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Environment

Environmental management and organic waste in urban areas: an analysis from 1992 to 2021

Gestão ambiental e resíduos orgânicos no meio urbano: uma análise de 1992 a 2021

Helder Araujo de Carvalho[I], **João Batista Lopes**[I], **José Natanael Fontenele de Carvalho**[I]

[I]Universidade Federal do Piauí, Teresina, PI, Brasil
[II]Universidade Federal do Delta do Parnaíba, Parnaíba, PI, Brasil

ABSTRACT

Environmental problems have provoked concerns that run through scientific research, laws, and even the definition of public policies. It is undeniable that efforts have been made to include environmental issues in legislation and improve existing environmental policies, especially with regard to proper waste management. This study aimed to analyze the evolution of publications and identify trends in the scientific environment in relation to environmental management and organic waste in the urban environment, considering the period from 1992 to 2021. This is a scientometric, descriptive, and exploratory study. Quantitative and qualitative approaches were used to process the data collected from the Web of Science (WoS) and Scopus databases. Recent scenarios have shown that environmental management and organic waste occupy a prominent place in journals considered to have a high impact factor. In addition, the topics covered in the publications are versatile, reflecting diverse disciplinary perspectives such as environmental science, public policy, cultural studies, and technological innovation. These diverse angles of analysis provide an understanding of how complex and comprehensive the issues related to organic waste management in urban environments are, thus revealing its potential and the ongoing interest of researchers.

Keywords: Research trends; Scientometric analysis; Environmental impact

RESUMO

Os problemas ambientais têm provocado inquietações que perpassam pelas pesquisas científicas, leis e até mesmo nas definições de políticas públicas. É inegável o esforço dispendido no sentido de incluir a questão ambiental na legislação e aperfeiçoar as políticas ambientais existentes, principalmente no que tange à gestão adequada dos resíduos. O presente estudo destinou-se a analisar a evolução

das publicações e identificar as tendências do meio científico em relação à gestão ambiental e dos resíduos orgânicos no meio urbano, considerando o período de 1992 a 2021. Trata-se de um estudo que se enquadra como cientométrico, do tipo descritivo e exploratório. Utilizou-se as abordagens quantitativa e qualitativa para o tratamento dos dados coletados nas bases de dados Web of Science (WoS) e Scopus. Constatou-se, em cenários recentes, que gestão ambiental e resíduos orgânicos ocupam espaço de destaque em periódicos considerados de alto fator de impacto. Além disso, os temas abordados nas publicações são versáteis, refletindo diversas perspectivas disciplinares, como ciências ambientais, políticas públicas, estudos culturais e inovação tecnológica. Esses diversos ângulos de análise permitem compreender o quão complexas e abrangentes são as questões relacionadas à gestão de resíduos orgânicos em ambientes urbanos, revelando assim o seu potencial e o interesse contínuo dos pesquisadores.

Palavras-chave: Tendências de pesquisa; Análise cientométrica; Impacto ambiental

INTRODUCTION

With the advance of environmental problems in different parts of the planet, there have been constant debates about the sustainability of different production systems, particularly organic waste. Therefore, efforts have been directed towards incorporating environmental issues into legislation, seeking to improve existing environmental policies with regard to proper waste management.

Thus, progress has been made in various contexts, albeit insufficient, on the subject of waste, and the National Solid Waste Policy (Law n. 12.305/2010) represents a milestone that is a good example of this movement (Brasil, 2010). Based on this legal framework, various areas of knowledge have looked at this issue, including approaches that include morphological aspects (Nemergut et al., 2008; Suleiman, 2016), socio-economic aspects (H. Silva et al., 2012), cultural issues and the effects of consumption habits on nature (Mucelin & Bellini, 2008), as well as modern debates, such as the effectiveness of smart cities (Ahvenniemi et al., 2017; Junior & Duenhas, 2020).

Conversely, municipalities are finding it increasingly difficult to create a waste management plan or even to properly dispose of solid waste. Recent findings indicate that out of 5,570 Brazilian municipalities, around 1,040 dispose of their waste correctly (Santiago et al., 2023), which corresponds to 18.13%. Another situation that precedes

the problem of the final disposal of waste at the municipal level is related to the difficulty municipalities have in collecting waste generated in the urban environment. The Brazilian Association of Public Cleaning and Special Waste – ABRELPE (2020, 2022) points out that the states located in the North and Northeast regions of Brazil experience this reality, highlighting the difficulties faced by the states of Ceará, Pará and Maranhão.

It should be noted that municipalities have used either selective collection or conventional models, in which residential solid waste is collected without distinguishing between types of waste. In addition, the adoption of selective collection by municipalities as a waste management strategy has led to incorrect segregation of waste, which has already been reported in the literature. A recent study in a municipality in the state of Paraná found that around 55 kg/month of waste, mainly organic, was sent to a recycling cooperative (Cembranel et al., 2021).

