

Thematic Evolution of Municipal Solid Waste Management Research

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Abstract

This study aims to learn the thematic evolution of Municipal Solid Waste Management research by revising Scopus indexed publications between 2001 and 2020. Within a longitudinal system, a scientific co-word inspection is conducted from 2001 to 2020. The publication series was split into two periods; the first period is from 2001 to 2010, and the second period is from 2011 to 2020. The findings, impact rates, and Municipal Solid Waste Management research's conceptual growth are verified. In this emerging field of research, the co-word review established three key topic areas, which are "Landfill", "Urban Area", and "Uncertainty". The themes "Municipal Solid Waste," "Waste Disposal," "Costs," "Waste to Energy" and "Environmental Impact Assessment" have changed from the first themes. The themes "Waste Management Systems," "Treatment Technologies", and "Leachate" were found to have newly emerged and indicated that Municipal Solid Waste Management had been varied over successive periods. Future researchers could use this information to recognise the focus of awareness and make verdicts in various ways. There are a few limits of this study: 1) some of the Municipal Solid Waste Management publications may not have been included; 2) this study only considered publication records from the Scopus database, and 3) accordingly, the subject area may have changed if other new databases such as Google Scholar, Microsoft academics, or Dimensions have been retrieved. This study's findings should be conceded as one proof-based structure for building future studies that benefit researchers, practitioners, and policymakers.

Keywords

Municipal solid waste; Bibliometrics; Science mapping analysis; Thematic evolution; Scopus database

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1. INTRODUCTION

The upsurge in the world's residents has resulted in enormous municipal solid waste (MSW) being generated. There are approximately 2.01 billion metric tons of MSW produced annually in the global community, which are projected to double in 2050, raising concerns in the future (Gautam and Agrawal, 2021). MSW is one of the world's biggest problems and is getting worse in developing and underdeveloped countries. This is particularly the case in many cities in those countries, where rapid urbanisation, insufficient urban planning and the lack of MSW management priorities are the key reasons (Aparcana, 2017).

The rate of generation of MSW in Asian cities increases exponentially, increasing urbanisation and commercial activities. Moreover, cities in developing Asia are deficient, inadequate waste management, and struggling with energy shortages (Sohoo et al., 2021). Ineffective waste management practices are among the leading causes of adverse impacts on public health and the atmosphere. In Europe, excessive exposure to adverse environmental conditions is

part of the complex cycle of dispossession and racial discrimination against marginalised minorities (Dunajeva and Kostka, 2021). Also, unsustainable and poorly MSWM has worsened in the East African Community (Ntagisanimana et al., 2021). MSWM in the United States is a complex system with several sub-components, including regulatory, administrative, market, technology and social; need much attention to be paid (Louis, 2004).

The positive or negative effects of MSWM on health and the resulting disposal activities are only partially understood at this time. MSWM can be integrated with other services or can be addressed in a discreet way (Chandrappa and Das, 2021). Currently, most parts of the world are in a lock-down situation, fighting to prevent coronavirus disease spread (Manigandan et al., 2020). According to the guidelines issued by the WHO, 2020, social distancing, the use of personal protective equipment (PPE), and the maintenance of personal hygiene are the essential preventive measures to be taken against coronavirus. Most of the PPE is made of paper, textile materials, and plastics. Paper and

textiles degrade after use and can be recycled, but plastic lasts forever if disposed of improperly. Consequently, the extravagant use of plastic-based PPE and sanitiser bottles for personal hygiene, along with unhindered single-use plastics for food delivery during the lock-down, has generated a global MSWM crisis (Mpofu, 2020).

Predominantly, the critical and fundamental means of MSWM is to control its generation (reduce waste as much as possible), improve the collection system and transport to treatment sites (Mbiba, 2014). MSWM is a very complicated process. For example, this includes optimising waste collection routes, the appropriate location of transfer stations, alternative strategy preferences, and cost minimisation. It must consider various social, political and environmental concerns (Dewi et al., 2010). MSWM reflects both nature and nurture and the interdependence between them. A larger quantity of waste is being discarded, and its composition is becoming more complex than ever before, due to plastics and electronic products (Vergara, 2012). MSWM involves waste collection routes, transfer station locations, treatment strategy, treatment plant location, and energy recovery. When designing and implementing a suitable MSWM, decision-makers should set local and regional goals on all or some of these stages and then plan a strategy accordingly. Most studies on MSWM strategies have only focused on two main phases: the waste treatment strategy and the treatment plant's location (Soltani et al., 2015).

