sustainability

Systematic Review

Urban Waste: Visualizing the Academic Literature through Bibliometric Analysis and Systematic Review

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Abstract: The management of solid urban waste is one of the biggest problems currently faced by society and the economy. It can be considered a negative externality that arises as a consequence of the production and consumption processes of industry and society. This study consists of a bibliometric analysis to recognize the articles published and included in high-impact scientific journals, as well as a systematic review of the literature. We have collected 1897 research articles from the Scopus database that have been published between 1981 and 2021. We have identified the main subject areas, authors, institutions, and countries of these publications, as well as research trends in terms of resource management. Our findings show that since the 20th century, there has been quantitative and qualitative growth in this line of research, especially since 2006, and that four main trends have been defined: environment, society, technical aspects, and economic aspects. The economic field makes reference to the circular economy and its link to the objectives and sustainable development goals of the 2030 agenda, in which there is an important need to provide solutions to the problems generated as a consequence of the inadequate management of solid waste.

Keywords: urban waste; waste management; circular economy; environmental sustainability; bibliometric analysis; systematic review of the literature

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1. Introduction

The poor management of solid waste is a global problem in terms of environmental pollution, social inclusion, and economic sustainability. This is due to demographic growth, industrialization, and the development of urbanization, which has allowed the exponential increase in the rate of generation of urban solid waste [1], becoming an important challenge of the urban environment in most of the cities of the world today. One of these great problems refers to the planning of treatment systems that can deal with the quantity and composition of urban solid waste [2]. However, the proper management of urban solid waste is a determining factor in improving the environmental conditions of cities, with favorable repercussions for all agents of society [3]. Therefore, the management of solid waste is determined as a complex task that has social, economic, technological, and environmental implications for society and for local administrations [4]. From the point of view of Negrete M. et al. (2022), conceptual analysis indicates a strong link between the circular economy and sustainable production, waste management, and recycling [5]. According to Kaur et al. (2021) and Salguero-Puerta et al. (2019), for environmental and economic sustainability, it is important to minimize waste and maximize recovery; therefore, an adequate management of solid waste is within the work agenda for sustainable development, based on the current scenario of environmental crisis at a global level for half a century. The slow transition towards more sustainable production and consumption models aims to unite efforts to minimize the use of natural resources and therefore make a more efficient use of urban solid waste, with the aim of recovering material and extending its useful life under the circular economy system [6,7].

According to Zeller et al. (2019), the circular economy concept is currently being promoted in order to achieve greater waste prevention and better resource management by extending and closing the material cycle [8]. Life cycle assessment is a technique that has been widely used to analyze the municipal solid waste management system (MSWMS); therefore, the conducted analysis reveals that the integration of recycling, treatment, and disposal technologies is the most appropriate strategy. The choice of technologies and their performance, however, depends on the technological and socioeconomic context of the region studied. Furthermore, it is precisely in these terms that the effectiveness of the management of urban solid waste is linked to the integration of the 2030 Agenda with the sustainable development goals [9]. In this sense, the 2030 Agenda, through its action plan in favor of people, the planet, and prosperity, manages to integrate the three dimensions of sustainable development—economic, social, and environmental—through its 17 sustainable development goals [10]. Among them, the management of urban solid waste in objectives 11 and 12 is explicit [11].

From this point of view, the purpose of this research is to analyze the progress of scientific knowledge regarding the management of urban solid waste, considering as a primary objective to identify the advances in this field of research, the knowledge gaps, and the trends and future lines of research in which future work will be framed.

This research contemplates the importance of analyzing and studying the economic, social, environmental, and technical aspects in the management of urban solid waste. Therefore, reviewing the literature that deals mainly with the management of urban solid waste involves answering a certain number of questions: How does municipal solid waste appear in the relevant scientific literature? Who are the main researchers/experts working from this perspective? What are the main institutions that deal with urban solid waste studies? What lines of interest could be addressed in the future? The issue of solid waste management is considered highly relevant today, since it is applicable in numerous sectors of economic activity, such as the automotive industry [12], hospitality industry [13], construction [14], agriculture [15], or intelligent manufacturing [16], among others. In addition, and according to the literature review, it is highlighted that several authors have worked on different articles using the bibliometric analysis methodology in the field of urban solid waste (USW) (see, for example [5,6,17–19], among others). Other authors have already used the systematic review of the literature to propose solutions from multiple perspectives for the management of urban waste: the use of new chemical compounds during the processing stage [20,21], industry 4.0 applications [22], the strategies implemented to promote recycling [23], or the influence of interested parties [24], among others.

In this sense, we have used the bibliometric analysis technique because it involves statistical methods of bibliographic counting to evaluate and quantify the growth of the literature on a particular topic [17]. In addition, we have conducted a review of the most relevant literature in the area of study, which is why we have worked with the SCOPUS database, in which a sample of 1897 scientific articles have been studied during a period from 1981 to 2021, where the topic of interest is the management of urban solid waste. The research scheme contemplates four essential aspects (economic, social, environmental, and technical aspects) in the management of urban solid waste as the focal point towards which we address our analysis. Accordingly, the results show the contributions in this line of research, allowing the main authors, journals, institutions, and countries to be identified.

2. Data and Methodology

The main objective *of bibliometric analysis*, or scientometrics, is to identify, organize, and analyze the metadata of a certain line of research to examine an area during a specific period of time [25–27]. For its part, the systematic review of the literature makes it possible to investigate, synthesize, and evaluate the academic literature of a certain area of knowledge to explore new and little-explored topics, as well as identify gaps in the literature and establish future lines of research [28,29].

The identification of the research documents has been carried out following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) methodology, which consists of a 27-item checklist and a flowchart. Figure 1 shows the flowchart according to PRISMA that has been followed for the selection of the studies to be analyzed, differentiating three phases: identification, analysis and visualization, and results and discussion (Figure 1).

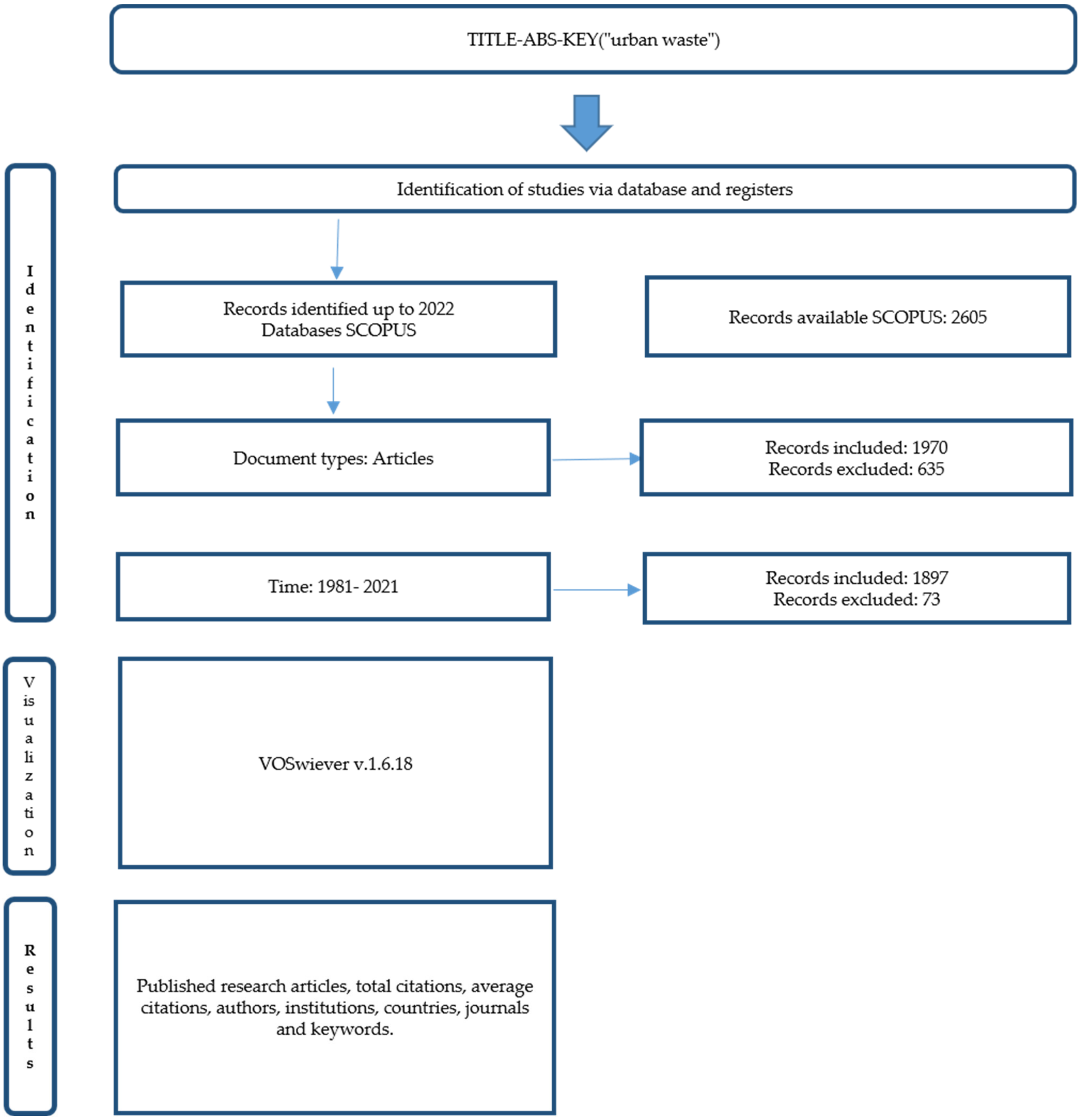

Figure 1. PRISMA methodology used.