In Brazil, for example, regardless of the model adopted by the municipality, there is the inherent challenge of inadequate disposal in all five regions of the country (Santiago et al., 2023). Similar data was identified in India by Pujara et al. (2019), where of the 243 million tons of waste generated in the country's 28 states, 158 million tons per year were deposited in dumps and/or incinerated.

Santana and Biluca (2020) found similar behavior in another region of the state and suggest that this habit is related to low environmental education, which corroborates the argument made by Pujara et al. (2019) about the importance of educational actions in parallel with selective collection programs. In this sense, Rodrigues et al. (2015) point out that inadequate management, whether at the collection stage or by the generating source, will incur greater costs for municipal management, the community and the environment.

Therefore, the municipal manager needs to develop actions aimed at expanding and implementing effective policies that serve the general interest, with the possibility of building a sense of trust and involvement of society with regard to environmental issues (Andion, 2012; Monteiro et al., 2017). The application of such policies is perceived

by Pujara et al. (2019) as a means of discussing sustainable waste management in the urban environment and thus seeking to promote social, environmental and economic development.

There are many studies on environmental management and solid waste management, focusing mainly on specific types of waste, such as construction waste and health care waste. However, organic waste types require attention, as they are just as polluting as other types. According to Zago and Barros (2019), the National Solid Waste Policy failed, for example, by not giving such importance to the organic fractions present in urban or rural areas.

Perhaps this is why the scientific community has put more effort into working on the management of urban waste as a whole. As a result, the literature does not show a proportional number of studies relating environmental management and organic waste compared to the number of studies in each area separately.

In order to better understand the reality of studies dealing with environmental management and organic waste, this study was carried out with the aim of analyzing the evolution of publications and identifying trends in the scientific community in relation to environmental management and organic waste in the urban environment, considering the period from 1992 to 2021.

THEORETICAL BACKGROUND

Studies on waste are not new to academia, but there is still a lot to be explored and debated. Furthermore, little is known about the types of waste, their potential impact and how municipal management can manage them more effectively. In this sense, organic waste has attracted the attention of many researchers and, consequently, has occupied space in editions of reputable journals (*Journal of Environmental Management*, *Waste Management* and *Journal of Cleaner Production*) with a high impact factor (Ayvaz-Cavdaroglu et al., 2019; Botti et al., 2020; Lu et al., 2020).

Due to their characteristics, organic waste can be treated and valued in order to

direct it towards the production of renewable energy and composting, thus reducing the overload on landfills, dumps and consequently reducing environmental impacts. This possibility requires a commitment from municipal managers and society to mitigate impacts and greenhouse gas emissions (Hebda et al., 2016; Wei et al., 2017).

Some studies have already shown that composting is a low-cost, easy-to-implement and effective strategy due to its potential to revitalize the soil and reduce greenhouse gas emissions (Pace et al., 2018; Wei et al., 2017; Yong et al., 2021). Others agree, based on their findings, that any and all actions by the municipality must be aligned with the search for sustainable development when it comes to managing and using its waste (Pujara et al., 2019; Silva et al., 2017).

In this way, popular participation is of the utmost importance, as it contributes to integrated waste management and leads managers to reflect on the potential of waste for use in gardens and community gardens. This positioning also motivates municipal managers to look at the matter with more attention and zeal, in order to practice sustainable development and thus value the social, environmental and economic sectors (Pujara et al., 2019; H. Silva et al., 2012).

This political concern and social pressure is accentuated when updated reports are released on the state of waste in the world. Kaza et al. (2018) report that around 70% of the waste generated by society is deposited in landfills or dumps. Brazil alone generates 79 million tons; 72 million tons are collected and 29 million tons end up in dumps and controlled landfills. The projections for 2050 are that there will be a jump in per capita generation of 19% in developed countries and 40% in others. In the case of Brazil, this will correspond to an increase of approximately 153 kg compared to the 379 kg recorded in 2019 (ABRELPE, 2020; Kaza et al., 2018).

In this sense, the proper environmental management of waste, especially the organic fractions, is relevant for the environment and consequently for the urban environment, as it improves people's quality of life, reduces the costs of correcting environmental impacts, contributes to the optimization of public money by directing

it to education or health and can generate inputs for social projects, such as fertilizers and biofertilizers, and renewable energy from the use of biogas (Isa et al., 2020; Yong et al., 2020, 2021).

MATERIALS AND METHODS

Due to its characteristics, this work is classified as scientometric, of the descriptive and exploratory type, since scientometric studies use qualitative data inherent to research in a database to understand existing paths and gaps on a given research topic (Macias-Chapula, 1998; Parra et al., 2019). Given these characteristics, the method does not limit itself to analyzing findings or judging a study in isolation.

