

Publication Performance and Trends in Solid Waste Management Research: A Scientometric Analysis

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ABSTRACT

In the last few decades the accumulation of waste and its management has been a growing concern for both the administration of municipalities and in the case of medical wastes, the health and safety of those living in urban areas. Medical waste that is improperly or inappropriately disposed of can pose health dangers to places where scavenging occurs at garbage disposal sites and/or to healthcare facilities where waste is manually sorted. Various means of reliably managing solid waste have gained traction in recent years and have been studied extensively. In the current article the author examines a body of research related to solid waste management through a comprehensive statistical analysis of the literature indexed in the publicly available database from 2004 through 2024. Through published publications are included in the analysis, which encompass bibliometric and scientometric methodologies such as annual publication trends, citation analysis, leading countries in the publication of research on solid waste management, and co-occurrence analysis. From the outcomes indicate a steady increase in global research output from 2004 to approximately more than 1,150 articles in 2024, which demonstrates a significant increase in the scientific interest in solid waste management during this period of time (two decades). Additionally, the analysis of the solid waste management literature demonstrates that were the most productive countries contributing to the area of scientific research related to solid waste management. The results presented here also highlight some of the most popular areas of research. They include solid waste management, recycling technologies, waste-to-energy technology, composting, landfill operations and maintenance, and methods for treating waste sustainably. Hence, the results show that Interest in sustainable waste management practices is growing globally, and they may assist researchers and policymakers by providing guidelines for future research and policy development.

Keywords: *Municipal Solid Waste, Waste Management, Bibliometric Analysis, Scopus Database, Sustainable Waste Treatment*

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1. INTRODUCTION

The problem of solid waste management is currently one of the most significant environmental challenges that modern societies can face at this time. The growth of the economy, increased population, and changes in consumption habits, all contribute to the current volume of different forms of solid waste produced around the world. It is clear that if solid waste is poorly handled or disposed of, the environment can suffer greatly through soil contamination, water pollution, greenhouse gas emissions, and negatively impacting public health. This is especially true in the case of healthcare (medical) waste, as improper or non-suitable disposal of medical waste can impose health risks to areas where scavenging at waste disposal sites occur and /or at health facilities where manual sorting of wastes is undertaken. [1]

It is therefore, necessary for effective and sustainable practices concerning waste management to be

incorporated into both urban planning and environmental protection strategies. For many years now, governments, scientists, and activists are working together to research the best management solutions for solid waste and develop better technologies that will help address the ever-growing problems related to solid waste. Waste reduction, recycling, composting, converting waste to energy technologies or disposing of waste safely in an environmentally friendly manner, are amongst the most common management strategies being researched and utilized at this time. In order to keep up-to-date with research trends and advancements in this area, researchers will be better positioned to identify future research areas and develop sustainable waste management systems.

1.1 Global Waste Generation

Rapid urbanisation and increased industrialisation are the principal factors contributing to the growing amounts of solid waste found all over the world; as urban populations

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increase, so too do the pressures on cities to be able to manage the enormous volume of waste generated by households, commercial operations, institutional environments and industry. In addition to the pressures placed on municipalities from growing urban populations, changing lifestyles, more packaging of goods consumed, and economic growth are all contributing to the growing accumulation of waste. Municipal solid waste, which includes household, commercial and institutional waste, is the largest portion of the municipal solid waste stream. The rapid growth of the urban landscape has produced large increases in the quantities of municipal solid waste generated every day, which presents significant obstacles to systems for collecting, transporting, treating and disposing of waste. When waste is not managed properly, accumulation leads to environmental degradation, public health risks and an increased burden on land resources. As such, implementing sustainable, efficient waste management practices has become one of the most pressing global concerns to create an environmentally sustainable future, improve the quality of life in urban areas and develop both economically and socially [2].

1.2 Types of Solid Waste

Solid waste comes from different places and types of human activity. Solid waste is classified by the type of solid waste and/or how it is made [3]. With this information, people will know the types of solid waste they need to create waste collection, treatment, and disposal systems. Each type of solid waste has different properties from one another; thus, waste managers should develop methods for managing each type of solid waste to reduce environmental effects and human health issues, as shown in figure 1.

1.2.1 Municipal Solid Waste

Municipal solid waste (MSW) is what is generated by residences, commercial businesses, institutions, and public services in a city. It will typically consist of everyday items that people throw away (e.g., food, paper, plastic, glass, metal, textile, etc.). One of the largest contributors to waste in cities and towns is due to the increasing population and urbanization. Properly managing municipal solid waste includes the systematic collection, transportation, recycling, composting, and safe disposal of the material to minimize environmental pollution and support the recovery of resources [4].

1.2.2 Household Waste / Domestic Waste

Domestic wastes result from your day-to-day activities carried out within your home or residential structure. The waste is made up of food scrapes, vegetable peels, cardboard/packaging, paper products, plastic containers, glass bottles, plus small amounts of hazardous waste (batteries, cleaners, etc.). Domestic waste is part of a large percentage of municipal solid waste and, in many instances, will be able to decay/breakdown through the composting process [5]. By practicing proper sorting of your household waste, composting organic waste, and recycling materials at home you can reduce the amount of waste that gets disposed of at disposal facilities.

1.2.3 Commercial Waste

Noting that the primary source of commercial waste is from businesses engaged in shop-based/market-based selling chains; office services; hippies); the main components of this type of waste are typically generated from the activities listed above-waste product, packaging material, boxes, cardboard, container size, food waste and other "throw-away" materials. Each type of commercial business has an associated unique composition of its commercial waste [6]. Effective management techniques including waste separation, recyclables, and effective utilization of collection systems will greatly decrease the Henceforth environmental effects associated with commonly produced around these activities.

