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Municipal solid waste management in a circular economy: A data-driven bibliometric analysis

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ABSTRACT

This study aims to present a systematic data-driven bibliometric analysis on municipal solid waste management as a foundation in a circular economy. The current literature has yet to be fully developed given the complexity of the corresponding concept and knowledge. Traditional bibliometric analysis lacks the ability to screen out important keywords for future directions, and the keyword frequencies are described numerically. This study applies the entropy weight method to convert the frequencies to weights and performs regional comparisons based on a database; hence, this study contributes to the literature by providing potential future directions. The database includes 413 published articles, and 41 indicators are listed. The results are used to identify valid indicators for improvement and provide a regional state-of-the-art comparison. The top 5 indicators for future study are incineration, life cycle assessment, plastic waste, sorting solid waste, and sustainability. A bibliographic coupling analysis provides a comparison of 5 regions and reveals that Africa and North America have less studies than other regions.

1. Introduction

The principal premises of a circular economy (CE) have emerged as closed and slowing loops, in which closed loops pertain to post-consumer waste recycling; slowing refers to product value retention through maintenance, repair and refurbishment, and remanufacturing to produce efficiency improvements in the ordinary linear economy (Bocken et al., 2017a; Kirchherr et al., 2017). A CE emerges when the value of resources, materials and products is preserved as long as possible in the economy, and the generation of waste serves as a tactic to develop low-carbon resource efficiency and competitive sustainability (Pires and Martinho, 2019). Waste management, particularly solid waste management (SWM) and municipal solid waste management (MSWM), is the foundation for a CE to achieve more waste prevention and better resource management by extending and closing the material cycles that account for waste input-output to create inventories of economic flows (Kalmykova et al., 2018; Zeller et al., 2019). However, the relationships between MSWM and CE entities are blurred in the existing literature, and these concepts are diffuse since they were proposed by different viewpoints in different fields (Geissdoerfer et al., 2017). Corresponding ways of theoretical understanding remain unclear because of deliberation regarding MSWM and CE concepts (Anshassi et al., 2019; Blomsma and Brennan, 2017; Bocken et al., 2017b).

Nevertheless, geographic advantages are achieved through supplementary efficient material cycles and reverse logistics with synergistic proximity to municipal waste sources and potential industrial source involvement (Van Berkel et al., 2009). For instance, Zeller et al. (2019) argued that adequate resource measures for effective market supply and demand and the ability to form municipal organizations and strategy are perceived as critical

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factors of a unique regional position in a CE. Pires and Martinho (2019) argued that an understanding of regional CE knowledge is needed to foster environmental outcomes and the total resource management chain. Understanding MSWM in a CE at the regional level is necessary to improve practices. As previously mentioned, MSWM in a CE remains limited, and qualitative and quantitative approaches and analyses are lacking (Korhonen et al., 2018a; Pires and Martinho, 2019; Zeller et al., 2019). There are challenges and opportunities for the development of MSWM in a CE since MSWM is increasingly complex and a CE has problems in practice, while a systematic literature examination indicates that the contributions of MSWM in a CE remain unrevised and need to be clarified. Systematic qualitative and quantitative approaches provide an overview of the state of the art of MSWM in a CE for future study directions and improvements in practice. The objectives of this study are as follows:

- To describe MSWM in a CE and map the field with proposed indicators from valid data sources
- To explore the knowledge gaps in geographical regions based on a proposed hybrid approach

Quantitative and qualitative approaches are proposed to enhance the outcomes of the systematic review. A hybrid method, including bibliometric analysis, the fuzzy Delphi method, and the entropy weight method, is proposed. Bibliometric analysis is used to visualize an overview of the bibliometric status and to reveal the indicators of MSWM in a CE from the data of all publications in the Scopus database, and the results are presented as visual information (Shukla et al., 2019). The fuzzy Delphi method aims to screen out unnecessary indicators based on expert judgments due to the complexity of a CE and the diversity of problems (Tseng, 2009; Tseng and Bui, 2017). The entropy weight method is applied to transform the indicator frequency data into comparable weights to determine the performance of regions on the indicators and to identify the critical indicators for improvement in this study (Wang et al., 2015; Tseng, 2017).

