Identification of the main topics about Cleaner Production: a guide to directing sustainable industrial practices in the next decade

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Abstract

The increase in the consumption of goods and services around the world has intensified the negative environmental impacts of industrial companies. Consequently, the concern with these impacts appears more and more on the international agenda, intensifying the pressure for companies to use sustainable solutions. One of the most used solutions since '90s is the Cleaner Production (CP) strategy. However, the CP study has only highlighted in the past ten years. Thus, it is important that governments, companies, and universities become aware of the importance of improvements in this area. The objective of this work is to identify in the literature the level of development of the Cleaner Production strategy through the analysis of its state of the art. To this end, a bibliometric study of the articles published during the last five and a half years (2014-08.2019) on the studied topic in the Scopus and Web of Science databases was carried out. The results show the main authors, countries, journals, keywords, and areas of study related to the CP literature. The study presented in this research enables new research on CP practices, encouraging its development.

Keywords: Cleaner Production, State of Art, Bibliometric Study

1. Introduction

The growth of goods and services consumed in recent decades has resulted in increased generation of polluting waste around the planet. These increases negatively impact the environment more and more and, as a consequence, international concern about the environmental effects caused by industrial companies has also been growing (Kubota and Catorski, 2013).

The intensification of concern by industrial companies pressures them to adopt management measures and minimize environmental impacts. Social pressures, market pressures, and pressures for international standardization make countries' environmental policies increasingly stringent, requiring companies to come up with sustainable initiatives (Yilmaz et al., 2015; Zhang et al., 2013).

Thus, sustainable development is increasingly present in the strategic planning of corporations. This concern has generated improvements in the production processes of companies that adopt sustainable practices, creating competitive advantages (Gonçalves Filho et al., 2018).

Sustainable development is conceptualized as development that meets current needs without compromising the ability of future generations to meet their own needs. Its concept presents a relationship between human beings, the economy, and the environment, in which cultural, technological and economic development is oriented towards the maintenance of human life and preservation of the environment. This concept was presented in Brundtland's report by the World Commission on Environment and Development in 1987 (Khalili et al., 2015; Faé Gomes et al., 2013).

Thus, the concept of sustainable development has become the basis for social and environmental changes of organizations and governments (Faé Gomes et al., 2013). The pursuit of sustainable development has promoted the creation of solutions aimed at reducing environmental impacts on industrial companies.

Among the various solutions developed in this context, Cleaner Production (CP) is an important strategy that promotes sustainable development. Thus, applied by many industrial companies managers (Krolczyk et al., 2017; Kubota and Catorski, 2013). CP aims to minimize the environmental impacts of companies' products and production processes using sustainable methods, resources, and technologies. CP promotes waste and operating costs reduction, more efficient processes, high-quality products, and improve the company's image to customers (Gonçalves Filho et al., 2018).

Therefore, CP practices help managers to take actions that integrate environmental protection with the economic development of companies, consolidating the construction of sustainable societies (Almeida et al.,

2015). Consequently, CP has presented a growing participation as a research theme in the academic environment due to its success. Jia et al. (2014), Aparecido et al. (2013), and Dobes (2013) proposed new methods and tools that facilitate the implementation of CP, driving their results and overcoming their difficulties. Hoof (2014), Huang et al. (2013), Kubota and Cantorski (2013) Zhang et al. (2013) developed case studies on the application of CP practices in different companies and countries, analyzing the results and difficulties.

Although the growing number of researches on the theme, CP still presents several barriers to its development. Thus, to ensure the success of its implementation in organizations, it is important to mobilize the governmental, business and academic community to engage in the development of new knowledge and experience in the area (Vieira and Amaral, 2016).

Thus, future research may be guided by studies that measure the level of CP development in academia. Among these studies, bibliometric study techniques are highlighted because they involve methods that generate quantitative indicators to identify the level of scientific development of some theme, pointing the contribution of scientific work in the advance of literature. Therefore, bibliometric studies are widely used by researchers to analyze trends and performance of a theme (Yang et al., 2013).

Also, although the theme is in the ascendancy, it is possible to verify that few studies quantitatively analyze the literature on the subject. This verification was made possible by searching the Scopus and Web of Science databases, using the words “cleaner production” and “bibliometric”. This fact highlights the importance and necessity of studies that analyze the CP development and compare what was developed with the difficulties faced by this strategy.

In this context, the question that guided the execution of this research work: “What is the state-of-the-art of Cleaner Production?”. Therefore, this paper aims to identify the level of development of the CP literature, its state-of-the-art, which will serve as a guide for future researchers, contributing to the advancement of their knowledge.

Thus, was performed a bibliometric study of the scientific articles on CP published in the last five years and a half (2014 – 08.2019) and available in the Scopus and Web of Science databases. Scopus is the world's largest database of scientific publications, with approximately 21,500 journals from over 5,000 international publishers (Elsevier, 2016). The Web of Science accesses approximately 12,000 journals from all fields of knowledge (Capes, 2019). These facts allow the study to contemplate most of the international knowledge on the theme.

