case study*	In this article, a Neuro-Fuzzy Inference System (ANFIS) was developed and used to model coagulante dosage at the drinking water treatment plant in Boudouaou, Algeria.
3	(Palacio, 2020)	*Application of Neuro-Fuzzy systems in the classification of reports in scheduling problems Introducción*	In this work, an application of Neuro-Fuzzy systems was proposed to classify reports in scheduling problems, a necessary step to identify in which resource the report will be processed, to build the sequence or work schedule for the day.
4	(Adelekan et al., 2022)	*Artificial intelligence models for refrigeration, air conditioning and heat pump systems*	This review discusses existing topographies of neural network models for modeling RHVAC systems, power and fault prediction, and detention and diagnosis.
5	(Yadav et al., 2022)	*Comparative study of ANFIS fuzzy logic and neural network scheduling based load frequency control for two-area hydro thermal system*	This article mainly focuses on technical issues in structured power systems related to load frequency control (LFC).
6	(Jamma et al., 2018)	*Direct Power Neuro-Fuzzy Controller Scheme of Three-Phase PWM Rectifiers for Power Quality Improvement*	This paper investigates the design of an adaptive Neuro-Fuzzy based direct power control (DPC) improvement scheme. Inference system (ANFIS) to mitigate power quality problems.
7	(Tojeiro et al., 2021)	*Fault detection based on Neuro-Fuzzy models and residual evaluation with fuzzy thresholds applied to a photovoltaic system*	This article presents an implementation of a fault detection scheme based on the identification of the Neuro-Fuzzy model of a photovoltaic system.
8	(Cabeza & Potts, 2021)	*Fault diagnosis and isolation based on Neuro-Fuzzy models applied to a photovoltaic system*	This article presents an implementation of a fault diagnosis scheme based on the Neuro-Fuzzy model for identifying a photovoltaic system in both conversion circuits (DC and AC).
9	(Amosov et al., 2017)	*Human Localization in the Video Stream Using the Algorithm Based on Growing Neural Gas and Fuzzy Inference*	The problem of human body localization in the video stream using growing neural gas and feature description-based om oriented gradient histograms is solved. The original Neuro-Fuzzy Neural Gas Growth Model for Reinforcement Learning (GNG-FIS) is used as the basis of the algorithm. It