For this purpose, a quantitative and qualitative approach was used to analyze the data collected in the Web of Science (WoS) and Scopus databases. The relevant quantitative data, which could be analyzed under scientific rigor, was evaluated using frequencies. The qualitative part focused on interpreting and translating the papers found in the data collection phase, as well as correcting the information contained in the database which, due to its characteristics, summarizes some of the information inherent to the papers.

In order to operationalize the search, the terms “environment* management”, “organic waste OR waste organic” and “municipal OR urban” were used in the “topic” search in an attempt to find the existing literature in the databases cited. In order to refine the search, we decided to look only at papers published between 1992 and 2021. We chose this search configuration and approach on the understanding that the time interval defined would be able to highlight the state of the art and point to trends on the chosen topic. After applying the defined filter words and excluding papers from both databases, the final sample consisted of 82 papers, 74 of which were published in qualified journals and eight in congresses[1].

[1] Congresses: Sustainable city II: Urban regeneration and sustainability (2002); Environment materials and environment management (2010); 3RD International conference on civil and environmental engineering for sustainability (ICONCEES 2015); International scientific and practical conference on environmental risks and safety in mechanical engineering (2020).

The journals are considered qualified to meet the research target because these databases use rigorous selection and indexing processes that take into account the impact and scientific quality of the journals. The application of these search and selection criteria aimed to ensure methodological rigor in order to obtain consistency in the studies analyzed and to meet the proposed objective of this research.

The choice for the WoS and Scopus databases took into account the way they systematize information on papers, relevance, scope in terms of journals and time coverage. The data resulting from the research was merged and then processed to avoid double counting/analysis and/or the absence of information that would make data analysis and interpretation unfeasible.

The papers included in the research were statistically analyzed with the support of the R statistics programming package and the bibliometrix library. This made it possible to analyze the publication frequencies of the papers found, the universities and partnerships that have emerged with an interest in the subject, the most cited authors, as well as the publication trend in recent years.

RESULTS ANALYSIS AND DISCUSSION

Table 1 shows data that makes it possible to understand the dynamics of the information contained in the papers covered in the period from 1992 to 2021. The collection resulted in 82 papers from 29 journals, with an increase in publications on the subject ranging from four to eleven publications over the last seven years (2014-2021).

The total number of papers also resulted in 1,300 words (998 Keywords Plus and 305 Author's Keywords) identifying them, originating from 339 authors, corresponding to an average of four authors per publication. Of the total number of papers, eight were single-authored, while the remaining papers had an average of four (4.05) authors each. The overall collaboration index, which takes into account both single-country and multiple-country publications, is 4.38.

The average years of publication, representing the average time between the

publication of the articles and the year of data collection (2021), was 7.3 years. This indicates that the analyzed articles include a mix of recent and older studies, which is acceptable considering the multiple approaches that have been adopted to study the topic.

Table 1 – Description of the data obtained in the survey

Description	Results
MAIN INFORMATION ABOUT THE DATA	
Time interval	1992 – 2021
Sources (journals)	29
Congresses (proceedings paper)	4
Documents	82
Average years of publication	7.3
DOCUMENT TYPES	
Paper	82
DOCUMENT CONTENT	
Additional keywords (ID)	998
Author's keywords (DE)	305
AUTHORS	
Authors	339
Authors appearance	339
Collaboration Index	4.38

Source: Elaborated by the authors (2021)

Figure 1 shows the journals in order of relevance and number of publications involving organic waste and environmental management in the urban environment. *Journal of Environmental Management* (impact factor 8.0, Q1[2]), *Waste Management* (impact factor 7.1, Q1), *Journal of Cleaner Production* (impact factor 9.7, Q1) and *Resources Conservation and Recycling* (impact factor 11.2, Q1) stand out for having more than five papers published over the period surveyed. This prominence is likely due to the journals' specific focus on waste and environmental management, highlighting the importance of these topics.