The research work is organized into five sections, considering this introduction. The second section is presented the theoretical framework of Cleaner Production that supported this study and the third section presents the research methods. The fourth section presents the bibliometric analysis of the results obtained from Scopus and Web of Science, and the fifth section presents the conclusions. Finishing the research work are presented the references.

2. Theorical Framework

The 20th century was marked by great technological, scientific, and industrial advances. According to World Bank (2019), between 1960 and 2019 the world population nearly tripled while the world Gross Domestic Product (GDP) average grew more than 40 times. At the same time, global consumption levels increased by more than 50% between 1995 and 2014 (UNIDO and UNEP, 2015).

In this context, several countries have reached high levels of development. However, in many cases, growth has been at the expense of high environmental exploitation rates. Emissions of greenhouse gases increased considerably among the five most polluting countries between 1970 and 2012, especially China and the United States. At the same time, some natural resources started to run out and the impacts of global warming have begun to be observable (UNIDO and UNEP, 2015; World Bank, 2019).

In response to these alarming data, between the 1980s and 1990s, several environmental initiatives began to be promoted. International institutions such as the United Nations (UN), the United Nations Industrial Development Organization (UNIDO) and the United Nations Environment Programme (UNEP) developed actions against the negative impacts that human actions had been causing against the environment. At the same time, industrialized countries in North America and Western Europe launched programs demonstrating the success of their companies by adopting waste and pollution prevention strategies, rather than end-of-pipe solutions (UNIDO, UNEP; 2015).

From these success cases, the concept of Cleaner Production (CP) emerged in 1989. Created by UNEP during the preparations for the Rio 92 conference, CP has the purpose of grouping together prevention and reduction strategies of industrial impacts that were being adopted by companies around the world (Hens et al., 2018).

The CP is defined by UNEP as the continuous application of a preventive and integrated environmental strategy applied to processes, products, and services aiming at the increase of overall efficiency and reducing risks to humans and the environment (UNEP, 2008). CP can be applied in a wide range of areas, from industrial processes to services (UNEP, 2008). According to Hens et al. (2018), around 2007 UNIDO and UNEP expanded

the concept of CP by adopting the expression Resource Efficient and Cleaner Production (RECP). The change enhanced the importance of resource efficiency, a key factor in the search for the Green Industry and Green Economy (RECNET, 2019).

According to Eras (2013) and Faé Gomes (2013), the application of CP concepts should be done throughout the production and product cycles, aiming:

- improve the use of resources efficiency, such as raw materials and energy, eliminating toxic materials and reducing all emissions of pollutants and waste;
- reduce environmental impacts throughout the products' life cycle, from raw material to disposal, ensuring their economic viability;
- change processes by improving their environmental performance and bringing new technologies and
- changes in organizational cultures.

According to Gonçalves Filho et al. (2018), the implementation of CP techniques can be done at three levels (Figure 1).

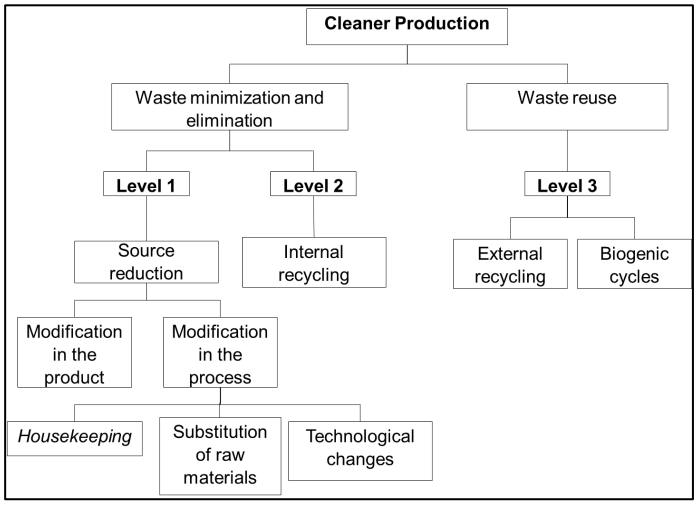

Figure 1. CP implementation levels (Gonçalves Filho et al., 2018)

Levels one and two deal with waste minimization and elimination. Level one is the reduction in the waste source, by modifying the product or process. This can be done by adopting new types of raw materials or more sustainable technologies. Level two, on the other hand, is based on internal recycling, where the process is designed to reuse the waste generated. Finally, level three is about the external reuse of waste. At this level, it is possible to find third party recycling companies or companies that use the wasted resources (Gonçalves Filho et al., 2018).

The results that companies have obtained with CP practices have shown several benefits, proving more and more the correlation between them and the improvement in business performance. CP's approach provides the minimization of waste and the improvement in the environmental performance of companies, besides financial benefits (Khalili et al., 2015).