			is also proposed to modify the GNG-FIS algorithm using two-pass training with fuzzy class remarking and construction of a heat map.
10	(Malami et al., 2021)	*Implementation of hybrid Neuro-Fuzzy and self-turning predictive model for the prediction of concrete carbonation depth: A soft computing technique*	This study provides experimental information on the carbonation depths of samples from 10 separate existing reinforced concrete structures, of which five are in the inland area (Nicosia), while the other five are in the coastal area (Kyrenia) of the Turkish Republic of Northern Cyprus.
11	(Khatibi & Nadiri, 2021)	*Inclusive Multiple Models (IMM) for predicting groundwater levels and treating heterogeneity*	This study developed multiple models with Neuro-Fuzzy.
12	(Araújo Júnior et al., 2016)	*Modelagem e prognose do preço de carvão usando um sistema Neuro-Fuzzy*	The article presentes results applying AI (Neuro-Fuzzy) to predict coal prices in the market.
13	(Olatunji et al., 2022)	*Modelling Biomass Elemental Composition: A Neurofuzzy Approach*	In this study, the effect of the custering technique on the performance of standalone ANFIS in predicting the elemental composition of biomass was evaluated..
14	(Borisov & Luferov, 2020)	*Neuro-Fuzzy Cognitive Temporal Models for Predicting Multidimensional Time Series with Fuzzy Trends*	A new type of Neuro-Fuzzy Cognitive Temporal Models (NFCTM) was developed, proposed to predict multidimentional time series (MTS) taking into account the fuzzy tendencies off all MTS componentes.
15	(ZANUNCIO et al., 2019a)	*Neuro-Fuzzy hybrid system for monitoring wood moisture content during drying*	The goal of this study was to evaluate the accuracy of the Neuro-Fuzzy hybrid system for monitoring wood moisture during drying.
16	(Lins et al., 2021)	*Neuro-Fuzzy modeling of eyeball and crest temperatures in egg- laying hens*	Considering the challenges faced by poultry farming, this stufy aimed to develop a Neuro-Fuzzy model to predict eyeball and comb temperetaures of laying hens based on enviromental conditions (dry bulb temperature and relative humidity).
17	(Bressane et al., 2018)	*Neuro-Fuzzy Modeling: a Promising Alternative for Risk Analysis in Urban Afforestation Management*	The presente work evaluated a methodology based on Neuro-Fuzzy for the integrated analysis of risk indicators in relation to urban afforestation.
18	(Adedeji et al., 2020)	*Neuro-Fuzzy resource forecast in site suitability assessment for wind and solar energy: A mini review*	This study presented a mini-reviw of GIS based MCDM facility location problems in wind and solar resource, place suitability analysis and resource forecasting using ANFIS based models.
19	(Suparta & Samah, 2020)	*Rainfall prediction by using ANFIS times series technique in South Tangerang, Indonesia*	This article aimed to predict rainfall by exploring the application of artificial intelligence techniques such as ANFIS (Adaptive NeuroFuzzy Inference System) in Indonesia.
20	(Huang et al., 2022)	*Solar radiation prediction using improved soft computing models for semi-arid, slightly-arid and humid climates*	In this research, a modeling was developed by applying Adaptive Neuro Fuzzy Interface System (ANFIS0, Radial Basis Funcition Neuro Network (RBFNN) and Multilayer Perceptron (MLP) models used to predict solar radiation (SR), Yazd (semi-arid) and Tehran (slightly arid), are considered as case studies.
21	(Anusree & Varghese, 2016)	*Streamflow Prediction of Karuvannur River Basin Using ANFIS, ANN and MNLR Models*	The applience Artificial Neural Networks (ANN) Adaptive Neuro-Fuzzy Interference Systems (ANFIS) and Multiple Non-Linear Regression (MMLR) to predict the daily flow at the out of Karuvannur river basin, located in Thrissur district, is presented in this study.
22	(Dasgupta et al., 2018)	*Towards operational SAR-based flood mapping using Neuro-Fuzzy texture-based approaches*	This study developed a flood mapping technique applying Neuro-Fuzzy using SAR images as inputs variables.

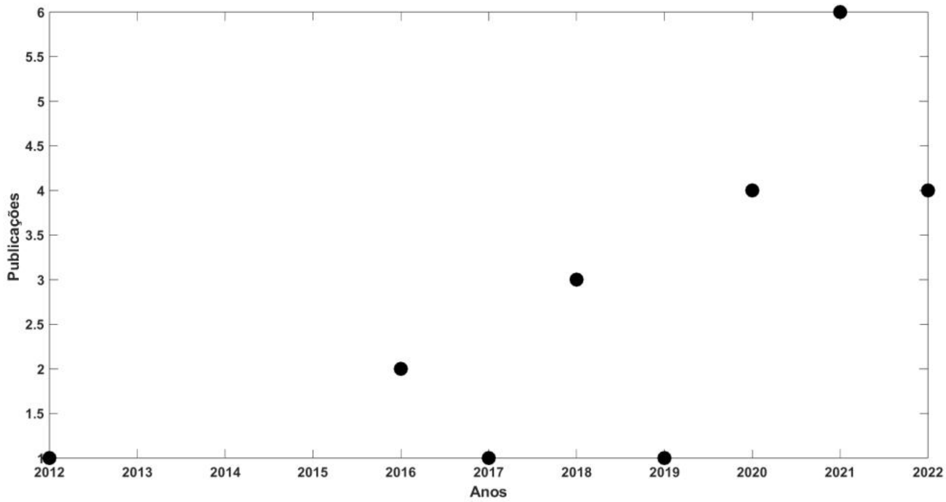
Source: Authors.

Chart 6 displays the listo fall 22 articles selected for the research and indicates de contribution of each one.

Based on the criteria adopted in this systematic review, it was possible to identify na advance in the scientific production related to the application of Neuro-fuzzy molding in production process, reinforcing that this research is na unprecedented work regarding the application of Neuro-fuzzy iin the chemical quantification of elephant grass, which reinforces its importance.