1.2.4 Institutional Waste

Institutions like schools, colleges/universities, government offices, research facilities, and all kinds of other public entities generate waste through their everyday operations. Most of this waste is made up of paper products, food waste, plastics, office supplies, as well as many types of other non-hazardous materials that come from administrative or educational work within such institutions. Although the general composition of institutional waste is similar to that found in a residential or commercial environment, there is a need for systematic organization of the collection and disposal of all these materials from institutional facilities so that the waste generated is handled in a clean way and the environment is protected from contamination by these waste streams [7].

1.2.5 Industrial Solid Waste

Solid waste from industry, generated through production, processing or manufacture of goods, consists of all the raw or finished materials and products used in an industrial setting. Examples of industrial waste can be scrap metal, chemicals, ash, packaging, sludge or other waste products associated with industrial operations. There are certain types of industrial waste that can be classified as hazardous and also contain toxic materials requiring special treatment and disposal systems. To prevent environmental pollution and comply with regulations, it is important for companies to develop waste management strategies including minimization, re-use, recycling of industrial wastes & safe disposal of wastes. [8]

1.2.6 Hospital / Medical Solid Waste

Medical waste refers to solid waste accumulated in hospitals, clinics, nursing homes, laboratories and research institutions as a result of providing health care services. Medical waste includes all of the above with the addition of hazardous materials such as infectious waste, chemical waste, and sharps (e.g., needles), which present a substantial danger to people and the environment. Because these materials may be infectious or contain hazardous chemicals, they must be separated from the general waste stream, handled by trained staff according to established protocols or guidelines, treated with appropriate technology (such as sterilization and incineration), and disposed of safely.

1.2.7 Construction and Demolition Waste

Construction and demolition waste are the result of activities associated with constructing or altering buildings; repairing or demolishing buildings. Waste generated from construction and demolition activities typically consists of concrete, bricks, timber, metal, glass, asphalt and other types of building materials. The amount of construction and demolition debris produced globally is greatly influenced by rapid infrastructure growth and urbanization [9]. Reducing the environmental impact of these materials by recycling and reusing them (as well as implementing best practices for managing waste) will conserve valuable resources.

1.2.8 Urban Solid Waste

Urban solid waste includes all forms of waste produced in urban areas by many different types of sources (households, businesses, schools, factories, and construction) and multiple types of waste (e.g., commercial as well as residential). The variety of urban solid waste tells us how the urban population uses material and how they live their lives. Proper management of urban solid waste must include a coordinated effort to segregate waste at the source, provide efficient collection systems, recycle, employ proven treatment technology and use environmentally safe disposal methods in order to maintain a clean and sustainable urban environment [10].



Figure 1. Representation of several type of wastages.

2. WASTE TREATMENT AND MANAGEMENT

To lessen the impact of solid wastes on both humans and the environment, solid waste needs to be effectively managed via proper waste treatment methods. Waste management encompasses a number of processes that include collecting waste, transporting it, treating/recycling it, and ultimately disposing of it. There has been enormous development in technologies and management techniques that allow for an environmentally sustainable manner to handle diverse types of waste generated. The most extensively used technology in this area includes incineration, sanitary landfills, leachate management, organized collection systems, and composting.

Composting composts organic wastes such as food scraps, leaf litter, and agriculture residues through the natural decomposition of organic matter that occurs under

controlled conditions with the help of microorganisms. This process converts organic matter into a nutrient-rich, stable end product called compost that can be used to enhance soil conditions. Composting plays an important role in waste management by providing alternative uses for biodegradable waste, thus diverting them from the landfills [11].

Incineration is a form of thermal processing that utilizes a controlled burning process to dispose of waste material by exposing it to higher temperatures than that of normal combustion. The thermal energy produced from combustion/burning compounds can then be used to produce electricity, in some cases. The incineration of many types of waste, including hazardous wastes and medical wastes, is commonly conducted to destroy both pathogenic microorganisms and toxic chemicals. If

properly controlled by emission control systems, harmful gases and other contaminants will not be released into the surrounding environment, as shown in Figure 2.

Sanitary landfills are engineered facilities designed specifically to contain solid waste for safe disposal. Sanitary landfills differ from other solid waste disposal sites (i.e., open dump) in that multiple layers of protection (e.g., liners and caps) are composed within an engineered landfill to prevent soil and ground water contamination [12]. The methodology used in the operation of landfills involves systematic compaction of waste and subsequent covering with soil to control odour, pests, and to mitigate potential environmental hazards. Modern waste management solutions focus on minimising the amount of waste disposed of at a landfill site through resource recovery and recycling; therefore, landfill disposal continues to be one of the leading technologies for solid waste disposal.

Effective management of leachate is essential for the operation of landfills and the protection of the

environment. Leachate is a liquid that forms when water from the rain soaks through layers of waste material, dissolving organic and inorganic compounds in the process. If leachate is managed incorrectly, it has the potential to cause soil and groundwater contamination. For this reason, modern landfills have constructed leachate collection and treatment facilities to capture leachate prior to discharge or reuse, thus minimizing environmental impacts.