This study contributes to (1) identifying important knowledge to assist further studies and the implementation of practices, (2) delivering guidelines regarding the directions of future studies by reviewing the bibliometric status of MSWM in a CE and identifying the critical indicators that need further examination, and (3) addressing the challenges and gaps among geographical regions to provide local viewpoints of MSWM in a CE.

The second section discusses related literature on a CE and MSWM. The third section more clearly presents the data collection process, methodologies, and proposed analytical steps. The results are revealed in the fourth section. The fifth section identifies future challenges and discusses regional comparisons of MSWM in a CE. Finally, conclusions are drawn in the last section.

2. Literature review

2.1. Municipal solid waste management

MSWM is defined as complex procedures comprising waste collection routes, transfer station locations, treatment and energy recovery strategies, and waste treatment techniques are the core means to achieve objectives, including human health and environmental protection, economic development, and fulfillment of social and regulatory requirements (Dewi et al., 2010). Sharholy et al. (2008) claimed that efficient MSWM requires support from both authorities and citizens, where the latter are individuals with evolving community awareness and societal interest. Soltani et al. (2015) presented that MSWM is a complex procedure involving multiple decisive factors, such as environmental effects, related economic outlays and benefits, regional features, and political and social issues. Therefore, sustainable MSWM is necessary for all stages of the system, from design, scheduling and neutralization to the preservation of environmental quality for future development goals (Pires et al., 2011). It is necessary to identify planning and monitoring methods for SWM to reduce the generated amount of waste, to recycle some waste with high economic value, and to define indicators that support that a suitable direction is important (Arıkan et al., 2017).

For solid waste intervention in a CE, Lee (2019) developed a recycling investment sustainability framework that involves uncertain petitions and nonlinear recycling expenses to balance existing manufacturing restrictions, production benefits, and recycling investments for a sustainable CE. Tisserant et al. (2017) presented waste treatment and waste footprint scales to design and assess policy instruments for a CE. Murphy and Pincetl (2013) showed that material flows are rounded up in a CE, with materials being used repeatedly to optimize consumption with no wasted materials; the products are reused, repaired or redistributed within the system at the end of life. If they cannot be reused or repaired, products can be recycled or recovered from waste and used as inputs, replacing the need to exploit natural resources (Song et al., 2015). Ghisellini et al. (2016) and Richa et al. (2017) suggested that a CE aims to prevent and eliminate waste by cycling materials or used products within a closed-loop scheme to obtain energy and resource effectiveness and profitability. Ness and Xing (2017) proposed that a CE aims to have no remaining influence on the ecosystem by recovering resource procurement damage while minimizing the waste produced through manufacturing and product life cycles. Waste reduction through recycling is stressed under the principal points of reducing raw material consumption, designing products in an eco-design manner, lengthening product lifetimes through maintenance and repair, and recycling and using products and raw materials recovered from waste flows. However, theoretical developments are not coherent for this concept and do not align with MSWM and a CE because zero-waste perceptions are limited, as even in closed-loop systems, resources are consumed and at least some waste is certainly produced (Blomsma and Brennan, 2017; Niero and Kalbar, 2019). In lieu of this discussion, the role of MSWM in a CE is irreplaceable and important for guaranteeing the precision of this supplementary approach.

2.2. Circular economy

A CE is a business operationalization concept whose implementation for sustainable development has been much debated. The concept stems from the Earth's limited capability to acclimatize to contamination in reaction to the necessity of economic development and resource consumption along with environmental influences (Korhonen et al., 2018a). Jiao and Boons (2014) indicated that the concept involves the actions of reducing, reusing, and recycling in the progression of production, consumption and circulation. Van Buren et al. (2016) proposed creating a triple bottom line with the social, environmental and economic dimensions of a CE. Mendoza et al. (2017) stated that a CE should take full advantage of resource efficiency, including (1) conserving and improving natural wealth by monitoring finite stocks and assessing renewable resource flows; (2) optimizing resource utility, products, processes, and materials within technological and biological circularity; and (3) promoting efficient coordination by disclosing and controlling undesirable externalities. Ness and Xing (2017) suggested that a CE aims to achieve more value and to reduce material throughput by involving resource utilization and management, closed-loop approaches, adaptation strategies, and sharing economy models.