According to Aparecido et al. (2013), the production processes efficiency improvement and the minimization of wastes generation results in the reduction of operational costs, which increases business profitability. In addition to financial benefits, it is possible to observe positive social impacts such as increased health and safety at work, resulting in increased productivity and employee satisfaction. External benefits can also be scored as the improvement of the company's relationship with its stakeholders, and the reduction of environmental and health risks, promoting an improvement in the company's image.

Despite such benefits, CP also faces barriers during its implementation. Inadequate integration between company departments can lead to a lack of authority and inexperience to expand CP into all its areas. In addition, the lack of monitoring, review, and expansion of implementations make it difficult to successfully implement CP, while long payback times, insufficient employee training, inadequate leadership, lack of employee involvement and resistance to change are also difficulties faced in the adoption of CP (Aparecido et al., 2013; Khalili et al., 2015).

According to Gonçalves Filho et al. (2018) and Dobes (2013), other barriers to CP are political difficulties; market insecurities; economic, technical and informational difficulties; besides organizational difficulties. All this creates insecurity for companies, which often do not prioritize environmental preservation efforts.

3. Research Method

The research work was developed following the methodological flow shown in Figure 2. It was divided into 3 stages. In the first stage, the objectives and the research method were established. In the second stage, the bibliometric study was performed, which was subdivided into four steps. These four steps include the definition of the criteria for searching the data to perform the bibliometric study, the search and collection of the data, the analysis of the data and the discussion of the results. Finally, conclusions were made.

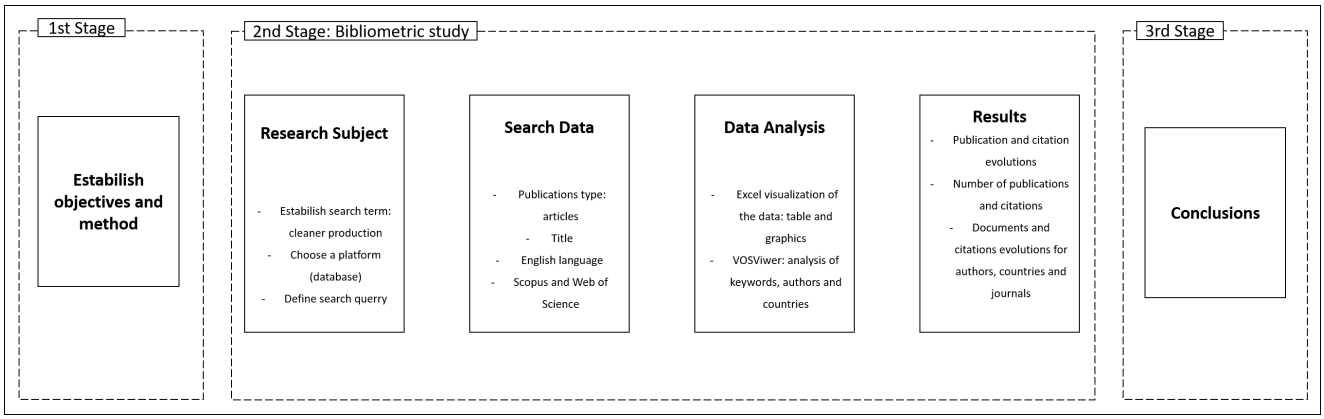

Figure 2. Methodological flow of research

In the first place, the objective and the research method of this study were defined. This study has the objective to identify the level of development of the CP literature, and the research method used was a bibliometric study.

Then, the bibliometric study was initiated (stage 2). First, a search was made in the Scopus and Web of Science (WoS) databases of articles with the term "Cleaner Production" present in the title, in English and published from 2014 to 08.2019. The research was delimited in this period because it was understood that these articles are still current and have already managed to pulverize knowledge and influence the state of the art in this field of study.

Then, articles that were present in both bases were eliminated, keeping only the article in the base in which it had the highest number of citations and also articles that did not fit the scope studied were eliminated.

Based on the collected data, several analyses were performed using Excel and VOS Viewer software, with the support of Scopus and WoS database tools.

Using Excel software, the tables of the ten most-cited authors, countries and journals in the last five and a half years (2014 - 08.2019) in the area of CP were built. It was defined that each one needed to have at least three publications in the area. It was also elaborated, with the same spreadsheet software, the categorization of keywords that obtained at least two citations through themes, a demonstrative table with the percentage evolution of each theme and the annual graphic demonstration of each of the explored themes. It is worth noting that it was possible to find only five journals with at least three

Finally, the analyses performed in the previous phase publications in the CP.

With VOS Viewer were analyzed the relationships between authors, countries and keywords through the networks generated by the software.

After finishing the construction of the graphs and diagrams, the analysis of the results was started. Based on the study, it was possible to identify the main countries, authors, journals, keywords and study areas related to CP publications. The research allowed discovering the level of development of CP literature, which are the areas of research that stand out most in the subject studied and the ones that are still incipient. Thus, it was possible to draw the conclusions of the work.

