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ENVIRONMENTAL DIAGNOSIS IN THE METALLURGICAL SECTOR: A BIBLIOMETRIC ANALYSIS OF PUBLICATIONS USING THE PLATFORMS: *WEB OF SCIENCE* AND *SCOPUS*

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Abstract: The environmental diagnosis is a management tool with the objective of characterizing the environmental components of the company, evaluating them regarding their adequate management, pointing out the organization's efficiency and, mainly, the opportunities to improve the environmental indicators in relation to the established goals, as well as its adequacy to current legislation. Thus, the adoption of actions for correct environmental and socio-environmental management by organizations, whether mandatory or not, begins with a correct diagnosis of their production system. The perfect characterization of the processes allows the analysis and definition of the local reality, allows the adoption of correction, mitigation or improvement measures, aiming at the sustainability of this production system. The metallurgical industry represents an important economic and strategic sector for the country, occupying in 2019, the ninth position in the world in the ranking of crude steel production. In view of this, the objective of this work was to carry out a bibliometric research and analysis of the results in order to establish an updated overview of these publications. The search was carried out in the Web of Science® and Scopus® databases using a bibliometric tool, analyzing the descriptors: "*environmental diagnosis*" and "*metallurgical industry*". The results showed that there is a lack of studies addressing the research topic, possibly constituting a gap in the literature to be explored, evidencing the environmental assessment of the metallurgical productive sector as an important subject for future studies.

Keywords: Environmental diagnosis, Metallurgical industry, Bibliometric analysis.

INTRODUCTION

According to IBGE data, in 2020 there was a growth of 28.9% in the metallurgical sector when compared to the previous year, showing the strength of this branch in the Brazilian economy (PRODUCTION, 2021). This significant growth is proportionally accompanied by environmental impacts due to the extractive nature of inputs and waste from physical and chemical processes. The metallurgical industrial activities are structured in several mineral processes that are basic operations, carried out on the raw ore, with the aim of obtaining commercially viable products. The smelting process, for example, is composed of several technological steps that generate some type of pollution, highlighting the slag of the production process, which is characterized by being a residue, whose disposal can pollute the soil, vegetation, air and water, by the metals discarded in sanitary landfills without waterproofing. The other by-products are discarded in the industrial yards and can propagate through the air, microparticles that can affect the food chain in ecosystems (CIRTINA et al., 2016).

Faced with this problem, an environmental diagnosis involving the production cycle, from the extraction to the tailings of these materials, becomes essential. The environmental diagnosis consists of a tool that offers methodologies and techniques for the recognition of environmental disturbances, characterizing the impacts on the natural resources of the disposal area, such as vegetation and water bodies (OROZCO-MEDINA et al., 2020).

The objective of this work was to carry out a bibliometric research of publications on the subject of environmental diagnosis, using the descriptors: "*environmental diagnosis*" and "*metallurgical industry*", in two databases, Web of Science® and Scopus®. The results were analyzed in order to establish a comparative quantitative basis of the publications in these databases.

THEORETICAL REFERENCE

Currently there is a recognition on the part of organizations that environmental issues are a relevant factor influencing their image in front of consumers, whose expectations are becoming more demanding every day. In addition, there is a need to adapt to environmental and socio-environmental standards and legislation. Within the concept known as: *people, profit and planet* (3Ps), introduced by John Elkington, environmental law has pressured corporations to comply with socio-environmental directives and to take responsibility for environmental issues, since these legislative instruments not only guide, but also identify problems and provide for punishment to companies that disrespect them (MUÑOZ ; COHEN, 2018).This scenario has promoted a growing search for environmental certifications and sustainable actions, as a form of credibility and commitment by companies, in addition to internal training and continuing education programs, making the concept of sustainability part of society's culture. The term environmental: ''*compliance*'' has appeared in the large manufacturing industries in Brazil and more broadly means to act in agreement and to be in compliance with some cause. It is an instrument linked to the top management of the company, working concurrently with environmental agencies with the aim of ensuring that their corporations comply with environmental regulations, thus avoiding inconvenience and penalties. It works in a preventive and corrective way, preserving the company's image as "sustainable" in the eyes of the community (GOMES; OLIVEIRA, 2017).