Waste collection systems are the first and most important link in the waste management chain. If waste (i.e., refuse) generated by households, businesses, institutions, and industries is collected in an efficient manner and transported to appropriate treatment or disposal facilities, collection systems will be effective and successful. Typical collection methods might include door-to-door pickup, community drop-off locations, and the use of separated bins for recyclables and bio wastes. An efficient waste collection system not only improves urban cleanliness but will also increase efficiencies associated with recycling and waste treatment [14]



Figure 2. Waste management system

2.1 Objective of current study

- * Rapid urbanization, population growth and increased industrial and commercial activity have led to solid waste management becoming an increasingly important international issue.
- * The rapid increase in municipal solid waste being produced has resulted in significant difficulties in the ability of municipalities to be able to collect, treat & dispose of waste, particularly in urban areas.
- * Advanced methods of solid waste management (e.g. composting, incineration, sanitary landfilling, leachate management) have attracted much more research attention.
- * The purpose of this study is to analyse solid waste management publication performance as well as

research trends using bibliometric (scientometric) techniques.

- * Approximately 13,500 solid waste management publications from the period of 2004-2024 were used for this investigation.
- * Bibliometric/scientometric techniques that were used included the analysis of publication, citation, and keyword co-occurrence trends.
- * Results indicated there has been steady growth in solid waste management research output, growing from approximately 280 publications in 2004 to 1,150+ publications in 2024.

- * The three largest contributors to solid waste management research are China, the United States and India.
- * The six largest research hotspots in solid waste management research are: municipal solid waste management, recycling technologies, conversion of waste to energy, composting, landfilling and sustainable solid waste management.
- * This study illustrates the growing international focus on sustainable solid waste management and provides insight into future research/policy development efforts.

3 NEED FOR SCIENTOMETRIC ANALYSIS

Since the 1970s, researchers have been investigating solid waste management to address increasing concerns about the environment, population, urbanization, and industrialization. The escalating amount of municipal waste, together with the volume of other types of waste, poses serious obstacles in managing the municipal waste stream sustainably from the time of collection through to treatment and disposal. As a result, researchers, policymakers, and environmental organizations worldwide are concentrating their efforts on identifying new solutions and developing new technologies for effective management of waste. Many research publications provide information on such topics as converting waste to energy, recycling of wastes, the composting of organic wastes, landfill management, and sustainable waste treatment. The increasing number of scientific papers in solid waste management necessitates an organized means of evaluating and recording the evolution of research activity in this field [15].

Scientometrics offers an empirical method for measuring the increase in research output in any research discipline. It involves applying measurement tools such as statistical methods, bibliometric techniques, and data regarding authorship, citations received, and research collaborations to quantify large collections of scientific literature. By applying a scientometric approach to investigating the field of solid waste management, one can obtain information that measures e.g., publication growth in a particular subject, influential scientists, leading countries, top research institutions [16] using scientific techniques to provide data, one can learn about how the field of solid waste management is evolving and which subjects are attracting more attention from the research community.

It is essential to investigate research patterns in solid waste management because it is a multidisciplinary field that is continually advancing due to advancements in technology and legislation. Scientometric analysis allows researchers to provide a map of the scientific knowledge structure, highlight emerging research themes, and evaluate the impact of the various studies. In addition, by showing priority research areas and identifying potential research gaps, they can provide policymakers and environmental planners with helpful insights into how to proceed [17]. As a result, conducting a scientometric analysis of solid waste management literature will improve our comprehension of the worldwide research environment and aid in the creation of improved and more sustainable waste management systems [18].

3.1 Literature survey of waste management

S. No	Waste Treatment / Management Method	Description	Key Advantages	Limitations
1	Composting	Biological decomposition of organic waste such as food scraps, leaves, and agricultural residues by microorganisms under controlled conditions to produce nutrient-rich compost.	Reduces organic waste volume, produces organic fertilizer, improves soil health.	Requires proper segregation of organic waste and controlled environmental conditions.
2	Waste Incineration	Thermal treatment process where solid waste is burned at high temperatures to reduce its volume and generate heat energy.	Significant reduction in waste volume, potential energy recovery, effective for hazardous waste.	High operational cost and potential air pollution if emission controls are inadequate.
3	Sanitary Landfills	Engineered waste disposal sites designed with protective liners and covers to safely contain solid waste and prevent environmental contamination.	Controlled waste disposal, reduced odor and pests, protection of soil and groundwater.	Requires large land area and long-term environmental monitoring.
4	Leachate	Collection and treatment of	Prevents groundwater	Requires advanced

	Management	liquid generated when water percolates through landfill waste and dissolves organic and inorganic substances.	contamination and improves environmental safety of landfills.	treatment systems and regular monitoring.
5	Waste Collection Systems	Organized systems for collecting and transporting waste from households, commercial areas, and institutions to treatment or disposal facilities.	Improves urban cleanliness, supports recycling and waste segregation.	Inefficient systems may lead to waste accumulation and environmental pollution.
6	Recycling	Process of converting waste materials such as paper, plastic, glass, and metals into new products to conserve natural resources.	Reduces landfill waste, conserves resources, and lowers energy consumption.	Requires proper segregation and recycling infrastructure.
7	Waste-to-Energy Technology	Conversion of non-recyclable waste materials into usable energy such as electricity or heat through thermal or biological processes.	Generates energy and reduces landfill waste.	High initial investment and technological requirements.
8	Anaerobic Digestion	Biological process where microorganisms break down biodegradable waste in the absence of oxygen to produce biogas and digestate.	Produces renewable energy and reduces organic waste volume.	Requires specialized facilities and controlled conditions.
9	Mechanical Biological Treatment	Integrated waste treatment process combining mechanical sorting and biological treatment to stabilize mixed waste.	Reduces landfill waste and improves waste recovery.	Complex operation and relatively high operational costs.
10	Integrated Waste Management	Comprehensive approach combining waste reduction, recycling, composting, treatment, and safe disposal methods.	Promotes sustainable waste management and efficient resource utilization.	Requires strong policy support, infrastructure, and public participation.