4. Results and Discussions

From the data collection, a sample of two hundred and fifty-one (251) articles was obtained, which were the basis for the studies performed in this work. The most cited elements in publications on CP in the studied period, such as countries, authors, journals, and keywords, were analyzed. In order to ensure the research results relevance, only the elements containing at least three publications were considered.

In this way, the data was tabulated for systematization and analysis. The tables inform the h index of the theme, the number of publications, the number of citations, the rate of citations per publication and the annual evolution of publications and citations.

Table 1 presents the Top 10 most cited countries in the CP theme, which were ranked in ascending order according to their h index in this theme. The purpose of this indicator is to quantify the productivity, impact, and relevance of scientific research. An author's index of h indicates that his N articles have at least h citations each, and the rest of them have no more than h citations each (Hirsch, 2005). Thus, the author's productivity and the number of citations have a direct impact on his index h, and both need to increase for the index to rise.

Table 1. TOP 10 countries with the highest number of citations (2014 -08.2019)

Countries	H Index Theme	Publications Number	Citations Number	Citations/Publications	Evolution of publications by year						Evolution of citations by year					
					2014	2015	2016	2017	2018	2019	2014	2015	2016	2017	2018	2019
Brazil	14	47	491	10,45	5	5	6	13	14	4	2	11	29	75	177	197
China	12	73	472	6,47	5	11	12	15	14	16	4	14	53	87	163	151
United States	8	20	326	16,30	2	3	5	3	5	2	0	16	62	69	95	83
Malaysia	8	18	235	13,06	2	3	4	7	2	0	1	13	36	54	72	58
India	6	18	159	8,83	0	2	5	3	4	4	0	0	14	35	46	63
Pakistan	6	8	93	11,63	1	0	1	3	1	2	0	3	2	21	31	35
Iran	5	11	172	15,64	0	0	2	3	5	0	0	3	2	21	31	35
Colombia	5	7	88	12,57	1	2	0	2	2	0	1	2	13	14	28	30
United Kingdom	5	6	86	14,33	0	2	2	0	1	1	0	3	9	14	34	26
Hungary	4	4	131	32,75	0	0	3	1	0	0	0	0	22	45	41	23

In Table 1 it is possible to observe that Brazil is highlighted for obtaining the highest h index and the highest number of citations. China reaches second place in the ranking due to its high production, with 73 publications the country presents a greater number of publications than any other. Even so, China does not present more citations than Brazil, so its h index is lower and its rate of citations per publication is the lowest of the top ten countries. Then, it is possible to notice that despite having high productivity Chinese publications have achieved less international prominence than the other countries.

Another country that stands out in the analysis of Table 1 is the United States, presenting the second-highest rate of citations per publication. However, its productivity is below Brazil and China, reaching third place in the ranking of the ten most-cited countries on CP.

Hungary has the lowest number of publications and consequently the lowest h index among the ten countries, but the rate of citations per publication is the highest. This can be justified by the international partnerships in the published articles. Hungary has international partnerships in his four published articles, while the United States has international partnerships in 17 articles out of 20 published. On the other hand, Brazil has a partnership in 12 of the 47 articles published. Thus, it is possible to identify the importance of international partnerships to achieve international prominence in the publications.

The diagram in Figure 3 shows the network of countries that stand out in the CP area. The size of their name indicates the number of publications and the straight lines connecting them indicate partnerships with other countries. It is possible to observe that the diagram reinforces the data in Table 1, indicating that China, the United States, and Brazil are the countries with the greatest number of articles and partnerships in the studied theme.

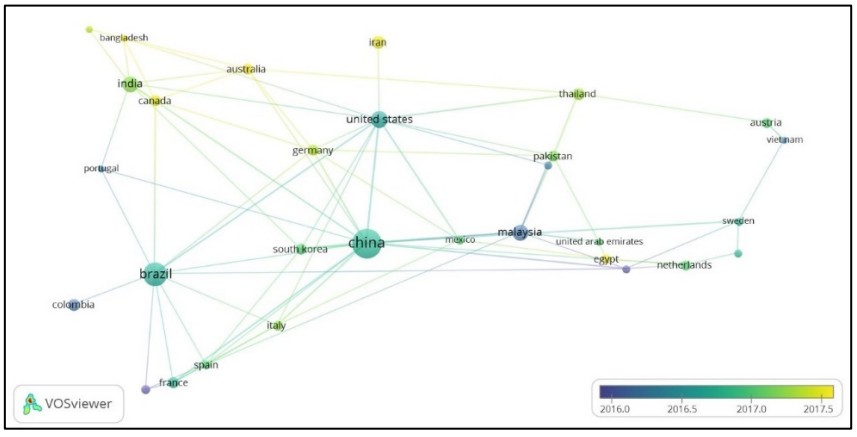

Figure 3. Network of countries in the production of articles on CP

China and the United States are central countries in the diagram, showing that they concentrate many of the partnerships on CP researches. As China has the largest number of publications, it has the name in the spotlight, followed by Brazil and the United States. Although Hungary has the highest rate of citations per publication, the country does not appear highlighted in the diagram because its number of articles and consequently partnerships is the lowest among the top 10 countries on the subject. This fact highlights the importance of high productivity for its prominence in the international context. The color of the countries indicates the period of time in which their work was published. Thus, it is possible to see that both China, Brazil, and the United States published most of their works from the first half of 2016.