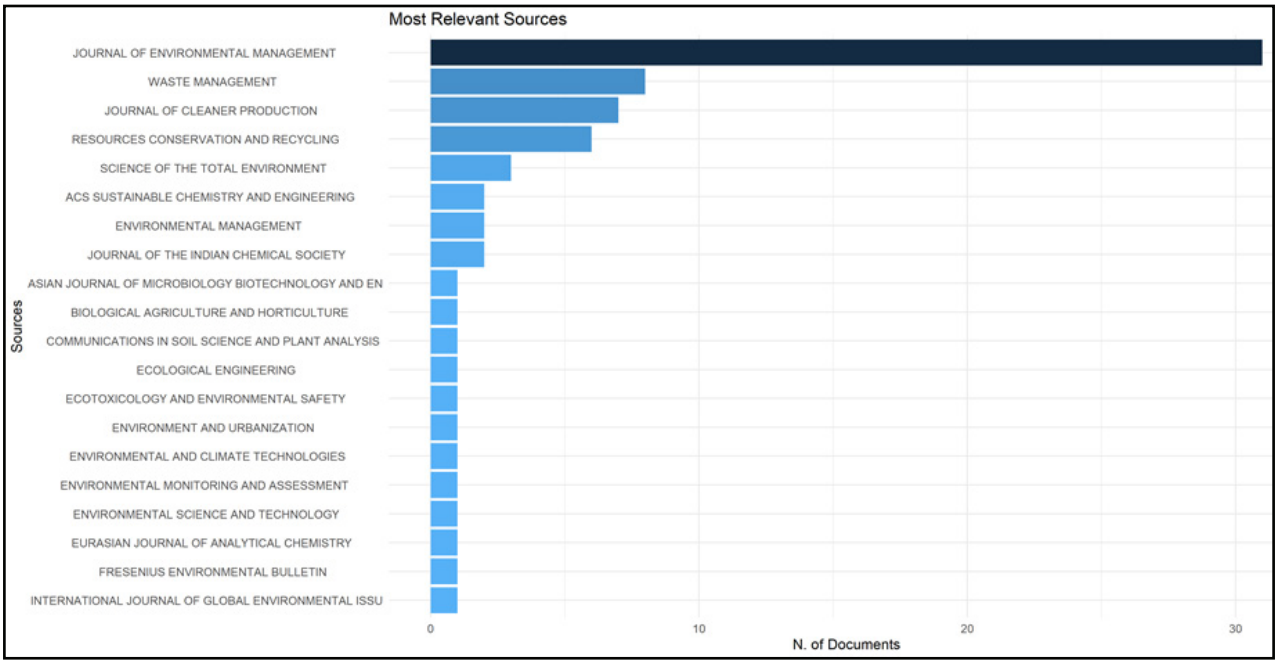
In addition to their scientific relevance and impact factor, due to the number of citations their publications receive, these journals share common interests, reinforcing

[2] Quartile 1 (Q1) includes the most influential journals in their field of study, characterized by publications with a high number of citations and considered of great scientific importance. These journals are qualified in the academic community for the relevance and impact of their research.

the observation that they have already recognized the importance of the topic or are moving towards expanding the space for topics related to organic waste management. For example, the Journal of Environmental Management addresses in its scope the improvement of environmental quality, focusing on waste management and pollution control.

Similarly, Waste Management demonstrates interest in waste management, presenting solutions for waste reduction, recycling, and disposal. The Journal of Cleaner Production mentions in its scope an interest in research on environmental sustainability and strategies for managing waste generated by production and consumption. Resources Conservation and Recycling publishes studies focused on resource recycling, including organic waste.

Figure 1 – Journals with the Highest Number of Publications



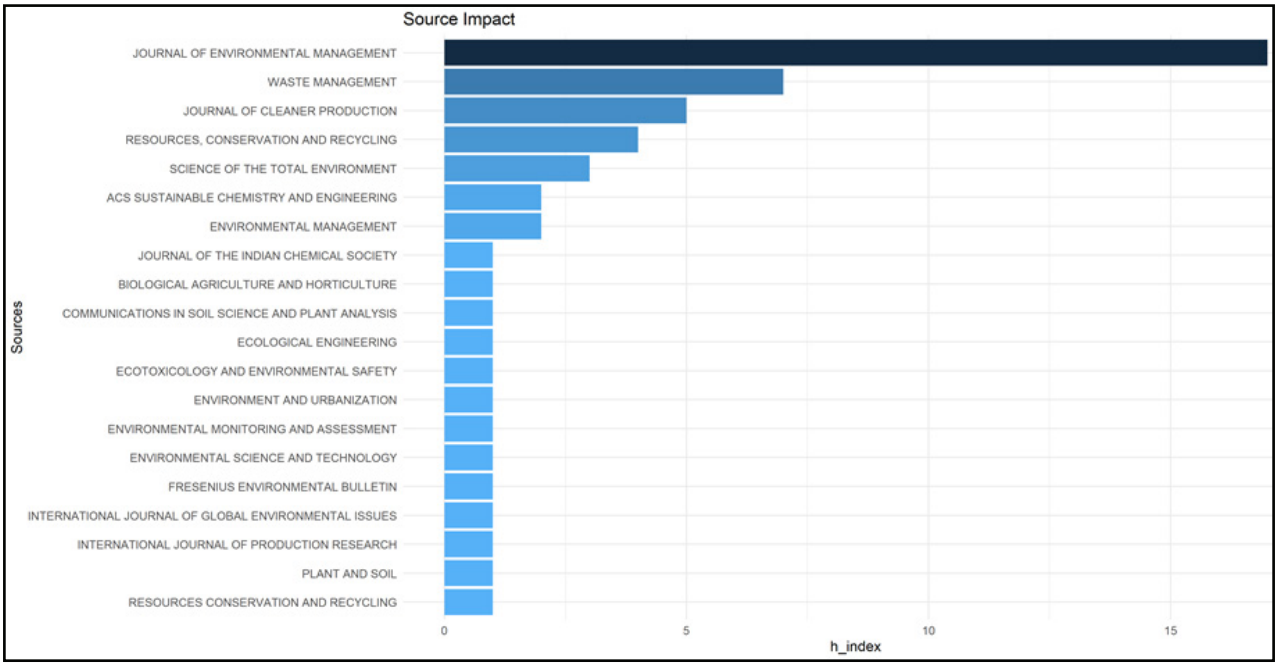
Source: Elaborated by the authors (2021)