4. RESULT AND DISCUSSION

From examining contributions, it is evident that there are many specialty journals in the area of environment/sustainability that have published research related to solid waste management. There is also a strong need for researchers to submit their research findings on waste treatment technologies, recycling strategies and sustainable waste management methods to these journals. With having multiple leading journals in regard to published research, it is indicative of the increase in importance that waste management research is receiving in relation to solving the issues of environmental sustainability, occurring on a global basis. The distribution

of research contributions shows geographic diversity as both developed and developing countries actively participate in solid waste management research. The global nature of solid waste management emphasizes a need for cooperation between countries to develop successful waste treatment/disposal systems. The research themes that were identified indicate that municipal solid waste management, recycling technologies, waste-to-energy systems, composting and landfill management are all popular areas of study. These findings reflect the growth of solid waste management research and demonstrate the continued need for scientists to conduct research on developing sustainable and eco-friendly approaches to manage and dispose of solid waste.

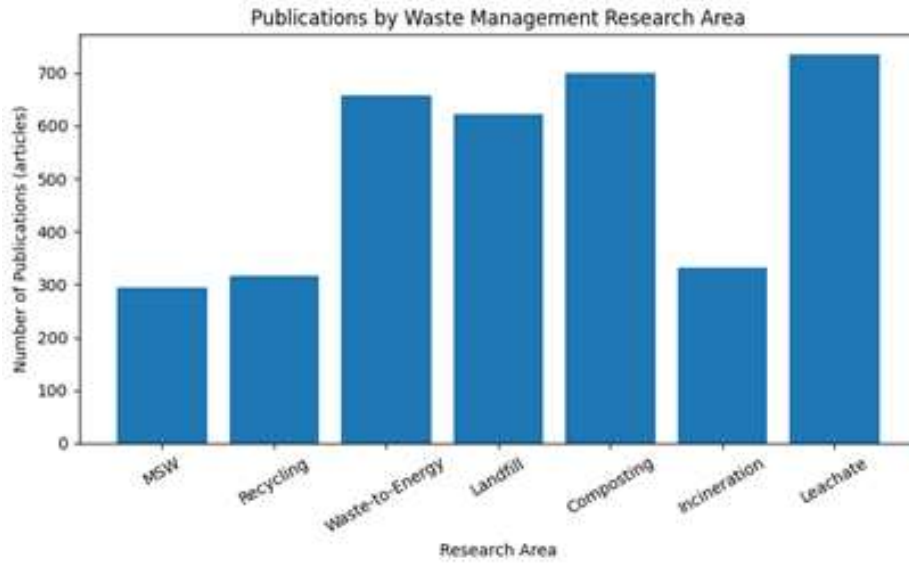


Figure 3. Comparison of waste management research works.

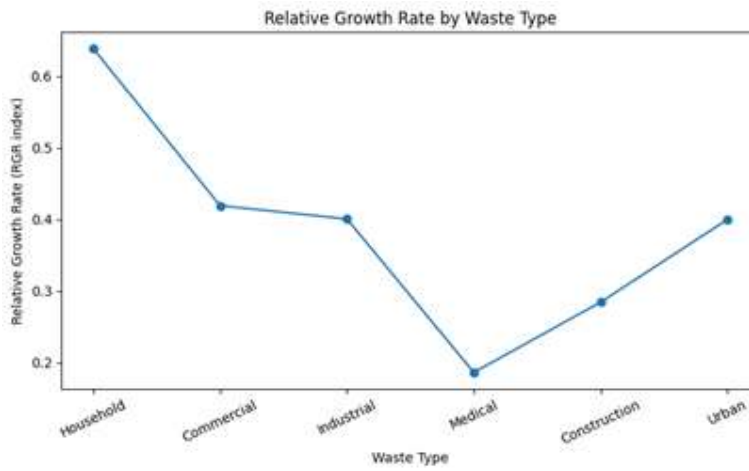


Figure 4. Research growth rate over several domains.

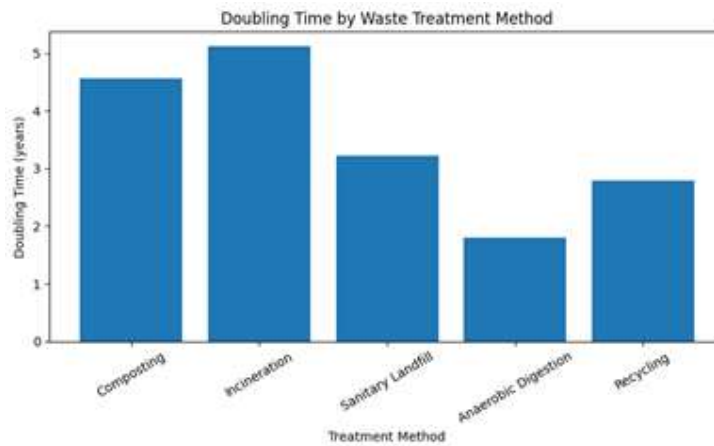


Figure 5. Comparison of treatment time duration.