In Table 2 it is possible to observe the ten authors most cited with the highest h index in the theme forming the TOP 10.

Table 2. TOP 10 authors most cited in the theme CP (2014 – 08.2019)

Author	H Index Theme	Publications Number	Citations Number	Citations/Publications	Evolution of publications by year 2014	2015	2016	2017	2018	2019	Evolution of citations by year 2014	2015	2016	2017	2018	2019
Severo, E. A. (Potiguar University/Brazil)	6	6	136	22,67	1	1	0	2	2	0	1	7	6	29	42	51
Huisingh, D. (Tennesse University/United States)	4	4	142	35,50	0	1	1	2	0	0	0	1	32	33	39	34
Klemes, J.J. (Brno University of Technology /Czech Republic)	4	4	131	32,75	0	0	3	1	0	0	0	0	22	45	41	23
Yetis U. (Middle East Technical University/Malaysia)	3	3	43	14,33	1	0	2	0	0	0	0	1	3	13	16	10
Ometto, A. R. (São Paulo University/Brazil)	3	6	56	9,33	0	1	2	1	2	0	0	0	2	13	24	17
Dorion, E. C. H. (Caxias do Sul University/Brazil)	3	3	94	31,33	1	1	0	1	0	0	1	7	6	27	26	27
Chuah, L. F. (Marine Departament/Malaysia)	3	3	89	29,67	0	0	2	1	0	0	0	1	14	23	29	22
Yusup, S. (Universiti Teknologi Petronas/Malaysia)	3	3	83	27,67	0	0	2	1	0	0	0	1	14	20	25	22
Giannetti, B. F. (Paulista University/Brazil)	3	3	64	21,33	0	1	0	1	0	1	0	1	13	7	18	25
Vandecasteele, C. (KU Leuven/Belgium)	3	3	48	16,00	0	1	0	1	1	0	0	0	2	3	13	30

The author with the highest h index in the theme is Severo, currently affiliated with the Potiguar University Brazil (Brazil), where research in the area of Environmental Sustainability, Innovation, Strategy, Entrepreneurship, and Social Responsibility. She produced 6 articles on the theme with a total of 136 citations.

It is possible to observe in the evolution of citations per year, that citations increased considerably from 2016 to 2017, corroborating the literature on the awareness of organizations about CP.

The author allocated second in the TOP 10 ranking presents the highest rate of citations per publication (35.50) because of its high number of citations (142) in the 4 articles published on the theme. This author presents relevance in the CP research area, presenting important contributions to the theme.

It is important to note that among the TOP 10, 4 authors work in Brazilian institutions, reinforcing what was presented in Table 1, in which Brazil is first in the top 10 ranking of the countries with the highest number of citations in CP. Figure 4 shows the diagram of the authors most cited in the theme where it is possible to visualize the interaction between them.

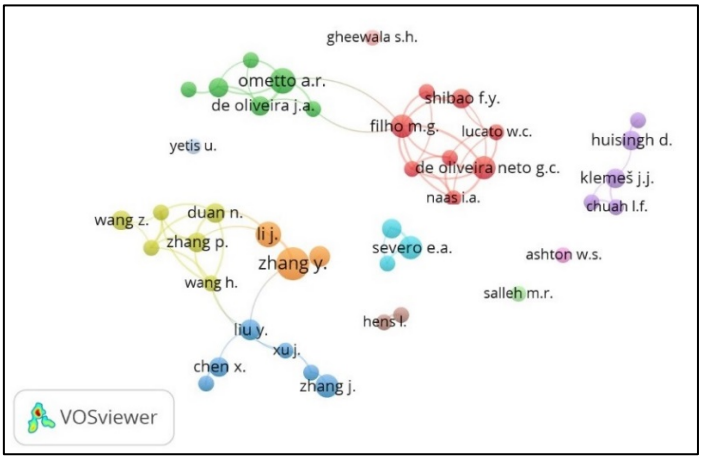

Figure 4. Network of authors most cited in CP articles

The network shows clusters that are formed from data analysis performed by the VOSViewer software of the most cited CP authors. It is possible to observe that the authors mentioned in Table 2 are present in the network, including that they interact with each other to produce articles.

Table 3 shows the main scientific journals where articles on CP were published between 2014 and August 2019. It was possible to list only five journals with at least three publications on the theme studied.