2.1. Identification

In the first place, the keyword "urban waste" is selected with the aim of carrying out a review of the urban waste literature to learn about the main advances in the direction of research, as well as the main trends that will draw the attention of the scientific community in the coming years.

Next, the database is selected. The main scientific repositories have been reviewed, such as Web of Science, Google Scholar, and Scopus [30,31], and the latter has been selected for the following reasons: (a) being recognized as a high-quality repository, as the correlation of its measurements is very high with Web of Science and its reach is greater [32,33]; (b) being the database with the largest volume of information on authors, institutions, and countries [8]; and (c) being the database with the largest volume of articles, authors, and journals that meet the scientific quality requirements of peer review [34,35]. A total of 2605 research documents on urban waste were obtained from the Scopus repository.

Subsequently, the following criterion for the type of scientific documents to be analyzed has been used: only research articles have been selected, because they are evaluated based on novelty and are evaluated following a rigorous blind peer review process; so for some authors, this is a guarantee of higher scientific quality [33,36]. A total of 1970 documents that meet the search requirements have been found, and 635 documents have been excluded.

Finally, the time horizon is defined to cover 41 years, 1981–2021. The period of time analyzed is wide enough to collect the largest number of research documents published in the relevant area of knowledge, thus allowing a faithful image of the evolution and fundamental characteristics of the solid waste literature to be represented, as carried out by other bibliometric studies in multiple fields (see, for example, [18,37,38]). A total of 73 documents have been excluded, and so the bibliometric analysis and systematic review of the literature have been carried out on a total of 1897 research articles available in the Scopus database, published in the period between 1981 and 2021.

The search has been performed in May 2022, and the resulting search string is: TITLE-ABS-KEY("urban waste") AND (LIMIT-TO (DOCTYPE,"ar")) AND (EXCLUDE (PUBYEAR,2023) OR EXCLUDE (PUBYEAR,2022) OR EXCLUDE (PUBYEAR,1980) OR EXCLUDE (PUBYEAR,1979) OR EXCLUDE (PUBYEAR,1978) OR EXCLUDE (PUBYEAR,1977) OR EXCLUDE (PUBYEAR,1976) OR EXCLUDE (PUBYEAR,1975) OR EXCLUDE (PUBYEAR,1974) OR EXCLUDE (PUBYEAR,1973) OR EXCLUDE (PUBYEAR,1972) OR EXCLUDE (PUBYEAR,1971) OR EXCLUDE (PUBYEAR,1968) OR EXCLUDE (PUBYEAR,1967) OR EXCLUDE (PUBYEAR,1942)).

2.2. Analysis and Visualization

For the analysis and visualization of the data, we have used VOSviewer v. 1.6.18, thus generating network maps that group and process words [39]. Consequently, for the documents that meet the search requirements, the interactions between authors, countries, institutions, and keywords have been analyzed, using procedures that have been widely used to visualize co-citations and co-occurrence maps based on keywords (see, for example, [40–43]) to examine conceptual domains.

In such maps, colors represent groups. The size of the circles, the number of times the keyword appears, or the number of publications by the author, institution, or country, as well as the distance between the bubbles represent the frequency of collaboration.

2.3. Results and Discussion

Finally, the main characteristics of the line of research have been analyzed, such as the number of research articles published, total citations, average citations, authors, institutions, countries, journals, and keywords, among others. For authors, institutions, and countries, cooperation networks have also been identified using the co-citation method. For its part, the analysis of the keywords has been carried out by the co-occurrence method, thus establishing a conceptual and thematic structure. The results of the bibliometric analysis and the systematic review of the literature make it possible to identify the most explored research topics and their main contributions and allow us to define the main gaps in the academic literature.

3. Results and Discussion

3.1. Evolution of Scientific Production

This section presents the results in terms of the main characteristics of scientific production in the research topic under study and the evolution of publications in the last 41 years.

Table 1 shows the evolution of the main characteristics of the articles published on solid waste. The time horizon has been divided into sub-periods to facilitate interpretation.

Table 1. Characteristics of scientific production from 1981 to 2021.

Year	Articles	Authors	Countries	TC	TC/A	Journals
1981–1985	49	107	15	22	0.45	34
1986–1990	67	125	14	70	1.04	47
1991–1995	134	269	35	241	1.80	125
1996–2000	160	410	35	859	5.37	152
2001–2005	172	555	40	1645	9.56	172
2006–2010	256	906	67	4214	16.46	229
2011–2015	363	1343	70	7668	21.12	272
2016–2021	696	2925	86	19,897	28.59	453

TC: total citations; TC/A: average number of citations per article.

In the first five years analyzed (1981–1985), only 49 articles have been published, whereas in recent years (2016–2021), the number of publications is 696, which represents an increase of 1420.40%. The number of publications in the last six years is especially significant since it represents 36.68% of the publications in the area of knowledge analyzed. However, an increase in the number of scientific publications is observed from the five-year period 2006–2010. Therefore, the line of research shows growth at the end of the 20th century (Figure 2).

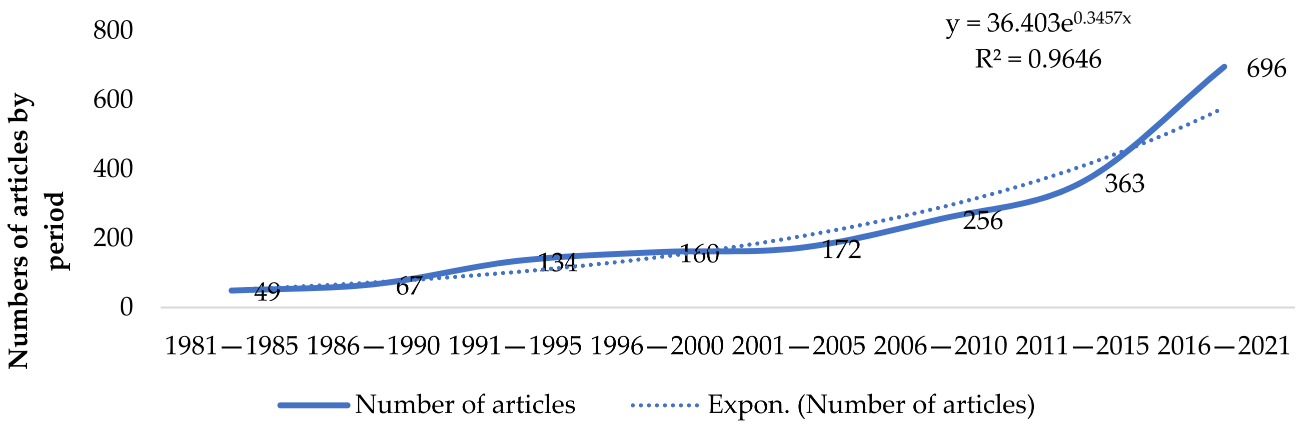

Figure 2. Evolution of the number of articles published.

A total of 6640 authors have contributed to this line of research. Subsequently, the number of articles has increased. Similarly, the number of authors has also demonstrated a significant increase over time: in the last five-year period 2016–2021, the increase in authors is 44.05%, compared with the increase in the five-year period 1981–1985 of 1.61%. However, the average number of authors per article has remained practically constant over time, from an average of two authors during the first five years to an average of 4.2 in the last.

This study reflects that the number of countries that have shown interest in the analyzed topic is 362. In this sense, a marked growth is visualized, rising from 15 during the five-year period 1981–1985 to a total of 86 in the five-year period from 2016 to 2021, which indicates a growth from 4.14% to 23.76% in a total of 41 years.

On the other hand, in the first five-year period analyzed (1981–1985), a total of 22 citations have been recorded, while in the last five-year period 2016–2021, 19,897 citations were recorded, which represents 57.48% of the total; hence, we have a total of 34,616 citations for all five-year periods analyzed, 1981–2021. In this sense, the average number of citations per article has increased from 0.45 in the five-year period 1981–1985 to 28.59 citations per article in the five-year period 2016–2021. This reflects the significant exponential growth of interest in the line of research.

The total number of journals in which the articles have been published is 1484. The first five-year period has 34 journals, representing 2.29% of the total number of journals, compared with the 30.52% represented by the 453 journals of the last five-year period studied, which represents exponential growth. In this sense, all of the indicators analyzed show a strong increase in international interest and scientific production, making it clear that this is a line of research that has undergone growth at the end of the 20th century.

3.2. Analysis of Scientific Production

3.2.1. Subject Area and Journals

The 1897 research documents that meet the search requirements can be organized into up to 26 subject areas (Figure 3), although a single article may fall into one or more of these categories; hence, the total number of documents identified in Figure 3 is 3401.