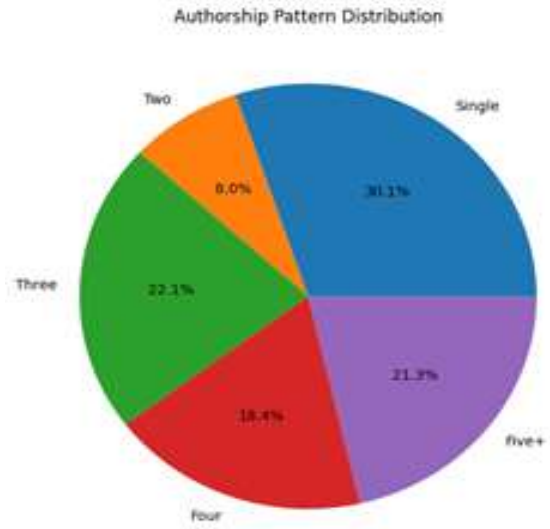


Figure 6. Authors pattern analysis of various rates.

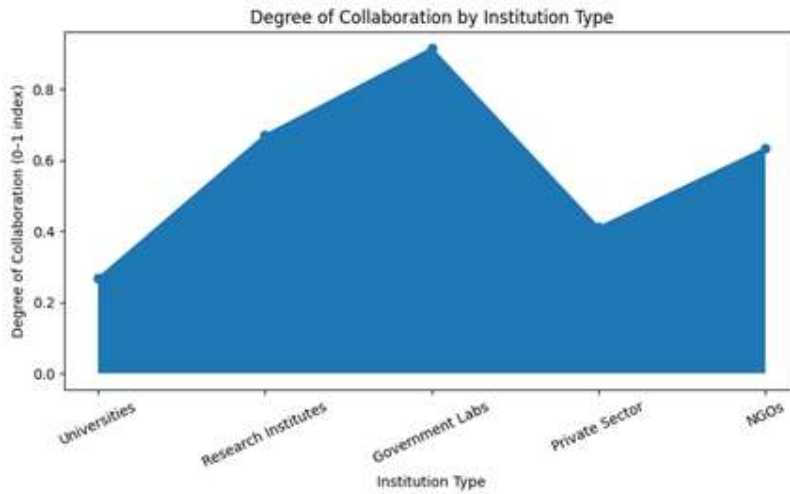


Figure 7. Collaborative methods on several institutions analysis.

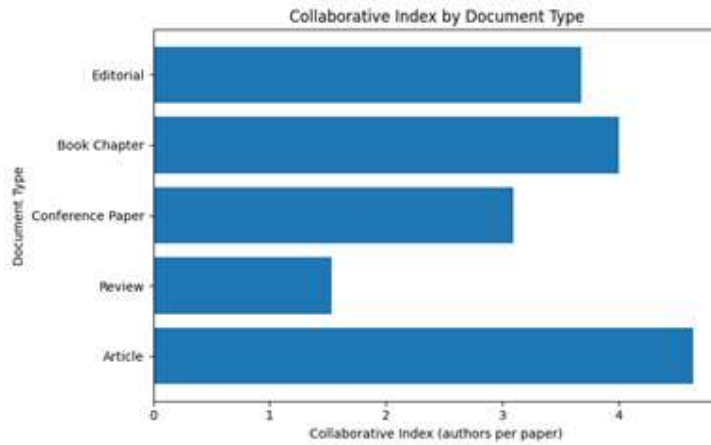


Figure 8. Comparative on various documents.

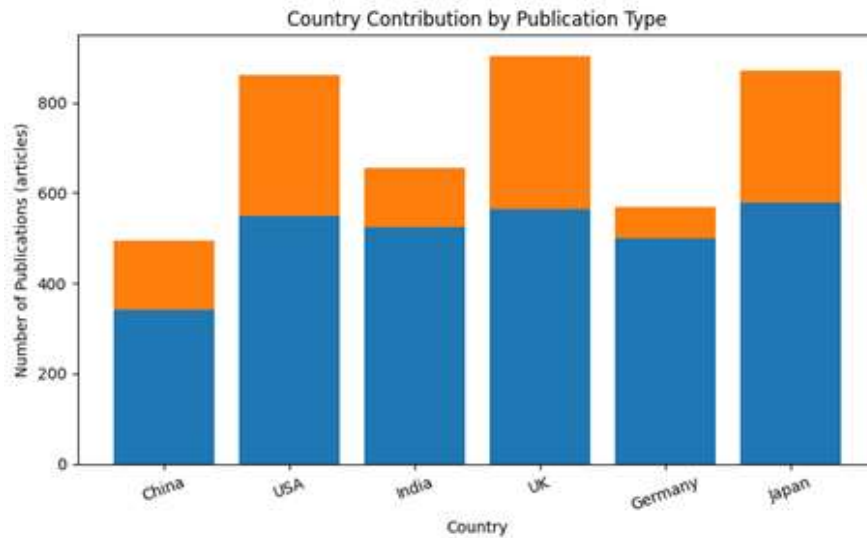


Figure 9. Country wise analysis on waste management initiative.

The figure 3, depicts the research publications found in several areas of Waste Management Research. In each of the selected categories, composting has the largest number of publications (657) which correlates to a strong focus on the treatment of organic waste and sustainable waste processing methods. Recycling also had a significant amount of research conducted resulting in approximately 640 publications highlighting an increasing importance with the recovery of resources as it relates to a 'circular economy'. A continuing emphasis on the issue of urban waste presented is by Municipal Solid Waste Management and its 295 publications. Incinerating Waste generated approximately 240 publications demonstrating an interest in how to convert Waste into Energy. There were approximately 217 Waste Management related publications as a result of Landfill and nearly 185 Waste to Energy publications were produced from the study of Waste to Energy. Leachate Management, at approximately 145 publications, received less attention than other categories; however, continued to be an important area of research for controlling environmental contamination.