Table 3. TOP 5 journals most cited in the theme CP (2014 – 08.2019)

Journal	H Index Theme	Publications Number	Citations Number	Citations/Publications	Evolution of publications by year						Evolution of citations by year					
					2014	2015	2016	2017	2018	2019	2014	2015	2016	2017	2018	2019
Journal Of Cleaner Production	24	166	2178	13,12	8	20	33	39	37	29	9	59	199	421	740	746
Clean Technologies And Environmental Policy	3	7	25	3,57	0	1	2	2	2	0	0	0	7	6	9	3
Sustainability Switzerland	2	3	7	2,33	1	0	0	1	1	0	0	1	0	0	3	3
Chemical Engineering Transactions	2	4	7	1,75	2	0	0	0	2	0	0	1	1	0	2	3
Arpn Journal Of Engineering And Applied Sciences	0	3	0	0,00	0	0	2	1	0	0						

It can be observed that there is a great concentration of works in the Journal of Cleaner Production. Among the papers published in the five main journals on the subject, those indexed to the Journal of Cleaner Production correspond to 90% of the total. The evolution of publications and citations in this journal shows that in 2016 an exponential growth was initiated in both cases, showing that this is a topic that is being widely studied.

The Journal of Cleaner Production was created by Huising D., the author with the second-highest h index of the top 10 and the one with the highest number of citations. The journal's areas are Cleaner Production, Environmental, and Sustainability, aiming to address and discuss advances in CP practices (Elsevier, 2020). Therefore, the Journal of Cleaner Production is the most sought after journal by researchers on this topic.

For the analysis of the most cited keywords, the word "cleaner production" was withdrawn because it was the main focus of the journal and the terms contained names of countries and region were eliminated from the analyses, leaving the terms that had a direct connection with the interest in the field of study. After the considerations, it was found that the term that has the most expression in this context was the "pollution control", presenting 202 occurrences and links with 102 words. The second word with the highest occurrence was "sustainable development", with 65 occurrences and 80 links. The third most prominent word was "environmental management" with 38 occurrences and 72 connections.

According to the demonstration of the Period of Figure 5, it turns out that the change of context of words occurred in early 2016 and fears of 2017. The word with the most expression cited at the beginning of the research focuses on environmental impact, with 22 occurrences, and now recently the most prominent words are "efficiency" and "agriculture" with 10 notes each.

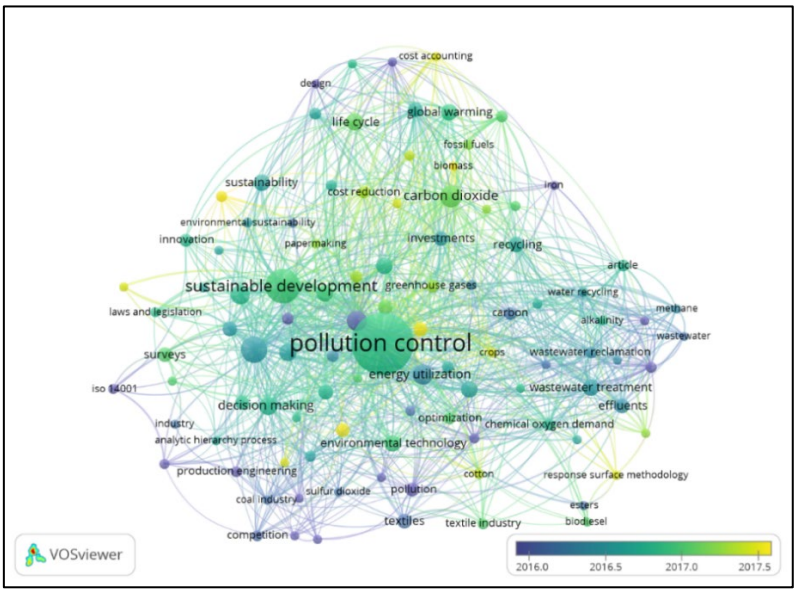

Figure 5. Keywords network in Cleaner Production

Table 4, the main keywords categorized into 13 parts are identified to reliably represent the characteristics of each of the respective themes (Phillips et al., 2015). The grouping technique aims to from the junction of words with the same nature, to enable the understanding of the individual trends of each distinct group (Cobo and Herrera, 2012).