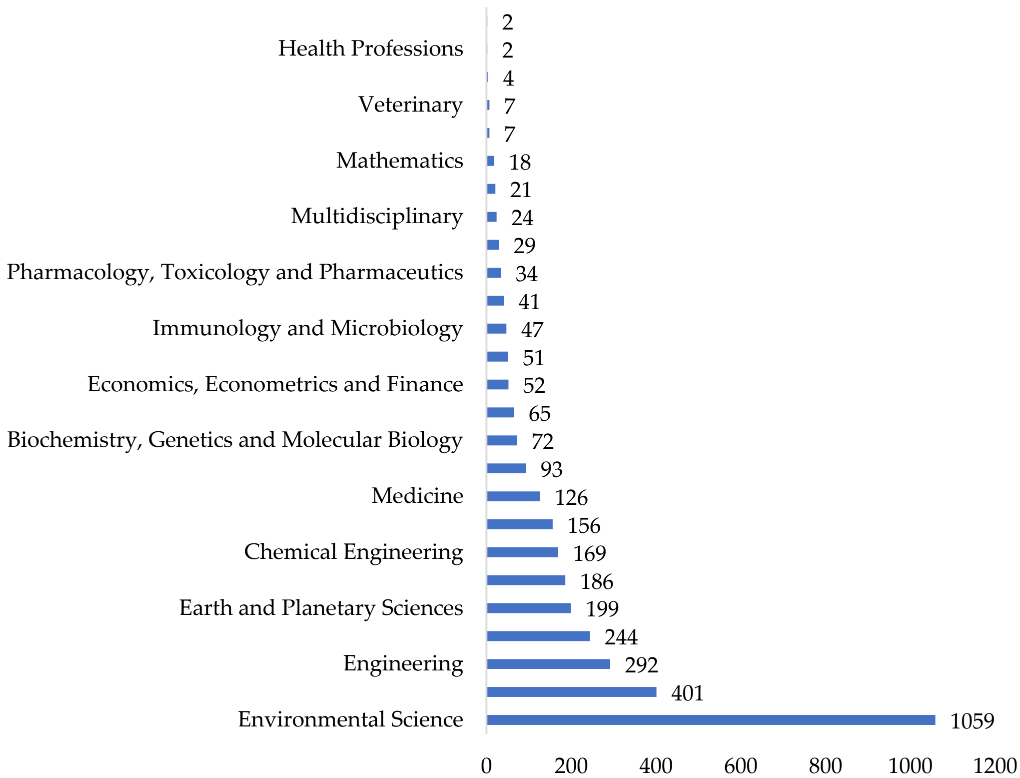

Figure 3. Number of articles published by subject area.

The five most representative subject areas in the period under study are environmental science (n = 1059; 31.54%); agricultural and biological sciences (n = 401; 11.79%); engineering (n = 292; 8.59%); social sciences (n = 244; 7.17%); and earth and planetary sciences (n = 199; 5.85%). In total, 65% of the documents under study are located in these five thematic areas, while the remaining 35% are distributed among 21 other thematic areas.

Table 2 shows the most productive journals on urban waste. A total of 50% are in the first quartile (Q1) of the SJR index in 2021. The 1897 articles analyzed have been published in up to 1484 journals, of which it stands out that the 20 most productive journals received a total of 375 articles, representing 25.26% of the total scientific production.

The table shows that the first three journals in the ranking are Science of The Total Environment, Waste Management, and Journal of Cleaner Production, described below, respectively. The journal Science of The Total Environment heads this ranking and has the highest number of articles (41) and total citations (1724), an average of 42.05 citations per article, an h-index of 16, belongs to the first quartile (Q1), and has an indicator SJR of 1.806. The second journal with the highest scientific production is Waste Management, which has a total of 39 articles, 1904 citations, an average of 48.82 citations per article, an h-index of 16, belongs to the first quartile (Q1), and has an SJR indicator of 1.74. The third journal, Journal of Cleaner Production, has a total of 35 articles, 713 citations, an average of 20.37 citations per article, an h-index of 13, belongs to the first quartile (Q1), and has an SJR indicator of 1.921. The journal with the highest impact index is Environmental Science and Technology, with a value of 2.702 (Q1), followed by Resources, Conservation and Recycling, with a value of 2.59 (Q1). On the other hand, in terms of the number of articles received, Science of The Total Environment is the most productive (41; 10.93%), followed by Waste Management (39; 10.04%) and Journal of Cleaner Production (35; 9.33%).

On the other hand, the *Chemosphere* journal is the oldest in the research area (its first publication being in 1983), being the only one that has published scientific articles during all four of the decades analyzed, while the *Techniques Sciences Methods* journal is the only one that has not. It has only received articles along this line of research in the last six years, which shows that the line of research is captivating the interest of researchers and, therefore, of scientific journals.

The journal *Science of The Total Environment* is the one that has received the largest number of scientific articles (41), of which 19 have been published in the last period (2016–2021); it is also the journal with the highest h-index in the research area, both in terms of the journal (275) and articles (16), followed by *Waste Management.*

Finally, it should be noted that 75% of the most productive scientific journals belong to member countries of the European Union, while 25% are found in North America (the United States), and the remaining 5% are from South America.

3.2.2. Authors

Table 3 shows the 10 most productive authors in the field of urban waste, as well as their main characteristics. It stands out that they are mainly European, highlighting the Italians (40%), Spanish (30%), French, and Danish (30%). For their part, up to 60% are currently publishing research articles on urban waste (2016–2021), which indicates that there is still interest in this line of research.

Table 2. Ranking of the 20 journals with the highest scientific production.

Journal	A	TC	TC/A	H-Index Articles	H-Index Journal	SJR	C	FA	LA	At							
										1981–1985	1986–1990	1991–1995	1996–2000	2001–2005	2006–2010	2011–2015	2016–2021
Science of the Total Environment	41	1724	42.05	16	275	1.806 (Q1)	Netherlands	1995	2021	0	0	2	1	3	7	9	19
Waste Management	39	1904	48.82	16	182	1.74 (Q1)	United Kingdom	1992	2021	0	0	1	0	3	9	12	14
Journal of Cleaner Production	35	713	20.37	13	232	1.921 (Q1)	United Kingdom	2012	2021	0	0	0	0	0	0	7	28
Sustainability Switzerland	27	348	12.89	9	109	0.66 (Q1)	Switzerland	1994	2021	0	0	0	0	0	0	3	24
Waste Management and Research	24	612	25.50	9	86	0.75 (Q2)	United Kingdom	2013	2020	0	0	1	2	3	3	8	7
Resources, Conservation and Recycling	23	602	26.17	11	150	2.59 (Q1)	Netherlands	1988	2021	0	1	5	0	2	3	5	7
Chemosphere	22	970	44.09	7	265	1.05 (Q1)	United Kingdom	1983	2021	2	1	3	2	1	4	2	7
Techniques Sciences Methods	19	38	2.00	5	10	0.145 (Q4)	France	1993	2014	0	0	7	5	1	4	2	0
Journal Of Environmental Management	17	585	34.41	7	196	1.481 (Q1)	United States	2008	2021	0	0	0	0	0	2	4	11
Water And Environment Journal	17	206	12.12	4	40	0.382 (Q3)	United States	1992	2016	0	0	12	2	1	1	0	1
Environmental Science and Pollution Research	15	178	11.87	4	132	0.831 (Q2)	Germany	2016	2021	0	0	0	0	0	0	0	15
WIT Transactions on Ecology and the Environment	14	51	3.64	5	24	0.173 (Q4)	United Kingdom	2006	2021	0	0	0	0	0	8	3	3
Environmental Engineering and Management Journal	12	52	4.33	4	39	0.229 (Q3)	Romania	2005	2021	0	0	0	0	1	0	2	9
Environmental Monitoring and Assessment	11	388	35.27	5	122	0.623 (Q2)	Netherlands	1988	2018	0	1	1	0	0	3	3	3
Marine pollution bulletin	11	283	25.73	6	193	1.508 (Q1)	United Kingdom	1985	2020	1	0	2	2	1	2	1	2
Water, Air, and Soil Pollution	11	390	35.45	2	118	0.546 (Q2)	Netherlands	1988	2021	0	1	1	2	2	0	3	2

Table 2. *Cont.*

Journal	A	TC	TC/A	H-Index Articles	H-Index Journal	SJR	C	FA	LA	At							
										1981–1985	1986–1990	1991–1995	1996–2000	2001–2005	2006–2010	2011–2015	2016–2021
International Journal of Environmental Research and Public Health	10	54	5.40	3	138	0.814 (Q1)	Switzerland	2014	2021	0	0	0	0	0	0	1	9
Communications In Soil Science and Plant Analysis	9	156	17.33	1	71	0.403 (Q2)	United States	1994	2018	0	0	1	3	1	0	3	1
Engenharia Sanitaria E Ambiental	9	22	2.44	3	20	0.214 (Q4)	Brazil	2014	2021	0	0	0	0	0	0	2	7
Environmental Science and Technology	9	655	72.78	4	70	2.702 (Q1)	United States	1991	2021	0	0	3	1	2	0	1	2

A: number of items; TC: total citations for all articles; TC/A: number of citations per article; Ha: Hirsch index in this subject; Hj: Hirsch index in diary; SJR (Q): Scimago Journal Rank; (quartile); FA: first article published; LA: last article published; At: subperiods.