The recent advances in treating MSW have been documented, which has helped put those countries in a better position for treating MSWM (Asase et al., 2009; Radwan and Mangi, 2019; Zand, 2020; Zhang, 2010). There are specialised programs in place for proper treatment and disposal of MSW. MSWM is often outsourced to local companies in the developing world, as with most developing world cities, spending 30% to 50% of their budgets on MSWM activities, collecting, transporting, and treating (Tayeh, 2021). This is because the problem could be caused by a lack of attention by policymakers and the private sector (Qdais, 2007). Therefore, this study's main objective is to analyse the scientific evolution of MSWM research through Scopus database articles from 2001 to 2020. This study also elucidated the longitudinal Science Mapping Analysis (SMA) Cobo et al., 2011 to identify the structure, conceptual evolution, and future MSWM research directions.

2. MATERIALS AND METHOD

2.1 Data retrieval

A bibliometric analysis was retrieved using the Scopus search engine on January 16, 2021. The Scopus database is chosen for two reasons; (i) the Scopus database contains reliable and high-quality research sources; which seeking individual researchers and their publications Montoya et al., 2018 and (ii) the database had a broader index than the Pubmed and Web of Science (Sweileh et al., 2017). The retrieved data was initiated to identify precise keywords, appropriate infor-

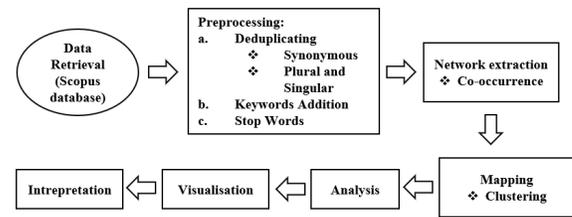


Figure 1. The Workflow of Thematic Analysis

mation, and the analysis's specific objective. The keyword "municipal solid waste management" based on TITLE-ABS-KEY was used to collect MSWM publications data.

2.2 Data examination

The workflow in Figure 1 describes the thematic analysis in this study. Data examination was initiated by acquiring the retrieval information to the pre-processing stage for identifying synonymous, plural, and singular keywords. Descriptive keywords were then manually inserted to make them complete, as many documents had no keywords. Lastly, irrelevant keywords with broad or general meanings were omitted in this conceptual context.

An SMA using SciMAT was performed to identify the most common research themes in MSWM. The timeframes were divided into two periods; the first period (2001-2010) and the second period (2011-2020). The SciMAT software tool was used to operate the SMA within a longitudinal framework (Cobo et al., 2011). Through the evaluation, SMA highlights the connection between disciplines, fields, specialities, and individual documents or authors into the research-creation employing spatial representation (Chinchilla-Rodríguez et al., 2016).

The SMA could also monitor scientific knowledge evolution and outline a field's development, pinpointing current research areas (Vargas-Quesada, 2017). The SMA co-word analysis is used to study the scientific fields' conceptual structure by identifying the most frequent keywords used in the publications (Callon et al., 1983). Moral-Munoz et al., 2018b have simplified the four procedure of SMA using SciMAT, as revealed in Table 1. In SciMAT, the low-dimensional space layout of research themes (strategic diagram generation) consists of four themes, as described in Table 2. (Cobo et al., 2011).

3. RESULTS AND DISCUSSION

3.1 Assessment of scientific themes

The distribution of MSWM publications over 49 years is shown in Figure 2 to better convey the study's focus and significance. Over the past 19 years (2001-2020), publications presented have increased exponentially. Therefore, the topic of MSWM is presently attracting an increasing amount of attention within academic circles. In this study, a strategic

Table 1. The Four Procedures for Establishing SMA

Procedures	Description
Research themes detection	A normalised co-word network is built based on the co-occurrence of keywords. After generating a research topic network, a simple centre algorithm is used to define interest themes in the research area. These keywords reflect some of the research areas and research problems of significance in the current literature.
Low-dimensional space layout of research themes	A two-dimensional strategic diagram is constructed where each cluster detected is plotted, and the detected clusters can be classified into four themes. The explanation of the four themes is presented in Table 2.
Discovery of thematic areas	The evolution of research themes detected in different periods is analysed to detect areas of growth in research, their origins, and their relationships. The study's evolution or development throughout the study period was determined by the group overlap between two repeated periods. The inclusion index is used to detect conceptual relationships between research themes. Research themes and their relationships indicate a particular research theme belongs to a specific thematic field or several. It may also demonstrate that particular research themes cannot be correlated with any of the established thematic fields, and could thus be viewed as the origin of a new thematic area in research.
Performance analysis	The relative contribution of the themes to the research area is calculated qualitatively and quantitatively. This can identify the most prominent, productive and impacting subfields. Therefore, the following bibliometric indicators apply to the various themes and subject areas detected: number of publications, citations received, and h-index.