Table 4. Categorization of keywords in themes

Research themes	Words of the themes
Biochemicals components	better-cotton, citric-acid, extracting-vanadium-from-stone-coal, fuel-properties, glycerol, microstructure, natural-dyes, pulp-and-paper-mills, methane
Cleaner production practices	cleaner-production-assessment, ecodesign, end-treatment, environmental-impact-assessment, lca, material-flow-analysis, product-end-of-life, remanufacture, resource-efficient-and-cleaner-production, cleaner-production-audit, eco-innovation, green-manufacturing, recycle, resource-efficiency, life-cycle-assessment, cleaner-production-(cp), cleaner-production
Economic aspects	disposal-costs, circular-economy
Emission reduction	emission-reduction, waste-reduction, carbon-dioxide-emission, carbon-footprint
Environmental impact	environment
Industrial companies	automotive-industry, Brazilian-industry, manufacturing, pharmaceutical-industry, small-and-medium-enterprises
Logistic	reverse-logistics, supply-chain-management
Management and systems	assessment-methods, continuous-improvement, implementation-strategy, process-integration, process-optimization, waste-management, environmental-management-system, environmental-management, innovation, lean-manufacturing
Organizational culture	higher-education
Quality	iso14001, quality-management, iso-14001
Renewable energy	bioenergy, biogas, biotransformation, energy, energy-conservation, energy-saving, renewable-energy, biodiesel, energy-efficiency
Sustainability	sustainability-assessment, sustainable, sustainable-agriculture, sustainable-innovation, eco-efficiency, environmental-sustainability, sustainable-manufacturing, sustainable-development, sustainability
Waste reduction	air-stripping, sewage-treatment, waste-water, wastewater-treatment, waste

An accurate analysis was sought in each word not to result in situations of duplicity, that is, the same word to serve two groups at the same time. The words found in the article set surveyed were 972. Of this total, 308 that did not have importance for the subject was subtracted, because they were referred to regions or also to expressions that did not contribute to the field of study. With this filter applied, it resulted in 664 important words that were embedded in the themes. Because the quantity of the terms was very relevant, we chose to categorize the words that had at least two repetitions. In these terms, 76 different words were obtained.

To elucidate the themes present, each of them will be briefly described. In (a) Biochemical components can be used for biogas production in an industrial environment (Naqi et al., 2019). To (b) Cleaner Production Practices are those that promote an environment that reduces environmental impacts, such as planning aimed at treating tailings in an ore exploration mine, for example (Yin et al., 2020). In (c) Economic Aspects are taken into account business efforts to focus on Cleaner Production and have a sustainable business model (Aryanasl et al., 2017).

In (d) Emission Reduction, we take into account projects that can favor the reduction of pollution by replacing materials and process adjustments (Forster et al., 2020). In (e) Environmental Impact, there are the strategic actions adopted by the companies and the positive or negative results that unfold these actions (Li and Zhao, 2015). In the theme (f) Industrial Companies, the intention is to analyze the characteristics of the implementation of Cleaner Production in different production sectors (Staniškis and Katiliūtė, 2019). (g) Logistic can be a powerful weapon for organizations, contributing to the regulation of inventories, so that organizations do not spend energy unnecessarily with a high surplus of inventories (Piyathanavong et al., 2019).

The (h) Management and System are closely linked to meeting the goals of a factory in cleaner production (Staniškis and Katiliūtė, 2019). In (i) Organizational Culture, companies incited to raise awareness of employees about the good practices they need to incorporate that can be carried out through corporate training and as for (j) Quality, we study how to improve the processes of Cleaner Production in organizations (de Oliveira Santos et al., 2019). Renewable Energy seeks an understanding of the current energy scenario and the possibilities in increasing supply and cost of implementation in production units (Yu et al., 2016). The (l) Sustainability approach was a way that organizations found to respond to stakeholder pressures to reduce environmental impact (Piyathanavong et al., 2019). The last theme addressed is (m) Waste Reduction, which consists of efforts to reduce the amount of waste, aiming to reduce the number of harmful emissions to nature and optimize productive resources (Staniškis and Katiliūtė, 2019).

Table 5 shows the evolution of percentages in Cleaner Production from 2014 to August 2019. From the keywords grouped, according to the sample of Table 4 that demonstrates the terms with at least two documents

identified in the studies, it can be seen that the topic of Cleaner Production Practices is predominant in all periods, which was already expected since it is the very term of the content surveyed.

Among the most important themes, in 2014 and 2015 Sustainability, Biochemical Components and Management and Systems were highlighted. In 2016 and 2017 Biochemical Components, Management Systems and Industrial Companies were highlighted. In the last two years, the Industrial Companies, Biochemical Components, and Sustainability were maintained. The issues that were least representative among those mentioned were Logistics, Quality, Environmental Impact, and Organizational Culture. Waste Reduction, Renewable Energy, Emission Reduction and Economic Aspects obtained intermediate positions in the analysis.