Table 3. Top 10 most productive authors.

Authors	A	TC	TC/A	Institution	C	FA	LA	H-Index
Montoneri, E.	25	666	26.64	Università degli Studi di Torino	Italy	2008	2018	12
Houot, S.	19	513	27.00	Universite Paris-Saclay	France	2004	2021	10
García, C.	13	898	69.08	CEBAS-CSIC, Centro de Edafología y Biología Aplicada del Segura	Spain	1992	2015	4
Boffa, V.	12	287	23.92	Aalborg Universitet	Denmark	2008	2020	7
Gigliotti, G.	11	685	62.27	Università degli Studi di Perugia	Italy	1992	2013	5
Hernández, T.	11	464	42.18	CEBAS-CSIC, Centro de Edafología y Biología Aplicada del Segura	Spain	1991	2015	4
Arques, A.	9	237	26.33	Universitat Politécnica de Valéncia	Spain	2013	2019	4
Giusquiani, P.L.	9	558	62.00	Università degli Studi di Perugia	Italy	1988	2003	3
Magnacca, G.	9	160	17.78	Università degli Studi di Torino	Italy	2014	2021	3
Magid, J.	8	252	31.50	Københavns Universitet	Denmark	2013	2019	3

A: number of items; TC: number of citations; TC/A: number of citations per article; FA: first article published; LA: last article published; h-index: Hirsch index in this research topic.

The most productive author is Montoneri, E., with a total of 25 articles published during the analyzed period (2016–2021), followed by Houot, S., with a total of 19 research articles. On the other hand, Giusquiani, P.L. is the most incipient author of the ten most productive authors, publishing his first article on the subject in 1988. However, Montenori, E. maintains a high-quality indication in the research area (h-index of 12).

In this sense, García, C., from CEBAS-CSIC, Segura Center for Edaphology and Applied Biology, is the author with the highest citation average (69.08). Finally, of the ten most productive authors, Houot, S. and Magnacca, G. published articles in the research area in the year 2021.

Figure 4 represents the collaboration network between the main authors. Cooperation is scarce, since, of the 6640 main authors, only 11 have collaborated in the form of scientific production on this topic.

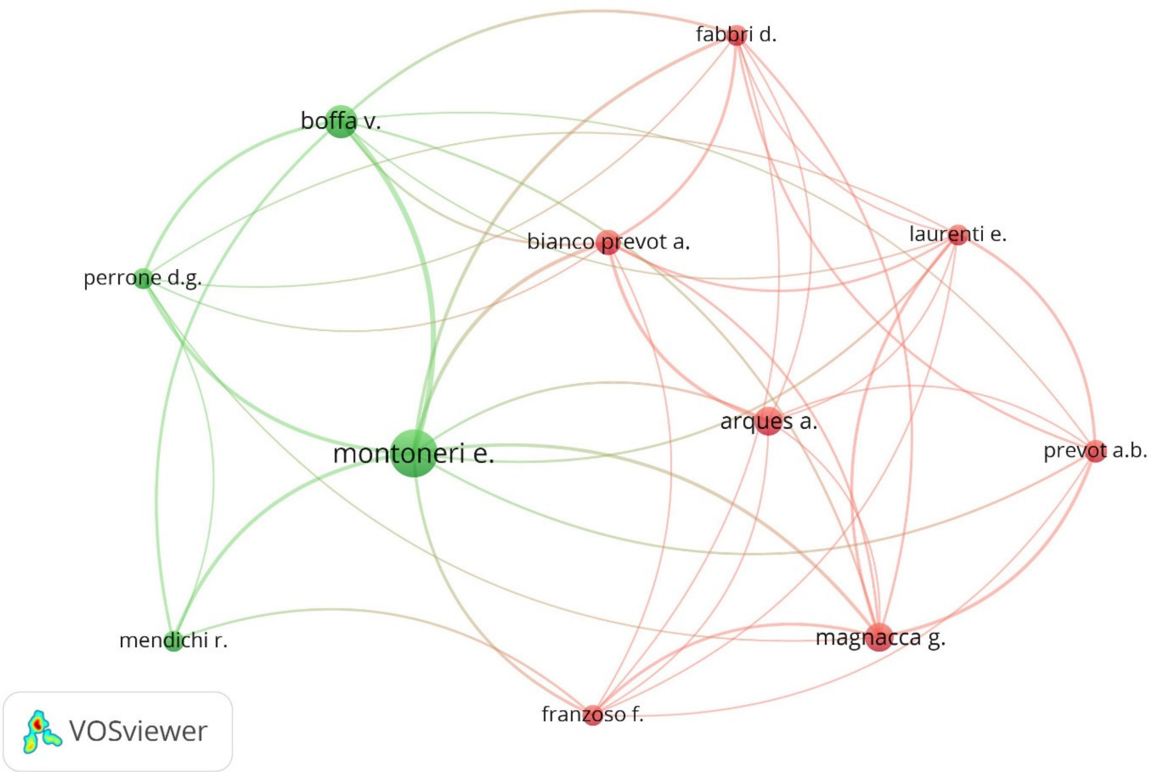

Figure 4. Author cooperation network based on co-authorship.

3.2.3. Institutions and Countries

This section shows the most productive countries and institutions in this field of research, as given in Table 4; 80% of the institutions are of European origin, including Spain (3), Italy (3), and France (2), and the remaining 20% are from South America, specifically Brazil.

Table 4. Top 10 most productive institutions.

							TC/A	
Institution	**C**	**A**	**TC**	**TC/A**	**H-index**	**IC (%)**	**IC**	**NIC**
Consejo Superior de Investigaciones Científicas	Spain	37	1812	48.97	14	32.4%	42.08	53.56
Universidade de Sao Paulo—USP	Brazil	37	588	15.89	14	32.4%	27.83	10.16
Università degli Studi di Torino	Italy	37	803	21.70	17	32.4%	26.17	19.56
Consiglio Nazionale delle Ricerche	Italy	31	405	13.06	12	16.1%	14.20	12.85
CEBAS- CSIC, Centro de Edafología y Biología Aplicada del Segura	Spain	29	1851	63.83	11	34.5%	27.50	82.95
CNRS Centre National de la Recherche Scientifique	France	29	489	16.86	13	48.3%	17.43	16.33
Sapienza Università di Roma	Italy	26	455	17.50	8	26.9%	17.29	17.58
Universidade Estadual Paulista Júlio de Mesquita Filho	Brazil	25	290	11.60	9	12.0%	35.33	8.36
Centre de recherche Île-de-France-Versailles—Grignon	France	22	510	23.18	10	45.5%	17.60	27.83
Universidad de Santiago de Compostela	Spain	20	617	30.85	6	30.0%	19.67	35.64

A: number of items; TC: total citations; TC/A: total citations per article; H-index: Hirsch index for this research topic; CI: percentage of articles developed with international collaboration; CI: number of citations in articles with international collaboration; NIC: number of citations in articles without international collaboration.

The Higher Council for Scientific Research is the one with the highest scientific production on the subject, with a total of 37 scientific articles, a total of 1812 citations, and an average number of citations of 48.97.

The Università degli Studi di Torino is the institution with the highest h-index of 17, followed by the Higher Council for Scientific Research with an h-index of 14. On the other hand, the Università degli Studi di Torino has a collaboration rate of 32.4%; therefore, of the 37 articles that have been published, 12 have been published with the collaboration of other countries.

The second position is occupied by the Higher Council for Scientific Research, due to its high number of articles (35). This Italian institution has a total of 1812 citations, with an average of 48.97 citations per article and an H-index of 14. In addition, it has a collaboration rate of 32.4%, the same as that of the Università degli Studi di Torino and the University of Sao Paulo (USP). The third position is occupied by the USP, with 37 articles. This institution of Brazilian origin has a total of 588 citations, with an average of 15.89 citations per article and an h-index of 14. In addition, it has a collaboration index of 32.4%.

On the other hand, the CNRS Center National de la Recherche Scientifique and Center de recherche Île-de-France-Versailles—Grignon are the two institutions with the highest rates of international collaboration, being 48.3% and 45.5%, respectively.

Table 5 below shows the most productive countries in the area of urban waste during the period analyzed (1981–2021), while Table 6 shows the cooperation results of the 10 most productive countries. It can be seen that 60% of the countries are of European origin (Spain, United Kingdom, Italy, France, Germany, and Portugal), followed by 20% of Asian origin (India and China), 10% from North America (United States), and finally, 10% from South America (Brazil).

Table 5. Top 10 most productive countries.