Figure 1 shows the number of publications per year obtained in the research, when using the Strings (Agriculture; elephant grass; *Pennisetum purpureum*; biofuels; pretreatments; Sodium hidroxide; Cellulose; Lignocellulosic biomass; *Neuro-Fuzzy), in one-dimensional models.*

Figure 1 - Publications per year.



Source: Authors (2023).

Figure 1 presents the number of publications per year, 22 documents in te last three Years (2019 to 2022), which demonstrates de advancement and relevance of the coverd topic.

In Figure 2, we have another result of the software that consideres the keywords of the article selected in the Search.

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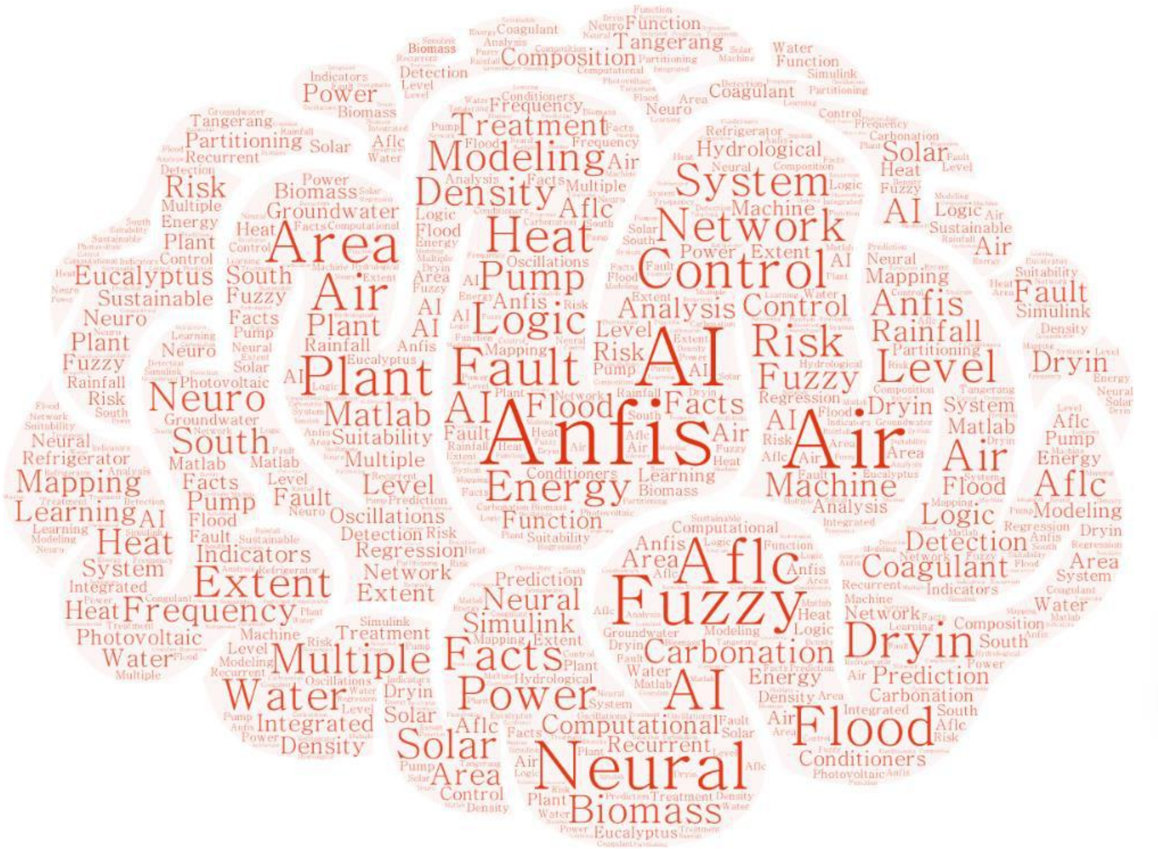
Figure 2 - Word Cloud.