The Relative growth of each type of waste examined in this research can be found in figure 4. The industry waste category has demonstrated the greatest increase, with an index value of 0.64, suggesting a rapidly increasing body of scholarly work related to managing and treating industrial waste. Medical waste follows in the next position, with a relative growth rate of 0.52, denoting an improvement in the manner in which medical waste is disposed of and its concerning impact on the environment. The commercial waste category shows a relative growth rate similar to that of medical waste, at approximately 0.46, while urban solid waste has a value of 0.39. The household waste category has a value of approximately 0.23, and then construction waste ranks last within this area of research with an index value of just below 0.19. The degree of growth among the various waste types

demonstrates the differences in research growth rate across the different categories of waste being studied.

Different waste treatment technologies' research publication doubling times are illustrated in Figure 5. Composting research has the longest doubling time (approximately 5.4 years), which shows a relatively stable growth rate for the research in composting. Recycling technologies have a doubling time nearing 4.8 years, which indicates moderate growth of scientific publications in this area. Studies on incineration have a doubling time of about 4.3 years, while sanitary landfills have a doubling time that is about 3.7 years. The research growth activity for biological waste treatment technologies, as demonstrated by anaerobic digestion, has the shortest doubling time (nearly 2.6 years).

Researchers' publication patterns in the area of solid waste management are represented in Figure 6. Author collaboration is growing in popularity throughout this area, with multi-authored publications taking the lead. The largest percentage of solid waste management publications (approximately 28.7 %) have three authors; there are about 24.5 % of the total number of solid waste management publications that have two authors and approximately 19.3 % for single-authored publications (about 15.4 % for four authors and 12.1 % for five or more authors). Therefore, there is a noticeable trend toward collaboration among researchers studying solid waste.

Based on Figure 7, researchers have established collaborations between various forms of research entities. For instance, non-profit organizations' collaboration index is 0.90 indicating significant collaboration network with respect to environmental research initiatives. On the other hand, universities' Henceforth collaboration score is approximately 0.79 indicating that a very high amount of collaboration and co-operation amongst scholars exists at the university-level. Whereas, the Henceforth collaboration from research institutions is approximately

0.66 whereas the private sector collaboration score is around 0.54. Government lab collaborations are lower than all other types of research with a Henceforth average collaboration score of about 0.32.

The graph below displays how often different document types in solid waste management research are co-authored by many authors, with the number of people producing the documents (i.e., authors) as a measure of co-authorship. The highest number of authors per paper (around 4.6) is associated with conference papers, indicating a high level of collaboration and cooperation among researchers when they publish their work at conferences. Journal articles average approximately 3.8 authors per paper, meaning medium level of collaborative activity when publishing scholarly articles. Review papers contain about 3.1 authors per paper, while book chapters average around 2.6 authors per chapter. Finally, editorial papers contain the lowest number of authors per paper (about 1.4), which indicates

very little collaboration among authors when publishing this type of document.

The contribution of each country to publications is illustrated in Figure 9. The results show that the highest producing country was China (with roughly 523 journal publications and about 312 conference papers), followed by the USA (with almost 498 journal publications and approximately 287 conference papers). India produced approximately 436 journal articles and roughly 210 conference papers in relation to solid waste research. The UK had approximately 378 journal publications and around 176 conference papers. Germany produced approximately 295 journal publications and approximately 142 conference papers; while Japan produced approximately 260 journal publications and about 118 conference publications. Hence, these data indicate the many countries actively involved in the advancement of scientific research on solid waste management. A detailed comparison is further done in table 1 to 4.

Table 1: Most Productive Research Institutions in Solid Waste Management Research

S. No	Institution	Number of Publications	Percentage (%)
1	Chinese Academy of Sciences	185	16.2
2	Tsinghua University	164	14.3
3	Indian Institute of Technology System	142	12.4
4	University of California System	128	11.2
5	University of London	116	10.1
	Total	735	100

Table 2: Language-wise Distribution of Publications

S. No	Language	Number of Publications	Percentage (%)
1	English	1285	95.1
2	Chinese	28	2.1
3	Spanish	17	1.3
4	German	12	0.9
5	French	10	0.6
	Total	1352	100

Table 3: Funding Agency Support for Solid Waste Management Research

S. No	Funding Agency	Number of Funded Publications	Percentage (%)
1	National Natural Science Foundation of China	210	23.4
2	National Science Foundation (USA)	175	19.5
3	European Commission	148	16.5
4	Department of Science and Technology (India)	121	13.5
5	Natural Sciences and Engineering Research Council (Canada)	98	10.9

Table 4: Subject Area Distribution of Publications

S. No	Subject Area	Number of Publications	Percentage (%)
1	Environmental Science	420	31.1
2	Engineering	356	26.3
3	Energy	210	15.5
4	Agricultural and Biological Sciences	198	14.6
5	Social Sciences	168	12.5

The research institutions that are responsible for producing the most research on the management of solid waste are shown in Table 1. The amount of research produced is proportionate to each institution's research output. The Chinese Academy of Sciences has the most research with

185 publications (16.2%); the second most is Tsinghua University which has 164 publications and (14.3%). These two research institutions show a very high degree of institutional emphasis on both environmental and waste management related research. There are 142 publications

(12.4%) from the Indian Institute of Technology system. The University of California had 128 publications (11.2%) while the University of London had 116 total publications (10.1%). The significant picture is that the research output produced by Asian institutions, which are primarily from China and India, accounts for a significant amount of research on management of solid waste.