Country	A	TC	TC/A	H-Index	R(A)							
					1981–1985	1986–1990	1991–1995	1996–2000	2001–2005	2006–2010	2011–2015	2016–2021
Italy	279	6347	22.75	95	5	15	10	17	24	47	61	100
Spain	263	9071	34.49	77	0	8	18	37	38	43	36	83
Brazil	194	2444	12.60	55	0	1	1	9	14	29	39	101
France	151	2823	18.70	51	4	10	4	7	25	22	36	43
United Kingdom	127	2756	21.70	48	1	0	14	21	16	16	22	32
United States	108	4150	38.43	25	3	0	10	13	8	9	22	44
India	103	1537	14.92	27	2	2	5	7	12	10	23	42
China	87	1184	13.61	28	0	0	1	2	1	6	14	61
Germany	57	1496	26.25	19	0	0	1	8	3	7	17	22
Iran	51	904	17.73	11	0	0	0	0	0	7	14	30

A: number of items; TC: total citations; TC/A: number of citations per article; h-index: Hirsch index in this research topic.

Table 6. Top 10 most productive countries in terms of international collaboration.

Country	NC	Main Collaborators	IC (%)	TC/A	
				IC	NIC
Italy	33	Spain, Germany, France, United Kingdom, Argentina	26.9%	27.97	20.83
Spain	30	Italy, Argentina, Portugal, United Kingdom, Brazil	29.7%	31.09	35.92
Brazil	20	United States, Italy, Portugal, Argentina, Spain	17.5%	21.79	10.64
France	36	Germany, Burkina Faso, Italy, Senegal, Morocco	41.7%	20.83	17.17
United Kingdom	25	Spain, Italy, United State, Brazil, India	37.0%	28.91	17.46
United State	33	Brazil, China, United Kingdom, Argentina, Australia	46.3%	59.76	20.03
India	16	United Kingdom, China, Iran, Saudi Arabia, Sweden	22.3%	33.70	9.53
China	20	United States, Denmark, India, United Kingdom, Australia,	35.6%	20.13	10.00
Germany	26	France, Italy, Austria, Spain, United Kingdom	66.7%	30.84	17.05
Iran	11	India, United State, China, Malaysia, Australia	21.6%	34.27	13.18

NC: number of collaborators; CI (%): percentage of articles carried out with international collaboration; CT/A: number of citations per article; CI: number of citations for articles with international collaboration; NIC: number of citations for articles without international collaboration.

The country with the highest number of articles published on the research topic is Italy, with 279, followed by Spain (263) and Brazil (194). On the other hand, Spain is the country with the highest number of citations (9071), with an h-index of 77, and the second highest citation average of 31.49—the United States ranks first in terms of average citations (38.43).

In the first period analyzed, Italy has the highest scientific production (5), followed by France (4) and the United States (3). However, Italy, France, and India have always published scientific articles in each of the periods analyzed.

Figure 5 shows the international collaborations among the most prolific countries. A total of 57 countries that have published at least 5 research articles have been included, grouped into 10 clusters.

The first group (red) is led by India. The scientific production of this collaboration group includes 219 articles, which represents a percentage of 10.36% of the total sample analyzed; this group includes Australia, Denmark, Egypt, Finland, Japan, Norway, Pakistan, and Saudi Arabia. The second group (green) is led by France. This group is made up of Burkina Faso, Colombia, France, Madagascar, Morocco, Senegal, Switzerland, and Tunisia. This group includes nine countries and 225 articles and represents 10.65% of the total research activity. Next, group 3 (blue) is led by Spain, along with Brazil. This group includes the largest number of articles published with a total of 511, representing 24.19%. This group is made up of Argentina, Chile, the Czech Republic, and Ecuador. On the other hand, group 4 (yellow) is led by Italy, has 398 articles (18.84%) published and is made up of Bulgaria, Iran, Romania, Turkey, and Poland. The fifth group (purple) is led by Canada and is made up of Belgium, Algeria, Ethiopia, Israel, and Mexico, and has a total of 121 published articles. The sixth group (light blue) is led by the United Kingdom together with the Netherlands; it consists of 237 articles and is made up of Ghana, Greece, Nigeria, and South Africa. In addition, there are groups seven, eight, nine, and ten; group seven (orange), led by Germany, consists of 85 articles and includes Croatia, Malaysia, Slovenia, and Vietnam; group eight (brown) is led by the United States and China and is made up of Singapore, South Korea, and Taiwan and has published 221 articles. Group nine (fuchsia), led by Austria, made up of Germany and Serbia, has published a total of 38 articles and group ten (pink), led by Portugal and including Indonesia, has published a total of 57 articles. This last group is the one with the smallest number of countries that comprise it.

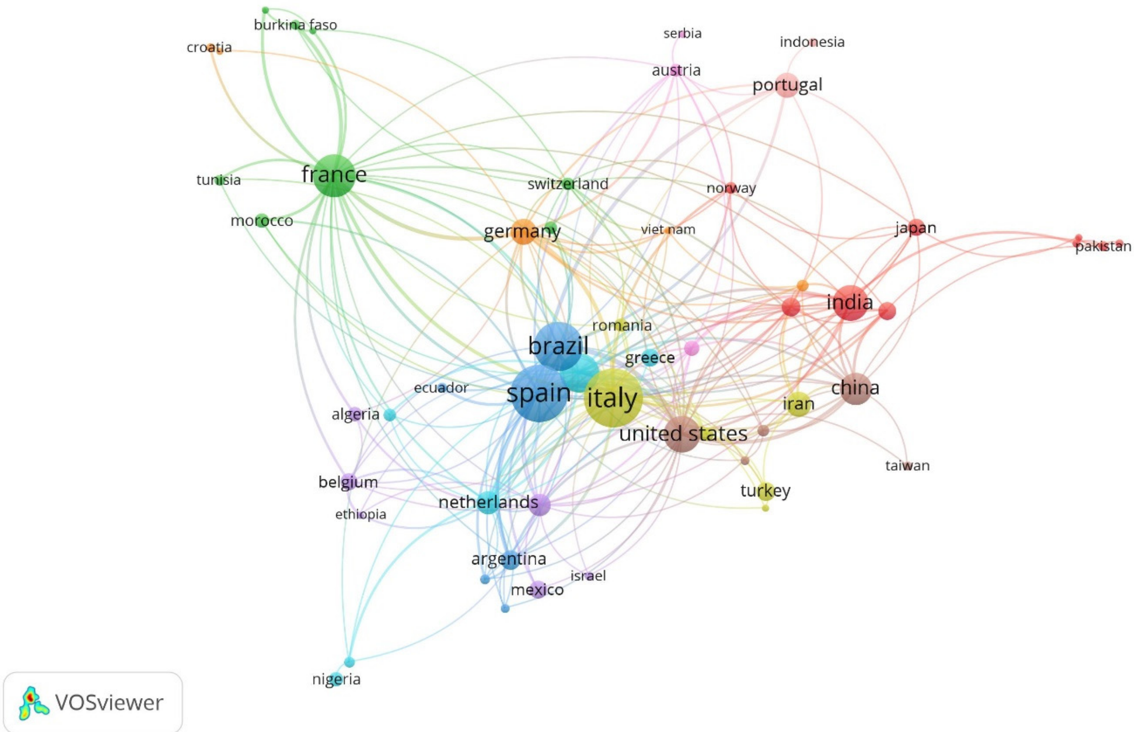

Figure 5. International cooperation based on co-authorship between countries from 1981 to 2021.

4. Keyword Analysis

For this analysis, a sample of 1897 articles containing a total of 10,016 keywords has been considered. These terms express the object of study of the articles, so their analysis allows obtaining information on the interests that have been generated along this line of research. Table 7 shows the 15 keywords that are relevant in three areas of urban waste research: environment, society, and techniques.

The first area of study focuses on the "environment", where the evolution of the main keywords in this thematic area is shown: environmental impact (included in 76 articles), a term that appeared for the first time in 1988, recycling (212), composting (126), pollution (79), groundwater (23), which appears for the first time in 1991, although it is not until the period 2011–2015 when it begins to have greater relevance, and finally, final closure (0), which surprisingly has not been used, at least as a keyword.

Within the area of "techniques", the most used term is landfill, which is found in 107 research articles, followed by environmental monitoring (100), as a very technical concept, solid waste management (81), and environmental impact assessment (39). However, bottom liner or liner, despite being one of the techniques that is currently receiving the most attention, does not appear. This could be because it is already being considered in "landfill", "techniques", or "urban waste" in a broader sense.

Table 7. Main keywords from 1981 to 2021.