Among the transformation industries, the activities of the metallurgical sector in Brazil deserve special attention. In 2019, the country produced 32,6,106 tons of crude steel, ranking among the nine countries that most produced this material. In the same year, the Brazilian trade balance in the sector showed a surplus of US\$ 4.8 billion with exports totaling US\$ 7.3 billion and imports of US\$ 2.5 billion, with the United States being the main importer (OLIVEIRA, 2020). This sector is of paramount importance to the national economy as it feeds other branches of activities such as the automobile industry, which fully uses flat steel and civil construction, which consumes long steel in building structures (FERREIRA, 2008).

The metallurgical processes use mainly aluminum, iron, manganese, nickel, chromium, molybdenum, copper, cadmium and lead as raw materials and produce residues of varied natures in addition to the metals themselves, such as, for example, core sand, used in the manufacture of cores. in foundry, which is considered a toxic residue (LANGE, 2010), due to the presence of phenolic resins, with the function of catalysts, in its composition. When these residues produced in metallurgical activities are poorly managed, they can contaminate the soil and water bodies and, consequently, organisms in general (BELLINASO et al., 1998).

In order to characterize the environmental aspects and impacts of activities in the metallurgy area, throughout its production cycle, the environmental diagnosis procedure is useful in defining an organizational scenario. It is an environmental management tool inserted in industrial management in order to identify the organization's relationship with the environment, the management of solid and liquid waste, as well as the monitoring and control of emissions to the atmosphere, in order to evaluate the organization's environmental performance, as well as highlighting aspects for continuous improvement, making the company more competitive (HAAS; TREIN, 2013).

The issue of emissions from metallurgy is guided by the resolution of the National Environment Council (CONAMA) 001/86,

which defines the characteristics of the physical, biological and socioeconomic environment to be considered and respected in the management of the area under the influence of metallurgical production tailings.

> a) the physical environment - subsoil, water, air and climate, highlighting mineral resources, topography, soil types and aptitudes, water bodies, hydrological regime, marine currents, atmospheric currents;
>
> b) the biological environment and natural ecosystems - fauna and flora, highlighting species that are indicators of environmental quality, of scientific and economic value, rare and threatened with extinction, and permanent preservation areas;
>
> c) the socioeconomic environment - the use and occupation of the land, the uses of water and the socioeconomic, highlighting the archaeological, historical and cultural sites and monuments of the community, the relationships of dependence between the local society, the environmental resources and the potential use future of these resources. (CONAMA, NUMBER 001/1986).

Bibliometrics is a quantitative technique used to statistically analyze, through indicators, a large number of scientific productions, in order to identify trends and forms of citation and co-citation, as well as interactions with the cataloged areas of knowledge (SILVA, 2019). It uses citation analysis as one of its tools to measure the impact of research by certain authors, groups of authors or institutions, making it possible to assess the type of document, language and the most cited journals. With this, a scientific mapping of one or more areas of knowledge with the scientific community is obtained (VANZ and CAREGNATO, 2003). In the present document, bibliometrics was the method adopted for the survey of relevant scientific works related to environmental diagnosis in metallurgy activities.

METHOD

Two databases were used, Web of Science and Scopus®, in the CAFÉ environment of the CAPES portal, without delimiting the search period, as shown in Table 1.

In the Web of Science database ® the search terms were written inside the field: ''all fields'' and the quote algorithm was used in the descriptors in order to search for the exact occurrence of the terms. Subsequently, a new search was carried out using the Boolean AND algorithm in order to search for words concurrently.

Following the same guidelines, in the Scopus® database, the descriptors were inserted in the field ''*search documents*'' and searched, inserting the search algorithm in quotation marks in the descriptors. Subsequently, a new search was performed using the Boolean AND algorithm. Among the scientific journal databases, Clarivate's Web of Science (WoS) and Elsevier's Scopus are the most important. They are multidisciplinary, paid and differ from each other in terms of coverage, focus and tools they provide to the target audience ALRYALAT et a., 2019. Thus, the results of the two surveys were compared, seeking cross-referencing of information and correspondence of citations among the bases considered..