In contrast, waste prevention in a CE includes reuse, refurbishment, and remanufacturing of material flows (Pires and Martinho, 2019). The fundamentals surpass a reuse loop and include remanufacturing, recycling and reprocessing to recover secondary components and return them to the same usage. Some end-of-life products and materials might shift to other processes, such as exports for reuse in another location; change to lower applications (downcycling), or be discharged from the system in the form of waste (Korhonen et al., 2018a; Palomar et al., 2019). The increasing growth in prior studies informs an evidence-based formulation of a CE and its implications for innovation. Kirchherr et al. (2017) conceptualized a model from the most frequent depictions of a CE by reviewing 114 definitions. Reike et al. (2018) explored controversies in a CE through a focus on reviewing the literature and resource value retention options to provide a heuristic that is useful in practice. Lacson et al. (2019) revealed fluoride networks and a CE as potential models for sustainable development because discarding of existing waste is reliant on incineration and the problems posed by landfilling in a linear economy model worsen environmental problems. The initial uncertainty and conflicts regarding a CE remain due to various practical activities. Identifying CE challenges in a sustainable global network scheme is an urgent problem (Korhonen et al., 2018a). A systematic review of MSWM in a CE is still lacking in the literature.

2.3. MSWM in a CE from regional perspectives

Geographic advantage is achieved through supplementary efficient material cycles and reverse logistics. Adequate resource proximity measures for market supply and demand effectiveness and the shaping capability of municipal planning and regulation frameworks are considered fundamental to a region's unique position in a CE system (Zeller et al., 2019). For instance, the European Union is currently leading in policy implementation and endorsing new ambitious procedures to promote a CE with the most modern waste legislation (European Commission, 2018). The concept involves reusable products and recyclable materials, such as metals, plastics, paper, and glass, and producing goods from organic waste (Zeller et al., 2019). Performing CE functions to upcycle waste management is pigeonholed by the use of materials, labor, and capital in each specific region and its technology and/or innovation level (Omoloso et al., 2020). In North America, including the United States, a CE highlights waste reduction, reuse and recycling over disposal (Van Ewijk and Stegemann, 2016). Japan and China are the key players in Asia to officially present a CE. Geng et al. (2010) worked on CO_2 reductions for situations of municipal symbiosis in Kawasaki, Japan. Fang et al. (2017) indicated carbon footprint and resource savings in Chinese national pilot cities. More nuanced grading with tinier decision loops such as restructuring, refurbishing, and repurposing to enable resource value retention over multiple product life cycles has recently been emphasized in a CE (Reike et al., 2018).

Stahel (2010) argued that a CE of reused products and recycling materials is ordinary in less-developed regions, where the CE begins with an end-of-life product that is utilized to yield new consumption under a grave-to-cradle assessment; thus, this approach reduces both the volume of waste generated in the lower value chain and the demand for virgin resources in the upper value chain. However, Diaz (2017) claimed that the original causes of low levels of a CE in countries such as those in Latin America and the Caribbean and Africa are weak political motivation; a lack of national waste management policy and legislation; inadequate budgets to implement a CE; and a lack of professional expertise, training and education at all levels. These causes led to the occurrence of informal reuse, recycling and recovery markets and raised various questions regarding the CE concept. Therefore, exploring MSWM in a CE is expected to improve the economy, conserve the environment and protect social fairness by offering an alternative model that is cyclical and reformative and that replaces traditional linear processes (Korhonen et al., 2018b; Millar et al., 2019).

3. Methods

This section more clearly presents the data collection process, bibliometric analysis, fuzzy Delphi method, entropy weight method, and proposed analytical steps.