Table 2. The Simplified of Four Themes in The Strategic Diagram (Cobo et al., 2011)

Themes	Position	Description
Motor themes	Upper-right quadrant	Well established and essential for the organisation of a field of research Centrality and density are very high These themes are related to each other in a similarly broad scope
Highly developed and isolated themes	Upper-left quadrant	Well-developed internal ties but inconsequential external ties Only marginal importance for the field These themes emphasise the necessary specialist and peripheral role.
Emerging or declining themes	Lower-left quadrant	Weakly developed and marginal Being low density and low centrality These themes representing either emerging or disappearing
Basic and transversal themes	Lower-right	Essential for a research field but are not developed These themes depict transversal, general and basic

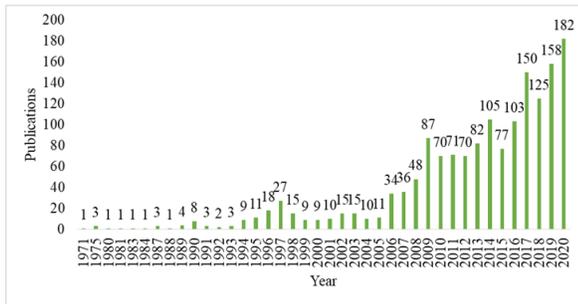


Figure 2. The Publication Growth of MSWM Research from 1971 to 2020

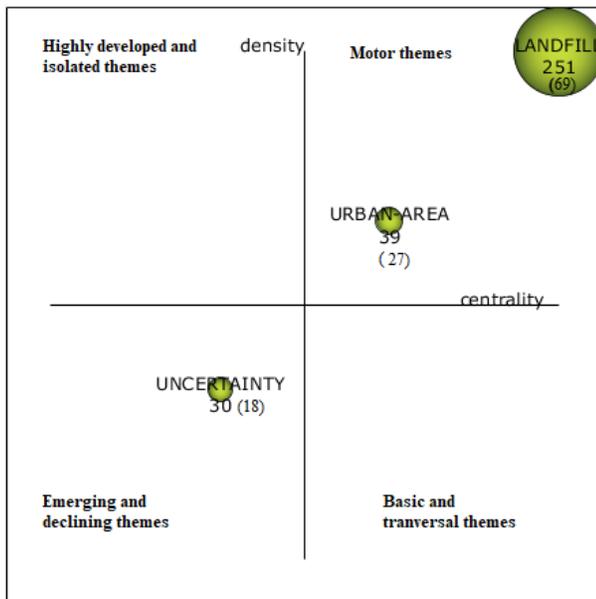


Figure 3. Strategic Diagram for The First Period (2001-2010)

diagram was established using SciMAT to analyse the most relevant information for each period selected (Cobo et al., 2011). The strategic diagram and analysis of performance were analysed in tandem. The number in or near the spheres represents the number of publications associated with the different themes (Moral-Munoz et al., 2018a, Moral-Munoz et al., 2018b). Finally, the number of citations for each publication is shown in the bracket.

3.2 The first period of thematic structure on MSWM (2001-2010)

Based on the information presented in Figure 3, there are only three significant themes apparent. Table 3 indicated the performance measures of themes during the first period.

In the first period, the motor themes comprised “Landfill” and “Urban Area” have played an essential role in defining MSWM. “Landfill” presents the highest number of

publications (251) and h-index (69). The theme is nexus firmly in the cluster network with “Municipal Solid Waste”, “Waste Management”, and “Solid Waste”. The motor theme “Urban-Area”, however, provided 39 publications with an h-index of 27 and strongly associated with “India” and “Developing Countries” in the cluster network. The strategic diagram indicated that motor themes “Landfill” and “Urban area” are well established and essential for an MSWM research organisation between 2001 to 2010. The theme “Uncertainty” was demonstrated as emerging and declining themes in the first period (2001-2010). The emerging and declining theme has fewer documents and citation representing either emerging or disappearing and weakly developed (Cobo et al., 2011). The cluster network of “Uncertainty” is allied to “Mathematical Modelling”, “Decision Support”, and “Costs”.

These findings are supported by the current scientific literature, highlighting the importance of these research lines (Dunajeva and Kostka, 2021; Ntagisanimana et al., 2021; Sohoo et al., 2021). “Landfill” is a critical aspect of managing MSW. Landfill sites have been set up with the utmost accuracy to help decision-makers solve SWM problems with minimal pollution and public health risks (Pasalari et al., 2019).