From the same perspective, looking at Figures 1, 2 and 3, there is evidence of a movement in which interest in the subject possibly began in the journals with the highest number of papers and then spread to other journals. This assumption is endorsed not only by the number of publications, but also by the high impact factor

(h-index3). We believe that, in some way, publications in these journals induce other authors to research and disseminate their results in more journals.

Some authors stand out as those who have produced relevant work, taking into account the journal's h-index. Names such as Lee C., Bater J., Edwards C., Klemes J. and Lim J. lead this list with an impact equal to or greater than two (h index ≥ 2) because they have signed two or more papers that have been cited at least twice each. In their studies, these authors deal with composting, black soldier fly larvae, anaerobic biodigestion, biogas and the energy potential of waste and the benefits for proper environmental management in the urban environment.

Figure 2 – List of journals by impact factor



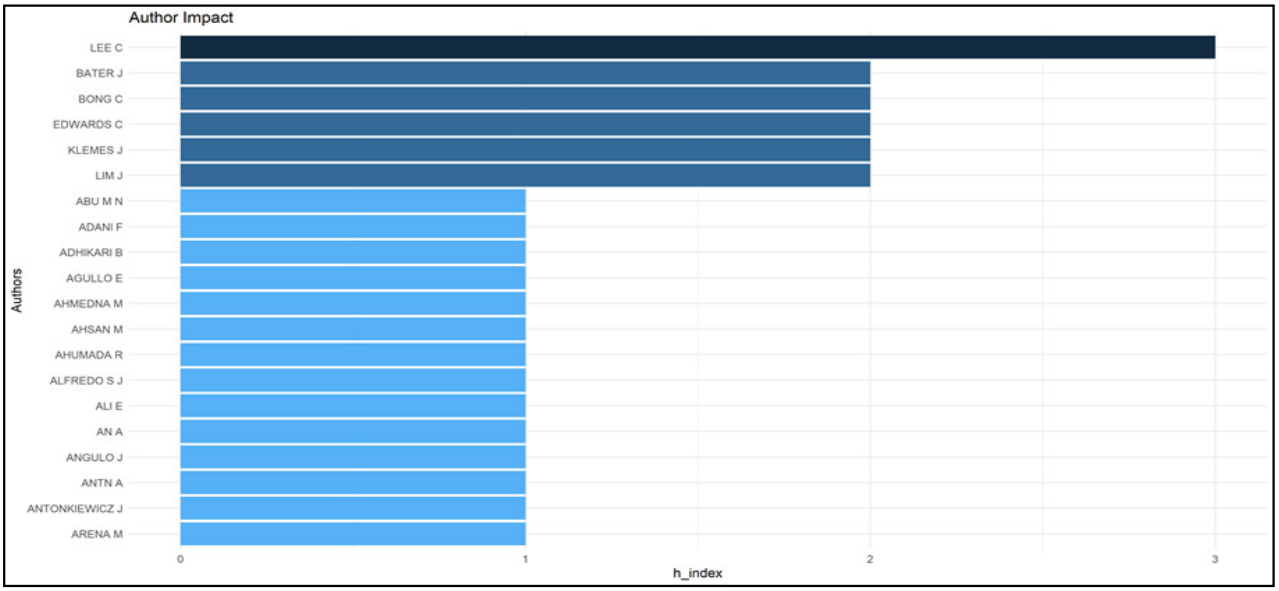
Source: Elaborated by the authors (2021)

In addition, it was observed that, regardless of the year of application, as in the case of the work by Edwards and Bater (1992), papers involving the subject of this study have gained greater prominence recently and this may have boosted citations in papers that studied organic waste from different perspectives. The justification for

[3] The h-index measures the productivity and impact of a researcher's published work by relating the number of published articles to the number of citations those articles receive.

this movement can be found, for example, in Raksasat et al. (2020) and Carvalho et al. (2022). According to these authors, organic waste has been portrayed in works from different theoretical approaches due to its annual increase, because it is a major problem for countries at different levels of development and because of the negative effects it causes to the environment when poorly managed.