Table 5. Evolution of the topics Cleaner Production from 01.2014 to 08.2019

Research theme	A 2014	%	B 2015	%	C 2016	%	D 2017	%	E 2018	%	F 2019	%	E - B
Biochemicals components	5	8,77%	7	9,09%	15	10,34%	24	13,79%	19	11,59%	13	13,00%	2,49%
Cleaner production practices	19	33,33%	27	35,06%	42	28,97%	44	25,29%	39	23,78%	23	23,00%	-11,28%
Economic aspects	2	3,51%	4	5,19%	6	4,14%	4	2,30%	6	3,66%	10	10,00%	-1,54%
Emission reduction	3	5,26%	2	2,60%	5	3,45%	10	5,75%	13	7,93%	6	6,00%	5,33%
Environmental impact	3	5,26%	1	1,30%	5	3,45%	6	3,45%	4	2,44%	1	1,00%	1,14%
Industrial companies	5	8,77%	8	10,39%	17	11,72%	14	8,05%	19	11,59%	14	14,00%	1,20%
Logistic	0	0,00%	1	1,30%	0	0,00%	3	1,72%	0	0,00%	0	0,00%	-1,30%
Management and systems	5	8,77%	6	7,79%	14	9,66%	21	12,07%	17	10,37%	11	11,00%	2,57%
Organizational culture	2	3,51%	5	6,49%	6	4,14%	7	4,02%	5	3,05%	3	3,00%	-3,44%
Quality	1	1,75%	1	1,30%	7	4,83%	4	2,30%	1	0,61%	0	0,00%	-0,69%
Renewable energy	1	1,75%	2	2,60%	8	5,52%	14	8,05%	10	6,10%	6	6,00%	3,50%
Sustainability	8	14,04%	9	11,69%	12	8,28%	10	5,75%	17	10,37%	12	12,00%	-1,32%
Waste reduction	3	5,26%	4	5,19%	8	5,52%	13	7,47%	14	8,54%	1	1,00%	3,34%
TOTAL	57	100%	77	100%	145	100%	174	100%	164	100%	100	100%	

To identify the growth in percentage points of the Cleaner Production knowledge field (Table 5), we chose to use the percentage values of the 13 themes of 2018, the last year that was evaluated an entire period, subtracting from the percentage values of 2015, because that period has more maturity than the initial year of the analyses. It was noted in this analysis that the theme that showed the greatest growth was the Emission Reduction, with a growth of 5.33%. The second fastest-growing theme was Renewable Energy, with 3.50% and the third Waste Reduction with 3.34%. Although Cleaner Production Practices was the item with the highest percentage of studies, it was the topic that presented the greatest drop, with 11.28%. The second item with the greatest drop was Organizational Culture with 3.44%. This information can be seen in Figure 6.

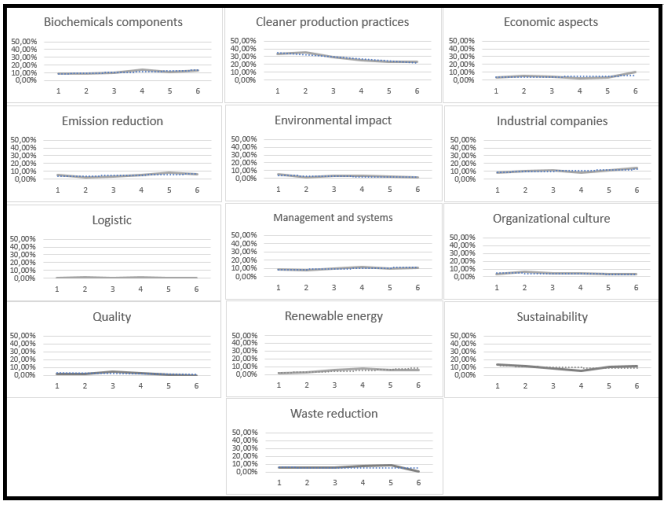

Figure 6. Graphical evolution of research themes

It should be noted that in 2019, the term Waste Reduction showed a drop, with information up to August of last year, while Economic Aspects showed an increase. The themes that present a clear sign of stagnation in the field of Cleaner Production are Environmental Impact, Logistic, Organizational Culture, and Quality, while

the other themes, although some present a decrease, are relevant and deserving of attention from the scientific community.

5. Conclusion

The purpose of this article was to identify in the literature the level of development of CP, being a guide for further research on the theme. Thus, bibliometric analysis provided some findings about the state of the art of CP. The ten countries and authors most cited are the ones that most take initiatives in the development of CP. These countries' and authors' works can be references for new studies on the theme. The analysis of the journals indicated those that most concentrated the articles published on CP in the studied period. The Journal of Cleaner Production stood out for publishing more than 90% of these works being the reference journal for future research on the theme.

At the same time, the analysis of keywords showed which are the main research topics in conjunction with the CP, and which are increasing or decreasing in importance. This analysis can be useful when choosing new research topics.

The scientific contribution of this work was to identify the advances in the literature and to analyze the state of the art on the theme. The practical contribution consisted in the identification of possible aspects to be researched and explored on the theme in future works.

The great novelty of this work was the bibliometric analysis on the theme, allowing the identification of the main countries, authors, newspapers, and keywords. Besides, the identification of keywords can be used as a guide for future researchers on which subjects related to CP should or should not be explored.

As future research, the authors suggest the identification of the scientific gaps in the most cited articles on the theme. Thus, new strategies, practices, and methods for the rising keywords identified in this work can be developed.

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