Group	Keyword	1981–2020		1981–1985		1986–1990		1991–1995		1996–2000		2001–2005		2006–2010		2011–2015		2016–2021	
		A	**%**	**A**	**%**	**A**	**%**	**A**	**%**	**A**	**%**	**A**	**%**	**A**	**%**	**A**	**%**	**A**	**%**
Environmental	Environmental impact	76	4.0%	0	0.00%	0	0.00%	7	5.2%	3	1.9%	10	5.8%	15	5.9%	18	5.0%	23	3.3%
	Recycling	212	11.2%	3	6.12%	11	16.42%	12	9.0%	9	5.6%	17	9.9%	25	9.8%	45	12.4%	90	12.9%
	Composting	126	6.6%	1	2.04%	8	11.94%	9	6.7%	6	3.8%	12	7.0%	21	8.2%	27	7.4%	42	6.0%
	Pollution	79	4.2%	1	2.04%	5	7.46%	3	2.2%	7	4.4%	10	5.8%	10	3.9%	20	5.5%	23	3.3%
	Groundwater	23	1.2%	0	0.00%	0	0.00%	2	1.5%	0	0.0%	0	0.0%	0	0.0%	9	2.5%	12	1.7%
	Final closure	0	0.0%	0	0.00%	0	0.00%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Society	Urban area	284	15.0%	3	6.12%	7	10.45%	25	18.7%	16	10.0%	33	19.2%	47	18.4%	61	16.8%	92	13.2%
	Decision making	43	2.3%	0	0.00%	0	0.00%	2	1.5%	0	0.0%	2	1.2%	7	2.7%	9	2.5%	23	3.3%
	Developing countries	38	2.0%	1	2.04%	2	2.99%	24	17.9%	4	2.5%	0	0.0%	0	0.0%	7	1.9%	11	1.6%
	Urban population	27	1.4%	0	0.00%	0	0.00%	1	0.7%	0	0.0%	4	2.3%	6	2.3%	8	2.2%	8	1.1%
Techniques	Environmental monitoring	100	5.3%	0	0.00%	0	0.00%	6	4.5%	6	3.8%	10	5.8%	17	6.6%	25	6.9%	36	5.2%
	Landfill	107	5.6%	0	0.00%	2	2.99%	4	3.0%	5	3.1%	11	6.4%	19	7.4%	26	7.2%	40	5.7%
	Solid waste management	81	4.3%	5	10.20%	15	22.39%	8	6.0%	2	1.3%	6	3.5%	12	4.7%	10	2.8%	23	3.3%
	Environmental impact assessment	39	2.1%	0	0.00%	2	2.99%	7	5.2%	3	1.9%	2	1.2%	7	2.7%	10	2.8%	8	1.1%
	Bottom liner/liner	0	0.0%	0	0.00%	0	0.00%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	Total articles	1897		49		67		134		160		172		256		363		696	

A: number of articles; %: percentage of the total articles published in that period.

The "society" dimension refers to the inclusion of the population in the different phases of urban solid waste management as an instrument of social empowerment and access to opportunities. This area of knowledge is related to the keywords urban area (included in 284 articles), decision making (43), developing countries (38), and urban population (27).

4.1. Research Topics

Figure 6 illustrates the relationships observed between the keywords, which are grouped according to co-occurrence. The color of the groups shows the networks of keywords, while the size of the bubbles varies depending on the number of times these expressions are highlighted in the articles. Thus, of the total 1897 articles, those with at least 15 interactions are shown with 292 keywords.

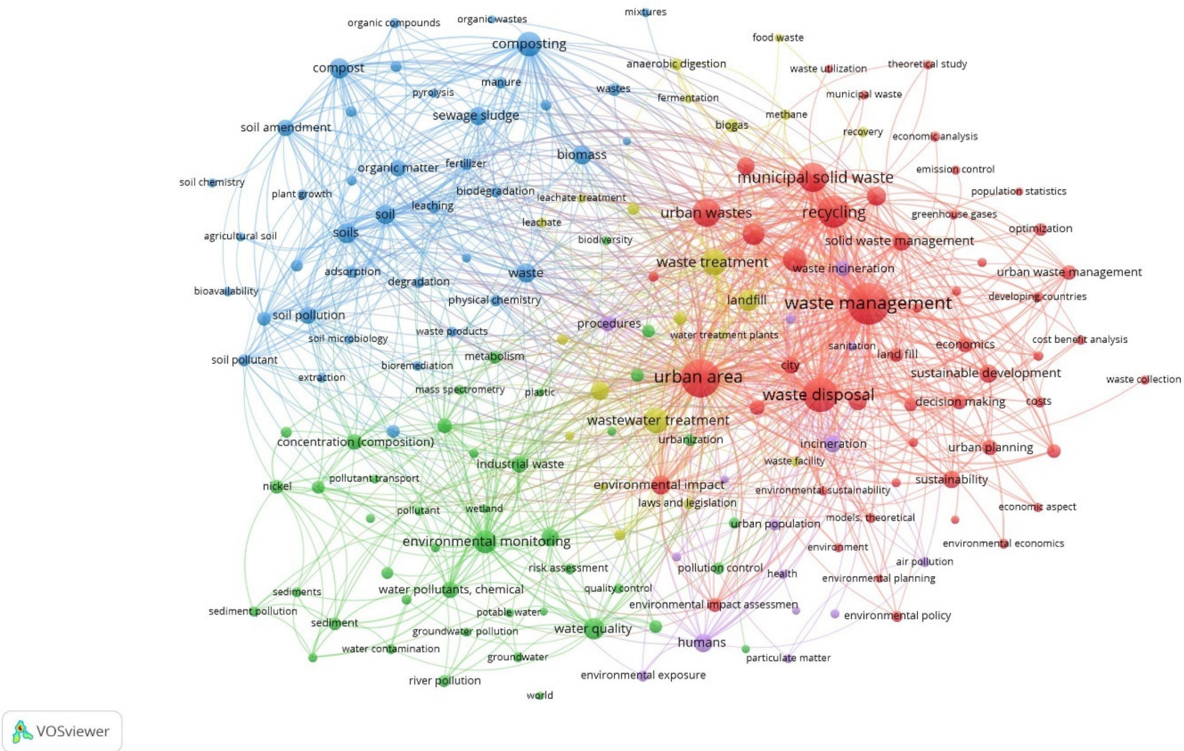

Figure 6. Network of main keywords according to co-occurrence from 1981 to 2021.

The keyword that heads the ranking is waste management (371), representing 19.55% of the analyzed sample, and this is due to the fact that the search carried out falls under the field of "urban waste". Therefore, most of the research that has been carried out is within this field of study. The keyword urban area, occupying second place, being found in 284 articles, is considered part of this theme since it is within the time horizon of this study. Additionally, its high number of occurrences allows it to be identified in all periods of the sample. Garbage deposit (234) is in third position, appearing for the first time in the period 1985–1990. Recycling (212) is the fourth keyword in the ranking, appearing in all periods. Finally, the keyword solid urban waste appears in 170 articles, and is used for the first time in the period 1986–1990.

Five clusters are recognized that refer to different lines of research. The first group (red) is represented by the concepts of waste management, urban areas, garbage deposits, recycling, urban solid waste, urban waste, and waste disposal. In this line of research, we identify relevant aspects in the management of urban solid waste. The second group (green) is directly related to the environment and environmental impact. Among the terms used are environmental pollution, contamination, environmental assessment, land use, biodiversity, and ecosystem. This group is also associated with the urban population, urban growth, and urbanization.

The third cluster (blue) is directed by the term composting. It includes the terms waste, organic matter, soil, leachate, pyrolysis, biodegradation, and biomass. It refers to the management of organic waste that is generated. The fourth group (yellow) is led by the term waste treatment. In addition, in this line of research, the terms landfill, leachate treatment, liquid waste disposal, recovery, etc., are used. This group basically focuses on the treatment of waste at its final disposal site.

Finally, the fifth group (purple) focuses on the social aspect, taking as its main focus the human being as such, integrating terms such as urban population, health, air pollution, environmental exposure, environmental pollution, sanitation, etc.

From the review of the most relevant literature in this field, we believe that it would be appropriate to establish four sections: (1) environment and urban solid waste; (2) society and urban solid waste; (3) economy and urban solid waste; and (4) technologies and urban solid waste.

4.1.1. Environment and Urban Solid Waste

The needs that come from human development generate environmental modifications that significantly alter natural environments [44]. Cities consume large amounts of resources, causing pressure and negative impacts [45]. According to Wilson D. (2015), the global amounts of waste generated are estimated to be between 7 and 10 billion tons per year [46]. According to figures handled by the World Bank, there is a growing global trend in the generation of solid waste worldwide of 2010 million tons per year, which is projected to increase by 70% in 2050 to 3.40 billion tons annually [47]. In addition, it is estimated that 47% of the total is deposited in landfills, 31% is recycled, and 22% is incinerated [48]. Therefore, the inadequate management of solid waste is a problem worldwide, directly affecting the environment. Dumping and open burning are the main systems utilized in the treatment and final disposal of waste, implemented mainly in low-income countries [49]; these bad practices generate serious contamination by heavy metals that become present in water, soil, and plants [50]. Therefore, the inadequate management of solid waste is the cause of severe and diverse environmental and social impacts, which do not allow improvements in sustainable development [49]. The 2030 Agenda aims to achieve economic growth and sustainable development through plans to reduce the global ecological footprint, changing our way of producing, consuming, and wasting goods and resources [51]. According to Muñoz-Menéndez et al. (2021), the comprehensive management of solid waste seeks to be compatible with environmental concerns and public health focused on the concept of sustainable development [52]. According to the European Commission, the circular economy can significantly reduce the negative impacts of the exploitation and use of natural resources and subsequently contribute to restoring biodiversity [53]. According to Petit-Boix and Leipod (2018), although the environmental benefits of the urban circular economy have been mentioned, few environmental assessments of urban initiatives are available, and environmental research related to the circular economy is rarely applied at the city level [54].