Figure 3 – List of authors by impact factor



Source: Elaborated by the authors (2021)

The word cloud in Figure 4 shows the terms and expressions related to the subject under investigation, such as environmental impact, waste, landfill/appropriate disposal, life cycle, LCA, composting, waste treatment, recycling, food or organic waste, and anaerobic digestion.

Some expressions are more prominent due to the frequency with which they appear associated with the topic. In addition, the associations highlight the various approaches to the subject, such as chemistry, biology, environmental management and life cycle assessment/studies (LCA).

This multiplicity of perspectives is possible due to the intrinsic potential of organic waste, which enables composting, the generation of biomass, biogas and other forms of reuse/utilization for effective environmental management in urban areas. These

products result from the use of organic waste and various studies have explored their benefits and impacts on effective environmental management in municipalities.

In recent years, governments have been faced with the growing generation of organic waste in urban areas, which has led to the need to achieve a circular economy for this type of waste. Babu et al. (2021) point out that there are different viable strategies for using waste, such as anaerobic digestion, composting, hydrothermal carbonization, pyrolysis and landfill (extraction of gas for energy generation), but that these will only become effective through the involvement of local and national governments.

Figure 4 – Word cloud of the most frequent keywords

Source: Elaborated by the authors (2021)
Note: The word cloud was generated using the bibliometrix library

In a municipal study that examined organic household waste from the perspective of environmental management and cost to the public purse, carried out in the state of New York, it was found that anaerobic digestion and composting are the most effective strategies and least costly to the public purse (Hebda et al., 2016). At the same time, other investigations have added LCA to waste management studies. In proposing an impact assessment model based on LCA, Deus et al. (2020) identified that few municipalities manage waste properly with the aim of recycling and reducing GHGs.

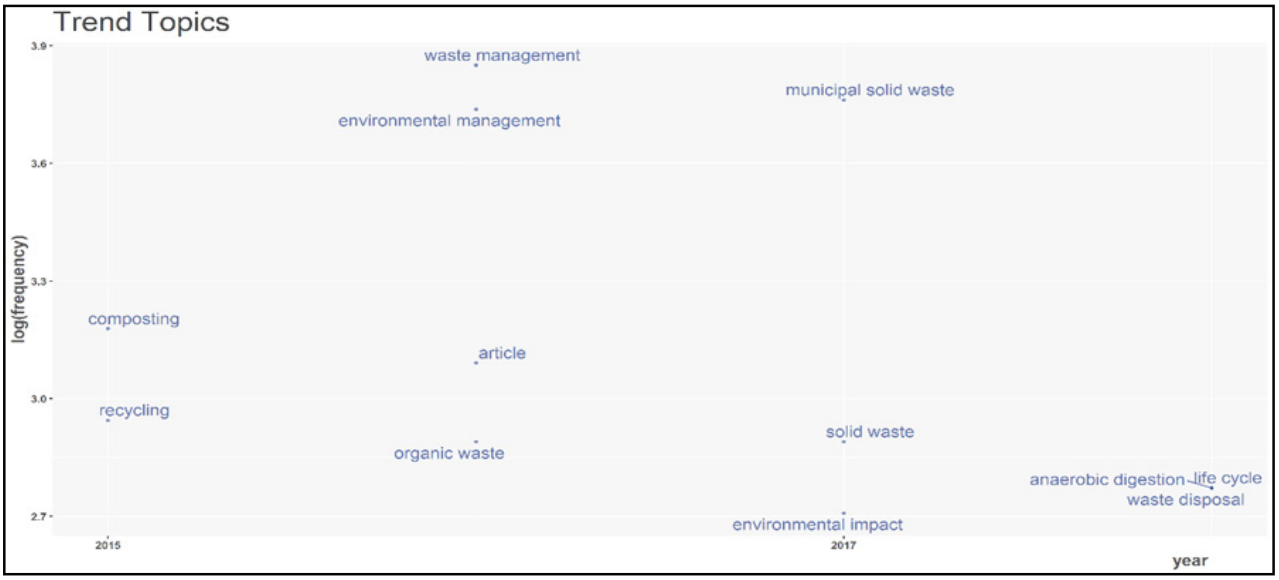
Of the twenty best-evaluated municipalities in the state of São Paulo, only

one (Ribeirão Grande) separates and composts vegetable waste. It has a waste separation system for composting and simultaneously emphasizes the importance of environmental actions through environmental education projects/actions (Deus et al., 2020).

One of the advantages of working with scientometric analysis is the possibility of extracting information that indicates current topics and/or topics covered in studies in recent years. Figure 5 shows the trend topics found in Scopus and WoS papers.

It can be seen that in the last five years, research on composting, recycling, life cycle, anaerobic digestion, management and final disposal of waste are topics that permeate or surround the subject of organic waste. Concurrently, environmental management and environmental impact also appear, signaling both the greater interest in recent research and its relevance to organic waste.