3.3 The second period of thematic structure on MSWM (2011-2020)

Several distinct patterns in Figure 4 are used to elucidate thematic evolution during the second period of analysis. Table 4 depicts the performance method of the themes in the second period. In this period, the motor theme “Municipal Solid Waste” presents the highest publication (797), h-index (52), and a strong position as the most vital theme (Cobo et al., 2011; Moral-Munoz et al., 2018a; Moral-Munoz et al., 2018b). Although the motor themes “Waste Disposal Facility”, “Waste to Energy”, and “Costs” has a fewer number of publications; the themes had provided an adequate h-index. During the second period, the thematic network of “Municipal Solid Waste” is collected of words associated with “Waste Management”, “Solid Waste”, and “Landfill” in the cluster network. The theme “Waste Disposal Facility” has a nexus with “Environmental Impact”, “Energy Recovery”, and “Decision Support System”. And, the motor theme “Waste to Energy” is closely linked to “Life Cycle Assessment”, “Biogas”, and “Recovery”. The last motor theme “Costs”, is related to “Uncertainty”, “Investment”, and “Government” in the cluster network. Notwithstanding this, the themes “Treatment Technologies”, “Waste Management Systems”, and “Environmental Impact Assessment” are considered emerging or declining themes. Theme “Treatment Technologies” is related to “Emission Control”, “Food Waste”, and “Global Warming Potential”. The most related themes in a cluster network of “Waste Management Systems” are “Waste Collection”, “Waste Generation”, and “Source Separation”. This could suggest that the themes are weakly

Table 3. Performance Measures of Themes in The First Period (2001-2010)

Theme	Centrality	Density	Publications	h-index	Sum Citations
Landfill	109.47	101.99	251	69	13,558
Urban Area	47.44	14.91	39	27	3,067
Uncertainty	23.46	14	30	18	1,210

**Figure 4.** Strategic Diagram for The Second Period (2011-2020)

incorporated and lacking in salience (Cobo et al., 2011; Moral-Munoz et al., 2018a; Moral-Munoz et al., 2018b). In this study, the theme “Environmental Impact Assessment” is firmly tight to “Ecosystem” and “Comparative Study”. Finally, “Leachate” is a highly developed and isolated theme that emphasises the necessary specialised and peripheral role and links to “Groundwater” and “Heavy Metal” for cluster networks.

The second period is focused on the theme “Municipal Solid Waste”. As MSWM becomes an integral part of the strategy, the sustainability plan should be realised in many countries. The theme “Municipal Solid Waste” has a strong link to “Waste Management,” “Solid Waste”, and “Landfill”, which means that these three elements are linked to each other in the cluster network. It is in line with the principle of MSWM, which focuses on treating sanitary landfills and incineration plants by popularising separate waste collection to benefit waste management strategy and impact assessment (Liu et al., 2017). This is because sustainable development is being approached as a new economic paradigm that sets a general context for organisations and institutions to develop their strategies and processes (Rodrigues et al., 2018). MSWM is also related to waste disposal facilities and

costs. It is indicated that sustainable waste management is increasingly becoming a focus to reduce public health risks and financial costs (Vaccari, 2018). Furthermore, the costs of managing MSW account for up to 50% of city government budgets; therefore, it is crucial that policymakers, urban planners and practitioners have an adequate understanding of what these costs are, from collection to final disposal (Aleluia and Ferrão, 2017).

3.4 Thematic evolution of 19 years of research on the MSWM (2001-2020)

The thematic evolution of MSWM research is shown in Figure 5. Unlike themes were featured in the columns for each of the different periods indicated below the appropriate column (Cobo et al., 2011). The theme cluster node size is relative to the number of published documents associated with each theme cluster. Themes that have a relationship between periods are associated with a link. The link thickness is relative to the Inclusion Index, which is explicated by the degree of commonly shared keywords between the two theme clusters (Cobo et al., 2011; Moral-Munoz et al., 2018a; Moral-Munoz et al., 2018b). Solid line links indicate the theme clusters that share keywords concerning themes, while dotted line links indicate the theme clusters that share keywords relating to themes that are not the main item (Cobo et al., 2011; Moral-Munoz et al., 2018a; Moral-Munoz et al., 2018b). Three themes designated “Landfill”, “Urban Area”, and “Uncertainty” from the first period have solid links with the themes on the second period, signifying the continuity of the associated keywords. Only theme “Urban Area” was appeared with the same keyword during the second period. The themes “Municipal Solid Waste”, “Waste Disposal”, “Costs”, “Waste to Energy”, and “Environmental Impact Assessment” have changed over from the first themes. The “Urban Area” is the motor theme during the first period; however, it became a basic and transversal theme during the second period, indicating essential for a research field but are not established. The themes “Waste Management Systems”, “Treatment Technologies”, and “Leachate” were found to have newly emerged and indicated MSWM was diversified at successive periods.