4.1.2. Society and Urban Solid Waste

Waste management is considered a current and relevant problem for society, since it is an essential service for health in developing countries. This problem is present in the political–administrative agendas of governments in several countries [44]. Its social relevance is mainly due to the growing public concern for the preservation of the environment and aversion to pollution. The political importance of this problem is evident not only from the point of view of the citizens, who are very aware of waste management when electing their representatives, but also from the point of view of the institutions that, to some extent, are also responsible for the handling and management of urban solid waste [55]. The enormous number of needs of today's society represent an increase in the exploitation of natural resources and the accelerated generation of solid waste, which allows an excessive increase in the volume of waste, therefore causing a problem that must be taken care of. The implementation of alternatives for the management of solid waste, in addition to establishing an approach that gives priority to waste generation, must consider the individual behaviors related to the generation, use, and final disposal of consumer products that become garbage and contaminate our cities, bringing with them an increase in public health problems [56]. On the other hand, as a result of solid waste management, it is also interesting to mention that part of the population is dedicated to informal recycling. A considerable part of the population is dedicated to this activity, particularly in low-income countries. In medium- and low-income countries where there are still no selective collection systems for recyclable materials [57], inclusion in formal solid waste management systems is not yet clearly defined. However, in some places, informal sector service providers are responsible for a significant percentage of waste collection, and informal recyclers play an important role in the management of plastic, aluminum, and paper waste, among others, which is recovered and sold to private companies dedicated to recycling, therefore generating environmental and social benefits [49].

In addition, the participation of society as consumers is essential within the framework of the circular economy. It is valid to aim for the empowerment of consumers and to provide them with savings opportunities, because this is a key complement of policies relating to sustainable products. Within its agenda, the European Commission considers it opportune to review the European Union legislation on consumer matters to guarantee consumer access to reliable and pertinent information about products at the point of sale, including their useful life and therefore the availability of repair services, spare parts, and repair manuals [46].

4.1.3. Economy and Urban Solid Waste

The increase in the production of urban solid waste is directly related to population growth and therefore to economic development [58]. In association, the unsustainable use of resources, increasing the costs involved in the management of waste, carries with it a high cost of investment by the municipalities, as well as the citizens who support this service through the payment of taxes. On the other hand, some private companies are interested in carrying out direct activities linked to the management and handling of waste and/or the use of many derivative companies, such as the recycling of materials and the production of energy from waste [55]. Additionally, Medina-Mijangos and Seguí-Amórtegui (2020) found that when an MSW management system is implemented, different impacts or consequences can be generated, which can be reflected as income or costs depending on whether the parties involved are positively or negatively affected [59]. A determining factor is the type of linear economy that is currently implemented in the world, which demonstrates the unsustainability and depletion of natural resources in addition to variations in the composition and quantity of waste, which causes an increase in the amount of waste. This has forced the design of strategies aimed at reducing the volume of waste generated, encouraging a circular economy model. Given this, one of the objectives of the new circular economy paradigm is to eliminate or mitigate waste through designs that focus on the minimization of the resources used in manufacturing and the reduction in the energy balance of production [7].

The concept of circular economy is based on the foundations of the ecological school of thought and proposes a change to the "reduce, reuse and recycle" paradigm. This is based on a deeper and more lasting transformation, which allows for reducing the impact of human activities on the environment. Therefore, this model gives waste a dominant role and is based on the intelligent reuse of waste, be it organic and/or technological in nature, in a cyclical model that imitates and connects with nature [60]. The circular economy model is heading towards a new paradigm, with a new way of making products that includes both their origin and design and allows doing business based on the economic growth of society, environmental sustainability, and risk reduction with regard to the volatility and uncertainty of raw material costs and energy resources [61]. According to Iqbal et al. (2020), the concepts of sustainability and the circular economy have advanced in the urban solid waste management system from basic disposal to recycling and resource recovery [9]. Life cycle assessment is a technique that has been widely used to analyze the MSW management system; therefore, the conducted analysis reveals that the integration of recycling, treatment, and disposal technologies is the most appropriate strategy. The choice of technologies and their performance depends on the technological and socioeconomic context of the region studied. To encourage the transition from a linear to a circular economy, the following steps should be considered: reuse, recycling, recovery, and prevention. However, prevention is the most important step of the new paradigm [9,62]. In Figure 7, the transition from the linear model to a circular one is shown.

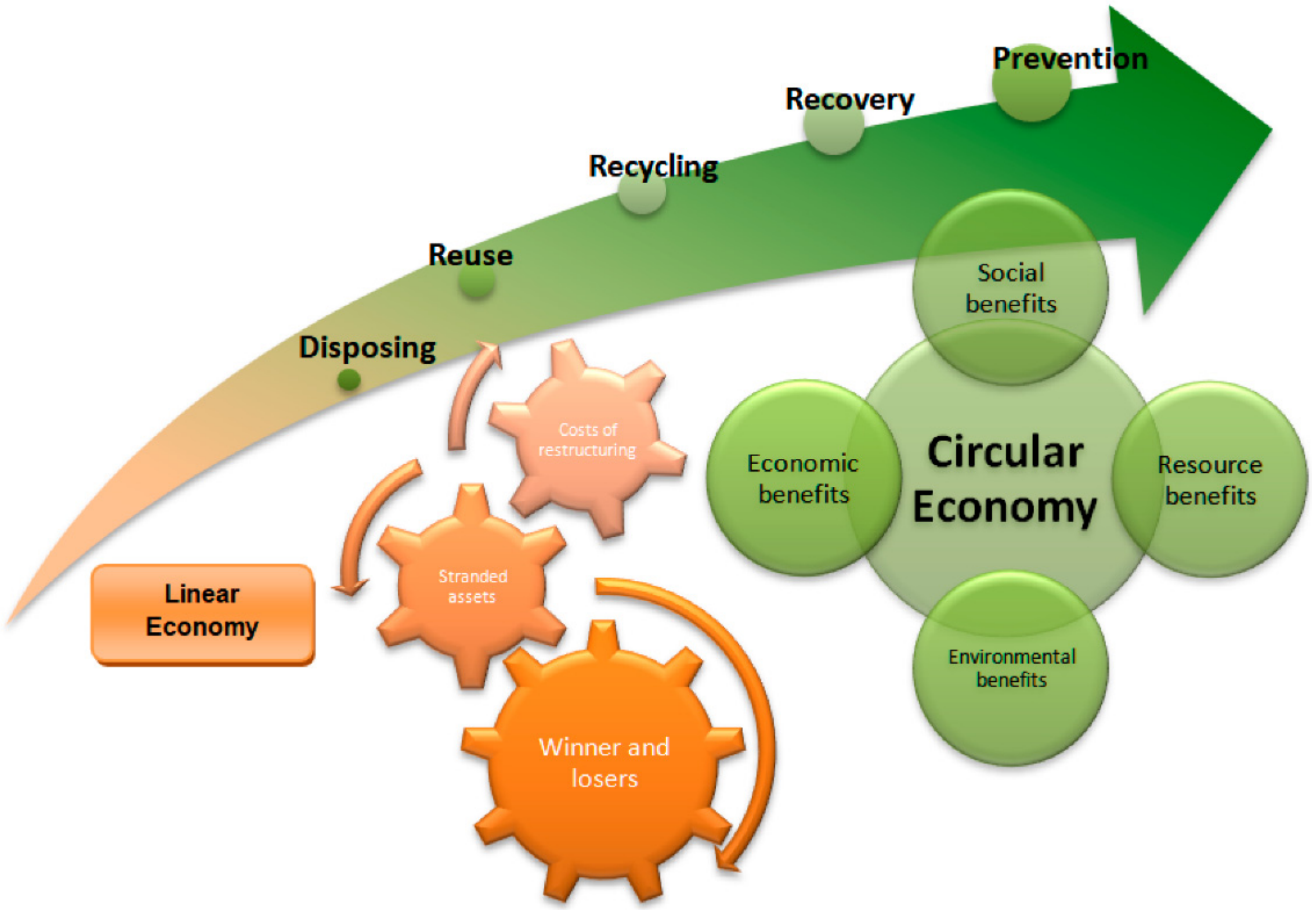

Figure 7. Transition from a linear to a circular economy model [45].

Currently, the circular economy model approach is implemented by many countries and companies [61]; the implementation of the circular economy is linked to evident advantages, allowing economic growth linked to environmental sustainability [29], thus achieving the link with the 2030 Agenda within the framework of the sustainable development goals. According to Tiserant A. (2017), the concept of the circular economy aims to extend the useful life of materials by promoting recycling to maximize their use in terms of the input of resources while also reducing environmental impacts and the use of resources. This concept is also closely linked to the 3Rs (reduce, recycle, and reuse) [48]. It is also interesting to mention that the European Commission has recently adopted a Circular Economy Action Plan. This plan presents a set of interrelated initiatives to establish a solid and coherent product policy framework that will make sustainable products, services, and business models more sustainable. Consumption patterns should be transformed so that waste is not produced in the first place; however, this is a process that will be implemented progressively. Europe will not achieve a change by acting alone. It is expected that the European Union will lead the path towards a circular economy worldwide, making use of its influence, experience, and financial resources to implement the sustainable development objectives of the 2030 Agenda. Additionally, between 2012 and 2018, in the framework of the circular economy, there is an increase in the number of jobs of 5%. Circularity is expected to have a positive effect on job creation for society, considering that the skills required by the green transition are currently available [53].