Figure 5 – Trend topics



Source: Elaborated by the authors (2021)

The rise of these topics is based on a number of issues that have motivated work in this area. The first problem, which leads to the others, is the growth of solid waste in urban areas, as well as its management and final disposal. Another problem concerns organic waste, which is aggravated by the increase in food waste and, according to

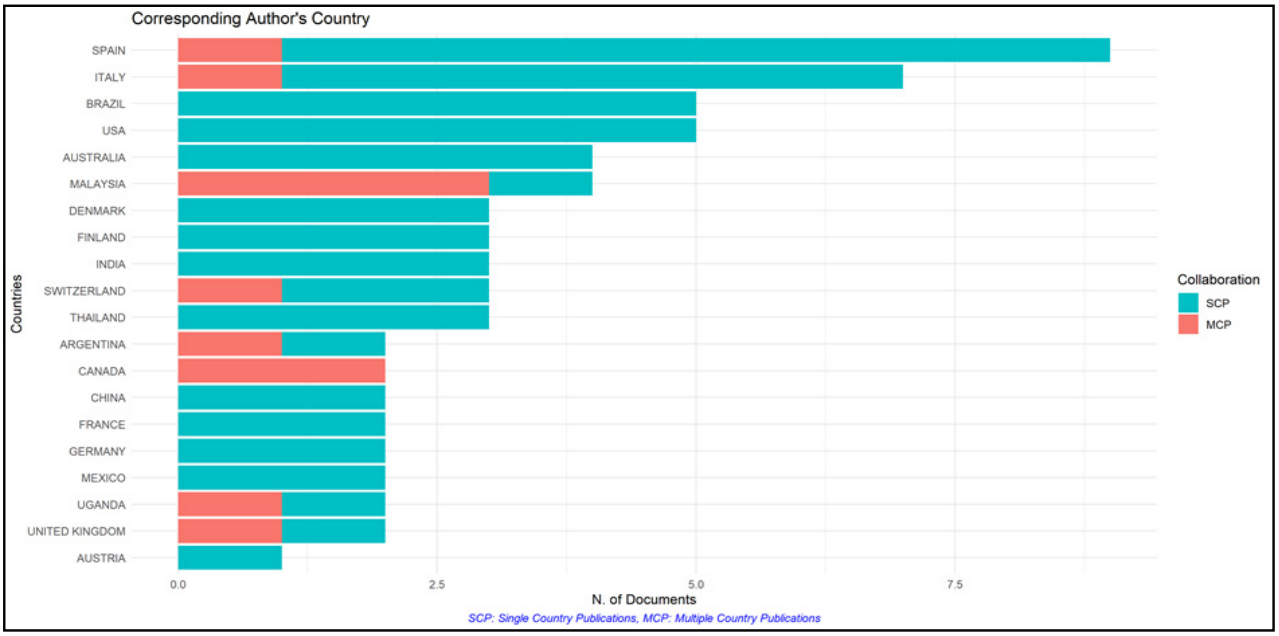
Thi et al. (2015), accounts for around 50% of the total weight of household waste in developing countries. Some studies report that this situation has accentuated the environmental impact in urban areas and overloaded final disposal sites (Raksasat et al., 2020; Wei et al., 2017).

The third aspect is related to the energy potential of proper organic waste management. This includes the segregation of waste to optimize processes such as composting, biogas production, and the creation of biofertilizers from recycled materials. With this in mind, studies linked to circular economy have emerged in recent years, aiming to assess the most suitable and profitable ways of redirecting this type of waste by public management, for example. Although these methods have been the subject of studies in countries with different levels of development, they are far from representing definitive solutions. According to Wei et al. (2017), cases such as those found in the UK, USA, Japan and China are a good illustration of the relationship between high effort/investment in implementation and low effectiveness. According to them, it is important to identify the barriers that prevent actions such as composting from becoming a reality in urban environments.

Figure 6 shows how production and cooperation has taken place between the authors who have published on the subject studied. Brazil, the United States, Italy and Spain lead the ranking of countries with the largest number of publications (greater than or equal to five papers), as a result of cooperation between authors of the same nationality (Single Country Publications – SCP). The network of collaboration between authors from different countries (Multiple Country Publications – MCP) is noteworthy because some countries, even with a lower number of papers, are more inclined to develop papers with the participation of authors from different nationalities.

The availability of cooperation, especially between authors of different nationalities, makes it possible to carry out cross-cultural studies or analyze cases that can contribute to research with greater visibility and scientific recognition, due to the relevance of the topic, innovation and breadth of investigation.

Figure 6 – Cooperation between authors



Source: Elaborated by the authors (2021)

Moreover, this situation reinforces the fact that waste management is the subject of research between and within countries, on different continents and at different levels of development. Among the examples of collaboration involving nationalities that have investigated the issue from some perspective, we highlight the partnerships between Malaysia, Japan and the Czech Republic, as well as the partnership between Switzerland and Uganda. These collaborations signal efforts to investigate diverse realities.