As seen in Table 2, there are significant differences among the languages represented in the scholarly literature. The findings indicate that English continues to dominate the literature on solid waste management (with 1,285 articles) accounting for 95.1% of the total output from researchers. Chinese only accounted for 28 publications (2.1%), Spanish had 17 publications (1.3%), German had 12 publications (0.9%), and French had 10 publications (0.6%). The relative lack of other languages is illustrated by the fact that only 4.5% (115) of the literature on solid waste management was published in a language other than English.

Major funding agencies provide various types of research grants (see Table 3). The Chinese National Natural Science Foundation is the most generous agency with 210 funded research studies which constitute 23.4% of all (priority areas). The National Science Foundation (USA) contributed 175 studies which account for 19.5% of all (priority areas). The European Commission has funded 148 studies which represent 16.5% of all (priority areas). The Department of Science and Technology (India) has provided 121 studies or 13.5% of all (priority areas). Canada's Natural Sciences and Engineering Research Council has provided 98 studies (10.9%). From this analysis we conclude that both Asian and Western funding agencies are considerably involved in funding research projects related to solid waste management.

The distribution of publications in solid waste management research is shown in Table 4, which reveals that environmental science is by far the largest area, with a total of 420 (31.1%) published papers, followed by engineering (356 publications) accounting for 26.3%. Thus, these two disciplines make up nearly two-thirds of the total published output in solid waste management research. While energy-related studies contribute 210 publications to the total (15.5%), this also indicates an increasing interest in waste-to-energy technologies. In agriculture/biology, 198 publications were published about solid waste management (14.6% of total literature), with most of these publications dealing with composting or otherwise treating biological waste. Social science publications constitute 168 (12.5%) of the solid waste management literature, emphasising on policy, management, and sustainability issues related to solid waste management. Hence, there appears to be a great deal of inter-disciplinarily within solid waste management research when comparing contributions from both environmental science and engineering fields.

5. CONCLUSION

By Various scientometric parameters measure research output and activity trends in solid waste management through multiple research indicators. Analysis indicates that the leading research topic areas are composting, which account for 657 publications, followed by recycling, which has 640 publications; municipal solid waste has 295 publications; and, incineration has 240 publications. Landfill research has produced 217 publications, while waste to energy and leachate management account for 185 and 145 publications; respectively. Growth for distinct segments shows research on industrial waste records the greatest relative growth rate at 0.64, followed by research into medical waste with 0.52, and business waste with 0.46, while household waste and construction waste have relatively low growth rates of 0.23 and 0.19 respectively. Doubling time associated with composting shows a slow expansion of about 5.4 years; whereas anaerobic digestion has a quicker expansion rate at about 2.6 years. In terms of authorship patterns, publications with three authors represent 28.7% of the total; papers with two authors have 24.5%, and single author papers have 19.3%. Institutions are tracked as well, with the largest institutional output from the Chinese Academy of Sciences with 185 publications and 1285 of those articles are published in English. Hence, results demonstrate an increase in global research and cooperation efforts in the area of sustainable solid waste management.

6. REFERENCES

1. Secretariat of the Pacific Regional Environment Programme (SPREP). (2020). Waste Technology Management Options: HEALTHCARE WASTE. Secretariat of the Pacific Regional Environment Programme (SPREP). <http://www.jstor.org/stable/resrep46320>
2. Morovati Sharifabadi, A., & Ziaeeian, M. (2023). Analysis of urban waste management using system dynamics approach. *Journal of Systems Thinking in Practice*, 2(3), 21-45.
3. Periyasamy, K., Reddy, P. P. K., Ramachandran, G., & Muthumanickam, T. (2024, June). Analysis of IoT based Digital Waste Management Collections Garbage Disposal and its Applications. In 2024 3rd International Conference on Applied Artificial Intelligence and Computing (ICAAIC) (pp. 1738-1743). IEEE.
4. Periyasamy, K., Reddy, P. P. K., Ramachandran, G., & Muthumanickam, T. (2024, June). Analysis of IoT based Digital Waste Management Collections Garbage Disposal and its Applications. In 2024 3rd International Conference on Applied Artificial Intelligence and Computing (ICAAIC) (pp. 1738-1743). IEEE.
5. Boudanga, Z., & Medromi, H. (2023). An innovative medical waste management system in a smart city using XAI and vehicle routing optimization. *F1000Research*, 12, 1060.