4.1.4. Technologies and Urban Solid Waste

According to Tsai and Feng Ming (2020), the management of urban solid waste is defined as complex procedures that integrate waste collection, transfer stations, treatment strategies, and energy recovery [19]. Waste treatment techniques are the main means to achieve these objectives, which prioritize human health and environmental protection, followed by economic development, and comply with established regulations or legislation and social requirements [19]. Particularly in the management of solid waste, it is necessary to identify planning and monitoring methods to reduce the generation of waste. This is in addition to establishing techniques such as the reuse and recycling of waste with commercial value and defining indicators that support the importance of proper management [62]. According to Salguero-Puerta et al. (2019), waste management is currently carried out in the following order: production, presentation, collection, transport, and treatment [7]. However, in developing countries, the scheme is similar. According to Yamunaque et al. (2021), in Latin America, the processes involved in solid waste management are as follows: cleaning, storage, collection, transfer, treatment, and final disposal [63]. However, Muñoz-Menendez et al. (2021) detail that in different countries, the ranking of alternatives is grouped as follows: prevention (prevention and source reduction), recovery, reuse, recycling, composting, energy recovery (anaerobic digestion, incineration, etc.), and final disposal in landfills [52]. Furthermore, the technologies involved affect the production systems since it is necessary to produce more with fewer resources; in this sense, the inclusion of the circular economy is essential.

According to Tisserant et al. (2017), the relative proportions of the different waste treatment processes vary according to the region [48]. For example, Russia, Brazil, Mexico, and Canada depend mainly on landfills, while Japan has the highest proportion of incineration. This is determined based on the space in the territory and the population density; however, in low- and medium-income countries, there is no control of the information on waste treatment, and therefore the poor coverage of landfills is clearly observed, often not being regulated in official statistics in addition to informal burning. According to Jiang et al. (2022), incineration has gradually become the most effective way to treat urban waste, due to its evident effects of volume and weight reduction and considering its proper handling due to the heavy metals and organic contaminants involved in the transportation of fly ash from waste incinerators. Solid waste generates a negative impact on human health and the environment [64]. According to the World Bank, by 2025 it is estimated that the urban solid waste generated in urban areas will reach 6.1 million tons per day, and the disposal of urban solid waste will have become a challenge faced by countries around the world [65]. Currently, some types of urban solid waste treatment have been identified, which are mainly dumping, thermal treatment, and recycling [66]; among them, the European Union focuses mainly on recycling (48%), landfills are used by the United States and India (54% and 75%, respectively), and Japan uses incineration most frequently (80%) [66–70]. High-quality recycling is based on the efficient selective collection of waste [54]; important actions in the goals of the 2030 Agenda include recycling (65% for solid urban waste, 70% for construction and demolition waste, and 75% for packaging waste), restrictions on landfills (reduction in waste of 10%), promoting industrial symbiosis and eco-design, and giving waste prevention top priority, as European legislation still lacks quantitative targets for waste prevention [71].

5. Conclusions

The objective of the study is to carry out a bibliometric analysis of the publications on the subject of "urban waste" during a period of 41 years from 1981 to 2021, taking into consideration the Elsevier Scopus database, resulting in 1897 published articles being obtained. In addition to identifying the main agents that contribute to the research topic, including authors, institutions, countries, and journals, we include the thematic areas with which the articles are associated.

In recent years, there has been a significant increase in the number of publications on "urban waste". This shows that the interest of the scientific community in this topic has increased, as in the last six years, 696 articles have been published (which represents 30% of the contributions on this research topic). In addition, environmental science is identified as the main subject area, representing a total of 31.25% of the articles, followed by agricultural and biological sciences with 11.78% and engineering with 8.51%.

Among the most productive journals were *Science Of The Total Environment* (41 articles), with the highest journal h-index and SJR (1806 Q1); *Waste Management* (39 articles), with a journal h-index of 182 and SJR of 1.74 (Q1); and *Journal of Cleaner Production* (35 articles), with a journal h-index of 232 and SJR of 1.921 (Q1), also began publishing articles in this area of research from 2012, generating the largest amount of work in the period of 2016–2021, where 28 articles of this type where published. The highest average number of citations per article (72.78) was registered to the *American Journal Environmental Science and Technology,* also having the highest SJR (2.702 Q1). In addition, the journal *Chemosphere,* which has published articles (22) in each of the periods analyzed (1981–2021), is positioned with an SJR of 1.05 (Q1) and a journal h-index of 265.

The most productive author is Montoneri, E., from the Università degli Studi di Torino (Italy), with a total of 25 articles and an h-index of 12; however, the author with the highest number of citations (898) and an average number of citations representing 69.08%, of the Segura Center for Edaphology and Applied Biology (CEBAS-CSIC, Spain), with a total of 13 articles and an h-index of 4, is García, C. On the other hand, of the ten most productive researchers, six have produced articles in the last period (2016–2021), which demonstrates the rapid expansion of this line of research.

The most productive institution in terms of published research articles on urban waste is the Higher Council for Scientific Research, Spain, with 37 articles, 1812 citations, and an average of 48.97 citations per article. However, the CEBAS-CSIC, Center for Edaphology and Applied Biology of Segura (Spain), has the highest average number of citations (63.83). The CNRS Center National de la Recherche Scientifique (France) presents the highest rate of international cooperation (48.3%), and Universidade Estadual Paulista Júlio de Mesquita Filho (Brazil) presents the lowest rate of cooperation in this line of research (12%).

Regarding the most productive countries in this line of research, we have found that the institutions in Italy have generated the largest number of research articles on urban waste (279). In addition, the countries that have published during the entire study period are Italy, France, and India, while Brazil (101), Italy (100), and Spain (83) were the countries that published the most articles in the 2016–2021 period. However, in the last period analyzed (2016–2021), there has been a significant increase in the generation of jobs in this line of research.

This study presents an analysis of the scientific production and main authors in the field of urban waste during the period 1981–2021. The general increase shown for this line of research dates back to the period 1991–1995, with a variation percentage of 100%, showing an increase in the number of articles, authors, countries, and journals that have shown greater interest in this line of research.

In turn, this bibliometric analysis allows us to identify lines of research framed in the management of urban solid waste. We define these lines as (1) society and the management of urban solid waste, (2) technologies for the use and treatment of urban solid waste, (3) technologies for the final disposal of urban solid waste, and (4) urban solid waste and the economy (transition from linear to circular). Taking into consideration the first line of research, the relationship between society and waste management stands out, being a topic of great interest for the scientific community, mainly academics. In this context, this line of research shows potential in the determination of techniques and technologies for the management, treatment, and final disposal of urban waste, in addition to aiding the decision-making process of the respective entities.

This analysis used the VOSviewer software as a tool for the analysis of keywords and the creation of network maps. This software can generate information that is slightly different from that obtained in the Scopus database, which is why it is considered a limitation and is important to recognize.

In terms of scientific activity, this bibliometric analysis shows that there is interest from the scientific and academic communities in the field of "urban waste", thus allowing the generation of scientific and technical information, as well as favoring better decision-making processes for the competent government entities mainly responsible for the management of urban solid waste.

According to the literature review, it is possible to identify three main solid waste treatments: recycling (48%) in the European Union, landfills in the United States and India (54% and 75%, respectively), and incineration in Japan (80%). In low- and middle-income countries, there is no control of the information on waste treatment, resulting in a poor coverage of landfills, which is often not regulated in official statistics.

In addition, greater attention should be paid to the production, consumption, and final generation of waste, carrying with it processes that allow the involvement and participation of the population in the circular economy scheme, favoring actions aimed at protecting the environment and human health.

Finally, the management of urban solid waste and the circular economy fundamentally focuses on changing the paradigm of "reduce, reuse and recycle". It seeks to reduce the impact of the poor management of urban solid waste on health and the environment. It is necessary to try to establish strategies that are oriented towards strengthening the technical capacities of governments, in addition to developing community projects oriented towards the separation of solid waste from the source.

The authors acknowledge that this study has some limitations, which could form the basis for future research. First, the time horizon and the type of documents analyzed may have affected our findings. Some of the research carried out on urban waste has not been considered; for example, the research papers prior to 1981, as well as all papers that are not research articles, which implies that part of the academic literature has not been explored. We propose that in future research the period of time analyzed be extended, as well as the types of research documents. The database used is also a limitation: Scopus. Despite being recognized by the academic literature as a relevant repository at an international scientific level, other relevant scientific repositories such as WoS, Google Scholar, or PubMed, among others, contain research documents with valuable information on urban waste. Consequently, the authors propose that other scientific repositories be used in future research, even in combination, which would undoubtedly help to create a broader image of this line of research. Finally, the authors recognize that the use of VOSviewer, compared with other computer software, such as SciMAT or similar programs, could have generated different keyword associations, as well as different results in terms of the cooperation between authors, institutions, and countries. Therefore, we propose that, in future research, other software that establishes these associations should be used.

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