RESULTS AND DISCUSSIONS

In this chapter, the results of the surveys will be pointed out, discussing the scope and each base in relation to the research topic.

RESULTS OF WEB OF SCIENCE®

The search results in this database highlighted twenty-one documents between the years 2012 to 2020 as shown in Figure 1 A and B. The production peaks occurred in the years 2014 with five publications and thirty-four citations and ,2017, with the same number of publications, which received one

Database	Web of Science ®	Scopus®
Descriptor 1	environmental diagnosis	environmental diagnosis
Boolean Algorithm	AND	AND
Descriptor 2	metallurgical industry	metallurgical industry
Algorithm: quotes	"environmental diagnosis" "metallurgical industry"	"environmental diagnosis" "metallurgical industry"

Table 1 - Database and search filters
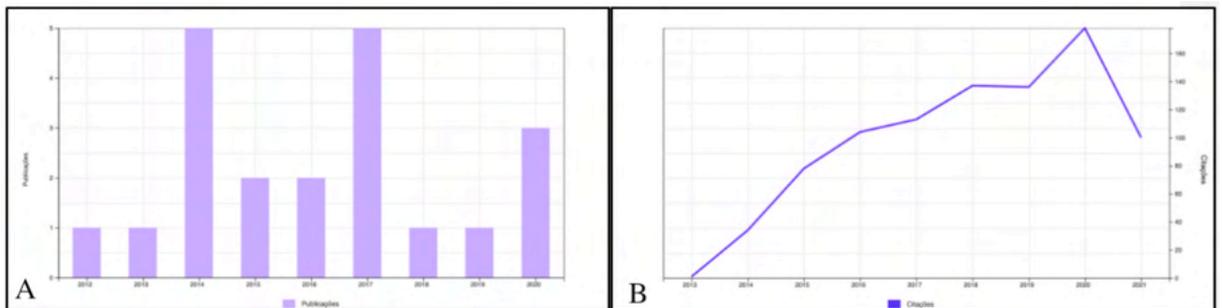
Source: Prepared by the author, 2021

Figure 1A - Number of publications over timeFigure 1B - Number of citations over time

Source: WoS, 2021

hundred and thirteen citations until the date of this research. Using quotation marks as a search operator, in order to search for the term in its entirety, we did not obtain results, so the search was carried out without this instrument.

When counting the results in relation to the areas chosen as having greater adherence to the theme of this work (Figure 2), only ten results were obtained, of which four (19%) were in the area of chemical engineering, three (14.3%) in the area of environmental sciences, three (14.3%) in multidisciplinary sciences, one result (4.8%) related to metallurgy and metallurgical engineering and one (4.8%) in the area of occupational health and environment public environment.

The twenty-one publications resulted in a total of eight hundred and seventy-four citations with ten H-index citations as shown in Table 2. The work entitled: *Hydrological droughts in the 21st century, hotspots and uncertainties from a global multimodel ensemble experiment* of 2014, published by the *National Academy of Sciences*, was the most cited, with three hundred and seventy-one citations in the period from 2017 to 2021. The keywords of this article were: *climate impacts, global hydrology, evaporation and global warming ,* terms compatible with and actuality of this theme.

SCOPUS RESULTS

Searching this database using quotation marks as a search operator with the intention of looking for the exact descriptors, led to only one result as shown in Table 3.