3.1. Proposed analytical steps

This study provides a data-driven bibliometric analysis from a literature review, identifying indicators for improving further studies and for accurately determining the differences in the status of research on MSWM in a CE in different regions. The analytical steps followed are as follows:

1. The search terms are identified, and the publication database is filtered using the Scopus website.
2. Bibliographic analysis is then conducted to find the indicators of MSWM in a CE from the database using VOSviewer software.
3. The fuzzy Delphi method is adopted to refine the essential indicators. Experts' opinions from a questionnaire are used to assess the proposed indicators.
4. The frequencies of the indicators are generated, and the entropy weight method is applied to transform the entropy of the indicators into comparable scales. In this study, regional comparisons are carried out.
5. The critical indicators are identified by subtracting the global weight of the fuzzy Delphi method from the entropy weight to examine the study gaps.

The details of the analytical process are described in Fig. 1.

3.2. Data collection

Appendix A presents the literature review of studies on a CE or MSWM that engaged in a systematic analysis approach. The Scopus database is employed in this study due to its wider coverage of publications and greater amount of relevant bibliometric data than those of other databases (He et al., 2017; Jin et al., 2018; Meho and Rogers, 2008). The collected data consist of several identifiers: the title, abstract, citation record, author, author affiliation, author keywords, country, and year of publication. A coding framework was developed for an iterative search process based on the authors' initial knowledge and the preliminary literature review.

Municipal solid waste covers numerous components, including food, paper, plastics, metals, textiles, and glass; it differs based on different cultures, policies and legislation and depends on the main economic features of regions (Burnley, 2007). Solid waste refers to the waste generated by local communities, industrial zones, commercial areas, conventional construction sites, demolition processes and civic services (Ngoc and Schnitzer, 2009). It contains all products associated with daily activities such as packaging, bottles, discarded food, newspapers, equipment, devices, batteries and dyes. Municipal solid waste refers to waste in a solid form produced in the course of daily activities by households and industrial, institutional and commercial establishments: waste from schools, offices, institutions, stores, hotels and supermarkets and from communal services such as yards, markets, hospitals, entertainment venues, and street cleaning (Arıkan et al., 2017; Yukalang et al., 2017). As a result, the following search terms were used:

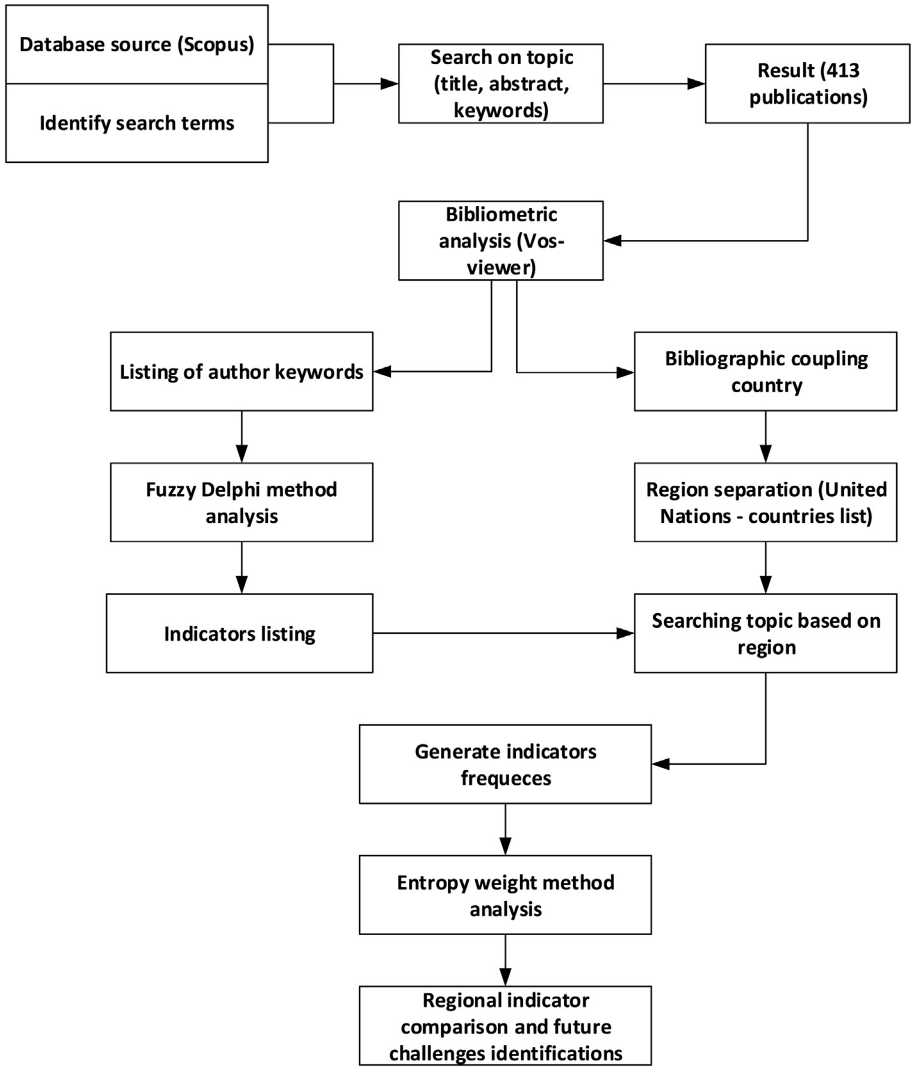


Fig. 1. Analytical procedure.
Note: ofmsw - Organic fraction of MSW.

“"circular economy” or “circular economic"” and “"solid waste” or “urban waste” or “e-waste” or " electronic waste” or “construction waste” or “household waste” or “demolition waste” or “plastic waste” or “medical waste"“. The inquiries were performed on September 12, 2019, with no chronological restrictions. The search results were generated from the titles, abstracts, or keywords, with no constraints imposed on the date of publication; additionally, the results were limited to only English articles and reviews. A total of 413 articles and reviews were generated, with the first published in 2008, proving that MSWM in a CE is a concept from the last decade.

3.3. Bibliometric analysis

Bibliometric analysis investigates the formal properties of knowledge domains by using mathematical and statistical methods . Fahimnia et al. (2015) referred to bibliometric analysis as a tool that provides powerful network analysis to identify established and emerging topical areas based on study topic, author and institutional characteristics. Zupic and Čater (2015) proposed that the method is a quantitative technique to handle increasing amounts of existing literature. In particular, bibliometric analysis provides information about a study field and (1) helps make handling a large number of publications easier and more reliable; (2) deeply analyzes the relationships among articles, citations, co-citations and keywords; and (3) provides strong visualization ability, which helps readers easily and clearly identify future research interests in a field (Feng et al., 2017). Therefore, this method has the potential to be applied to explore CEs, as a knowledge sphere that has not yet been fully understood (Ertz and Leblanc-Proulx, 2018).

The bibliometric analyses were performed using VOSviewer 1.6.11 software (van Eck and Waltman, 2018). The VOSviewer open-source software tool offers sufficient features to scientifically map the literature through document grouping that categorizes documents into expressive relationships by grouping documents that are related to each other into one cluster to describe the network among them. In the academic field, VOSviewer has been applied to map knowledge in artificial intelligence (Shukla et al., 2019), green building construction (Wuni et al., 2019), and SWM (Deus et al., 2018). Thus, VOSviewer is appropriate for visualizing a bibliometric network and identifying the MSWM indicators in a CE in this study through bibliographic coupling among the nodes; this coupling denotes the topic area and represents the countries and the linkages in the keywords of previous studies. This study uses this software to generate bibliometric information, including keywords, titles, and abstracts, to capture potential indicators from the database.

3.4. Fuzzy Delphi method

Ishikawa et al. (1993) proposed the combination of fuzzy set theory and the Delphi method to obtain a decision group to deal with the fuzziness of experts' decisions and to improve the quality of questionnaires. The combination's advantages of reducing the number of respondents and the inquiry period provide an efficient assessment of expert knowledge that is appropriate for transforming expert opinions into accurate data to obtain additional benefits regarding decision-making time and cost (Lee et al., 2018). In this study, 30 experts were approached face-to-face to ensure the reliability of the evaluation processes. The experts in the group had more than 10 years of experience working in and studying MSWM; the group included 15 experts from academia, 8 experts from government agencies and 7 experts from practical waste management organizations.