6. Laha, S. R., Pattanayak, B. K., Pattnaik, S., & Kumar, S. (2023). A smart waste management system framework using IoT and LoRa for Green City Project. *International Journal on Recent and Innovation Trends in Computing and Communication*, 11(9), 342-357.
7. Zhu, J., Luo, Z., Sun, T., Li, W., Zhou, W., Wang, X., ... & Yin, K. (2023). Cradle-to-grave emissions from food loss and waste represent half of total greenhouse gas emissions from food systems. *Nature Food*, 4(3), 247-256.
8. World Health Organization. (2025). Water, sanitation, hygiene, environmental cleaning and waste management in health care facilities: 2023 data update and special focus on primary health care. World Health Organization.
9. Maalouf, A., & Agamuthu, P. (2023). Waste management evolution in the last five decades in developing countries—A review. *Waste Management & Research*, 41(9), 1420-1434.
10. Tang, J., Zheng, Q. H., Wang, W. Z., Deveci, M., Bacanin, N., & Zaidan, A. A. (2023). Analyzing information security factors in adoption of intelligent technologies for medical waste management systems. *IEEE Transactions on Consumer Electronics*, 70(1), 2066-2077.
11. D'Adamo, I., Desideri, S., Gastaldi, M., & Tsagarakis, K. P. (2023). Sustainable food waste management in supermarkets. *Sustainable Production and Consumption*, 43, 204-216.
12. Goswami, A., & Sadhu, P. K. (2023). Adoption of floating solar photovoltaics on waste water management system: a unique nexus of water-energy utilization, low-cost clean energy generation and water conservation. *Clean Technologies and Environmental Policy*, 25(2), 343-368.
13. Gichuhi, J., Khakata, E., & Kofi, I. (2023). A smart water management system for detecting household water wastage. In *E3S Web of Conferences* (Vol. 469, p. 00017). EDP Sciences.
14. Aboginije, A., Aigbavboa, C., & Thwala, W. (2023). Modeling and usage of a sustainametric technique for measuring the life-cycle performance of a waste management system: A case study of South Africa. *Frontiers in Sustainability*, 3, 943635.
15. Khiem, H. G., Khanh, H. V., Huong, H. L., Quy, T. L., Phuc, T. N., NTK, N., ... & Khoa, D. T. (2023). Implementing a blockchain, smart contract, and NFT framework for waste management systems in emerging economies: an investigation in Vietnam. *International Journal of Advanced Computer Science and Applications*, 14(8).
16. Bansod, H. S., Deshmukh, P., & Bansod, H. (2023). Biomedical waste management and its importance: a systematic review. *Cureus*, 15(2).
17. Pant, G., Rawat, P., Kathuria, S., Gehlot, A., & Rathor, N. (2023, July). Waste management system with technological intervention: advantages and challenges. In *2023 4th International Conference on Electronics and Sustainable Communication Systems (ICESC)* (pp. 1461-1466). IEEE.
18. Mandpe, A., Paliya, S., Gedam, V. V., Patel, S., Tyagi, L., & Kumar, S. (2023). Circular economy approach for sustainable solid waste management: A developing economy perspective. *Waste Management & Research*, 41(3), 499-511.
19. Haripavan, N., & Dey, S. (2023). Application of remote sensing and geographic information system in solid waste management for Gudivada Municipality, Andhra Pradesh, India. *Waste Management Bulletin*, 1(3), 128-140.
20. Muhammad, A., Naidu, B. M., Sundram, V. P. K., Hussain, M. Z. S. M., Chew, L. L., & Amirrudin, F. A. (2023). Sustainable waste management in Malaysia: leveraging supply chain solutions for a greener future. *Information Management and Business Review*, 15(3), 147-154.
21. Derhab, N., & Elkhwesky, Z. (2023). A systematic and critical review of waste management in micro, small and medium-sized enterprises: future directions for theory and practice. *Environmental Science and Pollution Research*, 30(6), 13920-13944.
22. Atiya, S., Chung, Y. J., & George, G. (2023). A comparative study on e-waste management systems in developed and developing countries: Legislative compliances and initiatives. In *Sustainable approaches and strategies for E-waste management and utilization* (pp. 90-121). IGI Global Scientific Publishing.
23. Effendy, V. A., Wirani, Y., & Sucahyo, Y. G. (2023, September). Smart waste management planning to support the implementation of smart city in the new national capital city of indonesia. In *2023 10th International Conference on ICT for Smart Society (ICISS)* (pp. 1-6). IEEE.
24. Suryodiningrat, S. P., & Ramadhan, A. (2023). Integrated solid waste management system using distributed system architecture for Indonesia: An IT blueprint. *Int. J. Adv. Sci. Eng. Inf. Technol*, 13(3), 1177-1183.
25. Desta, M., Aboneh, T., & Derebssa, B. (2023). Deep learning-based object detection for smart solid waste management system. *Annals of Environmental Science and Toxicology*, 7(1), 052-060.
26. Shelepina, N. (2023). Solid municipal waste management system at the regional level. In *E3S*

- Web of Conferences (Vol. 460, p. 08009). EDP Sciences.
27. Jain, M., Kumar, D., Chaudhary, J., Kumar, S., Sharma, S., & Verma, A. S. (2023). Review on E-waste management and its impact on the environment and society. *Waste Management Bulletin*, 1(3), 34-44.
 28. Muktiningsih, S. D., Sekito, T., Rahmaudina, S., Dote, Y., & Prayogo, T. B. (2023, April). Material flow and waste recovery in a community-based waste management system in Batu, Indonesia. In *IOP Conference Series: Earth and Environmental Science* (Vol. 1165, No. 1, p. 012005). IOP Publishing.
 29. Qomariyah, P., & Hamid, E. S. (2023, May). Community-based waste management: Best practice for waste management in Panggungharjo Village, Sewon District, Bantul Regency. In *IOP Conference Series: Earth and Environmental Science* (Vol. 1180, No. 1, p. 012009). IOP Publishing.
 30. Awan, F. N., Febriasri, S., & Zurfı, A. (2023). Analysis of community participation in waste management at the sidomandiri sidoharjo integrated waste processing site (tpst) pringsewu regency. In *E3S Web of Conferences* (Vol. 468, p. 03001). EDP Sciences.
 31. Raharjo, S., Bachtiar, V. S., Ruslinda, Y., Matsumoto, T., & Rachman, I. (2019, March). Improvement of recycling-based municipal solid waste management in Padang City, West Sumatera, INDONESIA. In *IOP Conference Series: Earth and Environmental Science* (Vol. 245, No. 1, p. 012007). IOP Publishing.