When the search was conducted only

Figure 2 - Results chart by knowledge area

Source: WoS, 2021

Título do trabalho - Autores - Ano	2017	2018	2019	2020	2021	Total
Hydrological droughts in the 21st century, hotspots and uncertainties from a global multimodel ensemble experiment Prudhomme, C; Giuntoli, I; (...); Wisser, D Mar 4 2014	62	60	52	67	33	371
First look at changes in flood hazard in the Inter-Sectoral Impact Model Intercomparison Project ensemble Dankers, R; Arnell, NW; (...); Wisser, D Mar 4 2014	26	29	23	23	15	174
Multisectoral climate impact hotspots in a warming world Piontek, F; Muller, C; (...); Schellnhuber, HJ Mar 4 2014	13	12	13	6	9	106
Simulating the Earth system response to negative emissions Jones, CD; Ciais, P; (...); Wiltshire, A Sep 2016	4	17	15	10	5	52
Progress in the Development of Intrinsically Conducting Polymer Composites as Biosensors Prajapati, DG and Kandasubramanian, B May 2019	0	0	2	28	4	34
Recent developments in cokemaking technologies in Japan Nomura, S May 2017	2	3	9	7	2	23
A knowledge reasoning Fuzzy-Bayesian network for root cause analysis of abnormal aluminum electrolysis cell condition Yue, WC; Chen, XF; (...); Zhang, HL Sep 2017	0	4	5	9	4	22
Spatiotemporal changes in wheat phenology, yield and water use efficiency under the CMIP5 multimodel ensemble projections in eastern Australia Wang, B; Liu, D; (...); Yu, Q 2017	1	3	7	7	3	21
Occupational risk factors for idiopathic pulmonary fibrosis in Southern Europe: a case-control study Paolocci, G; Folletti, I; (...); Murgia, N May 21 2018	0	1	5	8	6	21
Modelling and simulation of rougher flotation circuits Yianatos, J; Carrasco, C; (...); Torres, C Sep 10 2012	2	4	3	6	1	19

Table 2 - Most cited publications in the range from 2017 to 2021

Source: Prepared by the author, 2021

Work title	Authors	Year	Pubblication Place
Environmental diagnosis of small and medium size manufacturing industries of metallic frames and metallic structures | [Diagnóstico ambiental de indústrias de fabricação de estruturas metálicas e esquadrias de metal de pequeno e médio porte]	Patrícia Dal Moro, Adalberto Pandolfo, Leila Dal Moro, Naira Elizabete Barbacovi, Leandro Doro Tagliari	2015	Scielo Brasil

Table 3 - Search result using the quote operator

Source: Prepared by the author, 2021

by entering the Boolean algorithm AND, following the search parallel of the previous database, we obtained eleven results. Figure 3 A and B shows that the peak of production occurred in 2015, with three documents, and in 2018, with two documents. The peak of citations occurred in the year 2019, with sixteen citations.

Regarding the distribution of documents by area of knowledge most adhering to the theme of this research, three (31.3%) articles in the areas of engineering stand out, 1 article (12.5%) in the area of earth and planet sciences and 1 article (6%) in the area of environmental sciences (Figure 4). In short, of the 11 articles identified by the database, based on the selected descriptors, only five (49.8%) correspond to studies that minimally adhere to the research topic.

The eleven publications had a total of one hundred and twenty-eight citations, the most cited work being the article: *Lead contamination in Uruguay: the "La Teja" neighborhood case*, 2008, cited seventy-two times in the period from 2017 to 2021, bringing key words such as: *lead level, lead exposure, blood lead level, lead contamination* and *lead pollution*. The Table 4 shows the number of citations of the five most cited works, with the other six having no citations.

COMPARATIVE ANALYSIS: WEB OF SCIENCE AND SCOPUS

Comparing Tables 2 and 3, in order to search for coincident citations, only one work was in both databases. The article: *Recent developments in cokemaking technologies in Japan,* de Seiji Nomura 2017, published on:*Fuel Processing Technology Jornal*, was cited twenty-three times and has as keywords: *coking coal, coal pre-treatment,* SCOPE 21, *coke oven repair* and *waste plastic recycling,* prevalent themes in current environmental problems.

From the analysis of the results of both platforms, the theme environmental diagnosis, which was the term used in the search, does not appear clearly and only one study, MORO et al., 2015, completely corresponded to the search descriptors, which reinforces the lack of objective studies in this area, showing that there is a gap to be filled in approaching this topic.