The significance value of the indicator b was evaluated by expert a as $j = (x_{ab}; y_{ab}; z_{ab})$, where $a = 1, 2, 3, \dots, n$ and $b = 1, 2, 3, \dots, m$; the weight j_b of b is $j_b = (x_b; y_b; z_b)$, where $x_b = min(x_{ab})$, $y_b = (\prod_{1}^{n} y_{ab})^{1/n}$, and $z_b = max(z_{ab})$. Then, the linguistic references and triangular fuzzy numbers were converted into linguistic values, as presented in Table 1.

The convex combination value D_b was generated by adopting an α cut using the following equations:

$$u_b = z_b - \alpha(z_b - y_b), \quad l_b = x_b - \alpha(y_b - yx_b), \quad b = 1, 2, 3, \dots, m \tag{1}$$

In general, the value of α is 0.5 for a general situation. This value can range from 0 to 1 for positive or negative perceivers. D_b is calculated as follows:

$$D_b = \int (u_b, l_b) = \delta[u_b + (1 - \delta) l_b] \tag{2}$$

where δ is employed to represent the positivity stage of a decision maker and to balance the ultimate evaluations among the expert committee.

The threshold for screening the important indicators is generated using $\gamma = \sum_{a=1}^{n} (D_b / n)$. If $D_b \geq \gamma$, indicator b is accepted; if not, it must be rejected.

3.5. Entropy weight method

This study analyzed the differences in geographical regions using the entropy weight method. The entropy weight method reflects the utility value of an indicator and gives more reliable indicator weights when revising information (Tseng et al., 2013). The method quantifies the disorganization of a system that is applied in weight measurement by using an indicator with a large entropy mean, and a great diversity of responses makes the indicator have a more substantial impact on the system reaction (Tseng, 2017; Wen et al., 1998).

First, a content analysis, as a tool to study documents and communication objects based on systematic reading or observation of texts or artifacts (Hodder, 1994), was employed for regional consistency checks of the codes independent of particular regions. To avoid repeating the same completed coding and to enhance the reliability of the results, all coding was tracked in a parallel Excel file. The indicator frequencies for each region were counted by searching regional data generated from publications on MSWM in a CE using country codes (shown in Appendix B). For instance, the search term "TITLE-ABS-KEY ("Argentina" or "Bolivia" or "Brazil" or "Chile" or "Colombia" or "Ecuador" or "Mexico")" was used to collect the regional data for Latin America and the Caribbean.

Then, the entropy weights were calculated, and the method involves the function $f_i : [0, 1] \to [0, 1]$, which fulfills the following three constraints to monotonically increase the range of $x \in (0, 0.5)$: (1) $f_i(0) = 0$, (2) $f_i(x) = f_i(1 - x)$, and (3) $f_i(x)$. The largest value of this function occurs at $x = 0.5$, and the value $(\partial^{0.5} - 1)$ makes the result fall in the range $[0, 1]$.

ε represents a coefficient identified with a value between zero and one, and the value is generally set to 0.5 as follows:

$$\tau_{0,i} = \sum_{m=1}^{n} w_m \varepsilon_{0,i}(m) \quad \text{for} \quad i = 1, 2, 3 \dots m \tag{3}$$

where each determined weight $(w_m, \sum w_m = 1)$ is computed using the entropy method.

The computational process of the entropy weight method is as follows:

Calculating the total coefficients in all arrangements for each indicator:

$$C_j = \sum_{i=1}^{n} \varepsilon_i(j) \tag{4}$$

Determining the entropy weight of each indicator:

$$e_j = k \sum_{j=1}^{n} w_e \left(\frac{\varepsilon_i(j)}{e_j} \right) \tag{5}$$

where w_e refers to the indicator frequency determined by the content analysis.