Though other than that, “Waste Disposal Facility” has a connection with “Environment Impact”, “Energy Recovery”, and “Decision Support System”. These elements best explain the current performance and demonstrate the current understanding of MSWM in many countries. The govern-

Table 4. Performance Measures of Themes in The Second Period (2011-2020)

Theme	Centrality	Density	Publications	h-index	Sum Citations
Municipal Solid Waste	171.22	59.85	797	52	11,993
Waste Disposal Facility	59.7	6.85	69	23	1,560
Costs	46.16	4.06	58	22	1,277
Waste to Energy	50.47	4.65	61	23	2098
Urban Area	28.55	2.88	41	14	662
Waste Management Systems	25.28	1.87	50	12	506
Treatment Technologies	19.03	1.89	10	6	278
Leachate	2.7	3.88	7	3	273
Environmental Impact Assessment	8.14	1.17	6	5	674

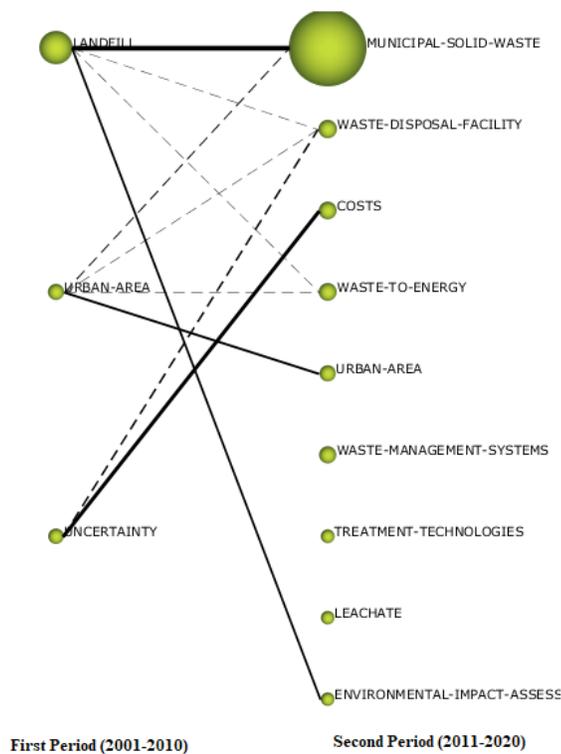


Figure 5. Thematic Evolution of MSWM Research During Successive Periods

ment needs to develop an effective waste disposal solution for a growing MSW volume that will hinder the waste generated by urban living and spur growth (Coban et al., 2018).

The thematic evolution map showed that MSWM’s themes were consistently diversified with emerging new themes such as “Waste Management Systems,” “Treatment Technologies” and “Leachate.” These themes are fascinating for MSWM’s future development. Management of MSW presents an ever-increasing and more complex challenge because of landfills leachate and pose high environmental risks. Landfilling with toxic leachate has been a typical problem with landfilling (Kamaruddin et al., 2017). And new and alternative tech-

nologies are still under investigation and compare global applications for an economical and straightforward approach to managing MSWM with leachate treatment technologies (Costa et al., 2019). When municipal solid waste is dumped in landfills, it is consumed by microbes, and then carbon dioxide, methane, volatile organic compounds, and liquid leachate are released (Ehrig, 2018). The knowledge of the nitrification and denitrification process helps select an optimised and efficient alternative for leachate waste’s biological treatment (Show et al., 2019). These factors have shown the interrelation of waste management systems, treatment technologies and leachates and the need for more study concentration.

4. CONCLUSIONS

The following conclusions can be drawn from these study findings. Some limitations of the analysis can be emphasised. First, the most commonly used MSWM is evaluated according to the literature, even though some were not included. Secondly, the Scopus database’s bibliographical use means that publications that are not indexed in the database were not analysed. The detected thematic areas could change if they were considered. The academic circle will now recognise thematic areas concentrating on the current research interest over time and other growing areas. In the last 19 years, MSWM’s citations and scientific output focus mainly on “Landfill”, “Urban Area”, “Municipal Solid Waste”, “Leachate”, “Waste Disposal Facility”, “Waste to Energy”, and “Costs”. These are the topics that have paramount importance in the global management of proper MSW and are essential for research. The emerging themes of “Waste Management Systems” and “Treatment Technologies” effectively help solve MSW problems with various uncertainties. The benefits of this research suggest that it will continue being a popular discipline. The study findings will provide a historical perspective on research conducted and inform new studies within this emerging field.

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