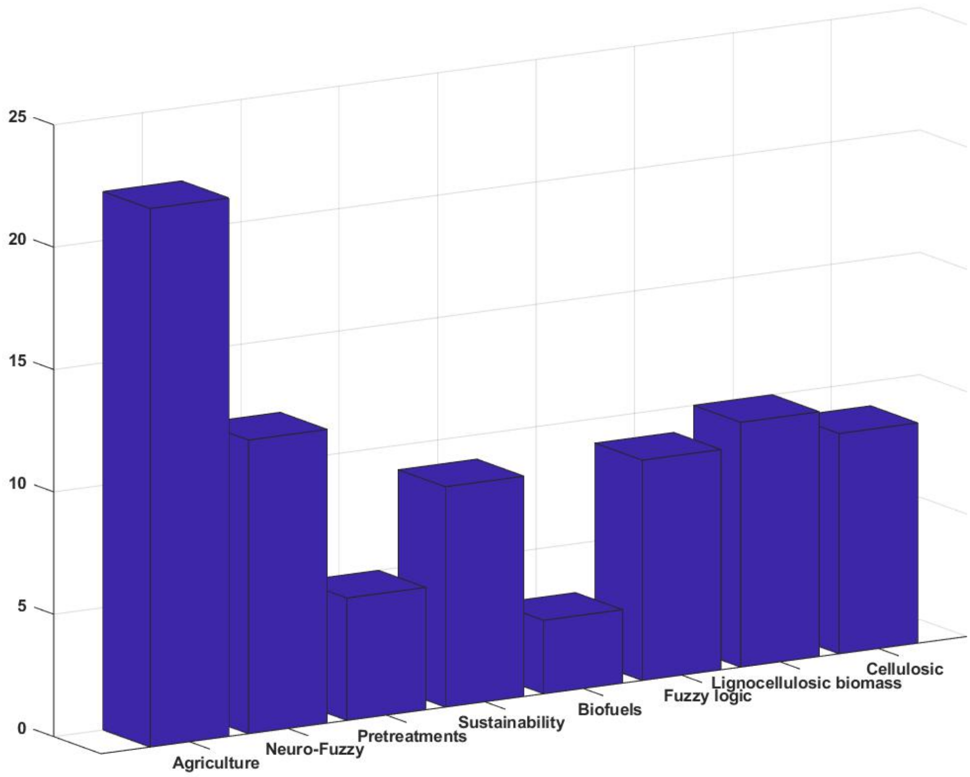


Source: Authors (2023).

Figure 2 shows the word cloud generated from the Keywords of the selected articles, highlighting the words: ANFIS, IA, Neural and Energy.

By analyzing the documents in full, it was possible to categorize the documets by applicability, being: Agriculture, Neuro-fuzzy, pretreatment, Sustainability, Biofuels, Fuzzy logic, lignocellulosic biomass and Cellulosic, as shown in Figure 3.

Figure 3 - Number of documents per application.



Source: Authors (2021).

Figure 3 demonstrates the separation made in the documents listed for the research, in order to identify the focus applications of each of them. The most relevant focuses were found, in greater quantities of articles, for Agriculture and Neuro-Fuzzy.

As seen in Figure 3, the word Biofuels appeared realatively low in the number of articles, however (Pereira & Paula, 2017) quotes that biofuel is considered an important and decisive fator for a sustainable enviroment for future generations.

4. Conclusion

After applying the SBR methodology to search and map published scientific data, it east possible to identify numerous applications for the use of Neuro-Fuzzy in different sectors, mainly in renewable energy. However, it was observed that this article presents a novelty on the application of the use of Neuro-Fuzzy for the process of chemical quantification of cellulose from elephant grass, in addition to the production of bioethanol in elephant grass.

Of the 22 documents analyzed in this research, 100% were articles in the form of applied research and literature review, demonstrating great relevance in this line of research, which is the elephant as biomass to produce bioethanol or second-generation ethanol.

Although it does not present any article with a specific reference to the use of the Neuro-Fuzzy in the chemical process of elephant grass in the laboratory, it opens space for new research into optimizing production processes using Neuro-Fuzzy.

Therefore, for future work, a new analysis is recommended, deepening into more scientific databases, to obtain more answers about the applicability and efficiency of Neuro-Fuzzy Artificial Intelligence in the production of bioethanol.

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