These partnerships enable the comparison of results and the adaptation of successful strategies in countries facing different economic, social, and/or cultural challenges. Furthermore, they improve the understanding of organic waste management in different contexts and can promote important reflections that will lead to the development and improvement of solutions aimed at reusing these materials or transforming (circular bio-economy) them to mitigate their impacts. Some authors did not limit themselves to discussing strategies and their applications but also considered the costs of the waste recovery process as a way to reduce greenhouse gas emissions (Lu et al., 2020; Wei et al., 2017). For example, they found that source segregation

proved advantageous, more cost-effective, and less environmentally impactful (Hebda et al., 2016), but it yields better results when municipal management directs organic waste, free of other materials, to windrow composting (Lu et al., 2020).

Finally, it can be seen that there is no specific region interested in investigating organic waste management, but rather that it is a global phenomenon that is requiring the attention of different players in order to achieve local sustainability. The complexity of urban waste is well exemplified by the finding of Wei et al. (2017), which points out that the effort to improve waste management and the effective results are not directly proportional. Since this is a complex and multifaceted phenomenon, it requires an in-depth understanding of how to deal with waste at different times, from its collection, transportation, processing, composting, regulation and promoting public awareness of the environmental impacts of this waste.

In addition to cultural and regulatory aspects contributing to the understanding of local particularities and aspirations, geographic factors also play an important role in driving studies. For example, population growth increases the demand for food, which in turn generates more waste, highlighting its potential for research opportunities under the circular economy perspective or environmental impacts (Babu et al., 2021; Lu et al., 2020).

CONCLUSIONS

The results obtained in this study indicate that organic waste management has been gaining ground in high-impact journals and specialized channels for disseminating knowledge on the subject under investigation, such as the *Journal of Environmental Management* and *Waste Management*. The relevance of these journals, as well as the papers published, encourages further studies to explore the gaps that still exist and encourages other journals to publish papers along the same research lines.

In this context, we conclude that we have achieved the proposed objectives of analyzing the evolution of publications on environmental management and organic

waste in the urban environment and identifying trends from 1992 to 2021.

The topics are considered versatile, as they can be studied from different perspectives, such as biology, chemistry, public administration and public policy. In addition, they also engage in dialog with relevant topics, such as life cycle studies, enabling research that combines various theoretical approaches.

The authorship of the papers corroborates the perceptions pointed out here about organic waste being a global problem, as the studies are conducted in several countries. In addition, the relevance and interest in the topics also led to the collaboration of authors from different countries to expand knowledge in relevant journals focused on the dissemination of studies on environmental management and waste.

The joint efforts of researchers around the world have enabled the development and understanding of strategies for using waste, with a focus on promoting the circular economy. Among the consequences of this effort, it has been noted that over the years researchers have broadened the scope of their research to measure the costs involved in recovery and at what point in the collection process there is greater recovery, lower cost and environmental impact, as a result of proper management. On the other hand, considering the existing and consolidated knowledge on strategies with less complexity and application costs, the literature continues to target countries at different levels of development.

In addition to contributing to the expansion of knowledge about organic waste management, its environmental impact and the benefits resulting from valuation strategies, international cooperation can move towards identifying not only effective technical issues, but also the limiting factors that prevent the effective application of organic waste management. Perhaps these are the reasons why research is conducted indiscriminately in countries with different economies.

Due to its multifaceted nature, the complexity of organic waste management implies the need to engage various actors linked to waste, from generation to final

disposal, which may be the underlying reason for the difficulty in achieving effectiveness in the process. It also demands the incorporation of knowledge from different areas in order to develop multiple solutions and strategies to manage it properly, such as economics, public administration, accounting, chemistry, law, and public policies.

As a next step, we recommend the construction of a framework that makes it possible to identify existing gaps in the broad areas of knowledge on environmental management with a focus on organic waste, in the search for a healthy environment, anchored in the broad aspects of sustainability.

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Contribuição de Autoria

1 – Helder Araujo de Carvalho

Universidade Federal do Piauí
https://orcid.org/0000-0002-5349-4660 • heldercmaad@gmail.com
Contribuição: Conceptualization, data curation, formal analysis, investigation, methodology, project administration, resources, software, writing – original draft.

2 – João Batista Lopes

Universidade Federal do Piauí
https://orcid.org/0000-0002-0133-4366 • lopesjb@ufpi.edu.br
Contribuição: Data curation, methodology, supervision, writing – review & editing

3 – Jose Natanael Fontenele de Carvalho

Universidade Federal do Delta do Parnaíba
https://orcid.org/0000-0003-3748-390X • natanaelfontenele@ufpi.edu.br
Contribuição: Data curation, methodology, validation, visualization, writing – review & editing

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