FINAL CONSIDERATIONS

The analysis of the results of the applied metric, first showed that, in spite of the remarkable projection in the world economy of the metallurgical production system, there is a reduced number of studies specifically on environmental diagnosis in the industries of the sector. Reading the titles and abstracts
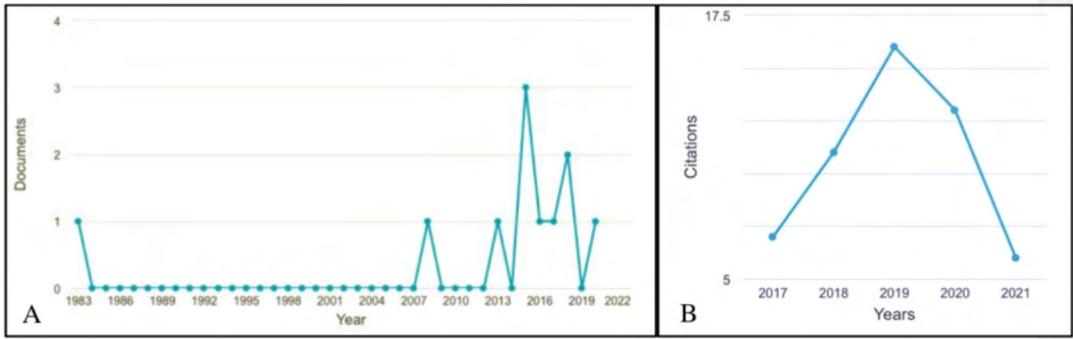
Figure 3A - Number of publications over time Figure 3B - Number of citations over time
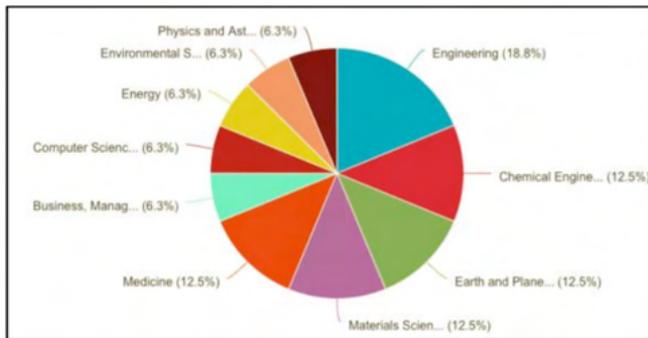
Source: Scopus, 2021

Figure 4 - Results chart by knowledge area

Source: Scopus, 2021

Título do trabalho - Autores - Ano	2017	2018	2019	2020	2021	Total
Lead contamination in Uruguay: the "La Teja" neighborhood case Manay N.,Cousillas A.Z.,Alvarez C.,Heller T 2008	51	5	8	6	2	72
Spontaneous abortions in an industrialized community in Finland Hemminki K.,Kyyronen P.,Niemi M.L. 1983	28	2	0	0	0	30
Recent developments in cokemaking technologies in Japan. Nomura S. 2017	2	4	8	6	3	23
Environmental Problems and the State of Compliance with the Right to a Healthy Environment in a Mining Region of México. Mendezcarlo Silva V. , Mendezcarlo Silva V. 1 July 2020	0	0	0	1	1	2
Fault diagnosis for supporting rollers of the rotary kiln using the dynamic model and empirical mode decomposition. Zheng K.,Zhang Y.,Zhao C.Li T. 2016	1	0	0	0	0	1

Table 4 - Most cited publications in the range from 2017 to 2021

Source: Prepared by the author 2021

related to the theme of this work showed that, in addition to a few works, most dealt only with solid waste management, such as the works by MORO et al., 2015, JONES et al., 2016, DANKERS et al, 2014, PIONTEK et al., 2014, MENDEZCARLO SILVA and LIZARDI-JIMÉNEZ, 2020, MAÑAY et al., 2008 and NOMURA, 2017, neglecting the other environmental aspects of this branch of production.

The multidisciplinarity of the theme was quite evident, corroborating almost all studies involving environmental aspects within the management procedures of organizations. The environmental diagnosis is the first step towards the management of sustainable production, not only with regard to solid waste, but in relation to the entire production cycle. This becomes even more pressing when considering some of the sustainable development goals for the 21st century, such as building resilient infrastructure, promoting inclusive and sustainable industrialization, stimulating innovation, sustainable production and consumption patterns and urgent measures to combat climate change and its impacts, for which organizations have adapted and projected goals to be achieved in the next 20 or 30 years.

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