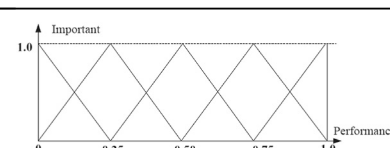
Summing the entropy values:

$$E = \sum_{j=1}^{p} e_j \tag{6}$$

Weighting each indicator:

Table 1
Triangular fuzzy numbers linguistic scale.

Linguistic terms (performance/importance)	Corresponding triangular fuzzy numbers
Extreme	(0.75, 1.0, 1.0)
Demonstrated	(0.5, 0.75, 1.0)
Strong	(0.25, 0.5, 0.75)
Moderate	(0, 0.25, 0.5)
Equal	(0, 0, 0.25)



Triangular fuzzy membership functions for performance/importance

$$w_j = \frac{\frac{1}{p} - E(1-e_j)}{\sum_{j=1}^{p} 1 \Big/ p - E(1-e_j)} \ , \ j = 1, 2, 3, \ldots, p \quad (7)$$

4. Results

A bibliographic coupling analysis of MSWM in a CE was conducted based on the literature. The fuzzy Delphi method and entropy weight method results are shown. The critical indicators for future investigations are examined in this section.

4.1. Bibliometric analysis results

This study undertakes a co-occurrence bibliographic coupling analysis of author keywords extracted from Scopus (presented in Table 2). There are 41 keywords that occur at least 5 times in the analysis, with CE (226 occurrences), recycling (occurrence weight equal to 63), waste management (occurrence weight equal to 36), municipal solid waste (occurrence weight equal to 32), e-waste (occurrence weight equal to 25), and sustainability (occurrence weight equal to 22) having the most occurrences among the publications. Fig. 2 shows the distribution of author keywords in the bibliographic coupling analysis. The visualization reveals that the “circular economy” node represents the central keyword and has network linkages among the rest of the keywords. From this central position, the CE node directly links to the smaller main nodes of municipal solid waste, waste management, sustainability, recycling, e-waste, and life cycle assessment (LCA), representing the fundamental contributors to the establishment of a CE as an implementation concept for sustainable development through waste reduction, reducing and recycling material throughput by involving closed-loop approaches in production, and circulation progression (Jiao and Boons, 2014; Ness and Xing, 2017). The concept was confirmed to be oriented towards value conservation by covering those MSWM activities based on reuse loops consisting of recycling, remanufacturing, and reprocessing to return them to the usage cycle (Stahel and Clift, 2016). The purple nodes comprising waste electrical and electronic equipment, e-waste, environmental waste, and solid waste are related to a CE and MSWM, and this finding is helpful for explaining the fundamental development of a CE from the waste management viewpoint. The green nodes, comprising recycling, reverse logistics, recovery, municipal solid waste, waste management, sustainability, LCA, and packaging, represent the next phase in the study of CEs as an expansion of production lines and supply chain management. The yellow nodes, comprising plastic waste, biowaste, biogas, the organic fraction of municipal solid waste, and developing countries, show the latest keywords of publications in this field.

There are 69 countries/territories that have accumulated a minimum of 1 document. The bibliographic coupling results by year are shown in Fig. 3, and the most productive countries/territories include the United Kingdom, China, Italy, the United States, and Spain. The countries that were first concerned about CEs included China, Japan, Ghana, Norway, Switzerland, Slovenia, Kenya, and Vietnam, with their earliest years of publication occurring prior to 2017. Countries such as the United States, the United Kingdom, Italy, Sweden, and Brazil followed later, with publication years ranging from 2017 to 2018. The latest publications came from Israel, Saudi Arabia, Colombia, and Qatar, with their earliest years of publication occurring since 2019. Then, the 69 countries/territories were separated into five geographical regions according to the United Nations (2019) for further evaluation (Table 3).

4.2. Fuzzy Delphi method results

From the bibliometric analysis, 41 keywords are proposed for evaluation by the fuzzy Delphi method. The evaluation is based on expert experience and judgments, and linguistic terms are converted into corresponding triangular fuzzy numbers, as shown in Table 1. Then, a technique is implemented to screen out the critical indicators of MSWM in a CE (Equations (1) and (2)) with the threshold $\gamma = 0.613$, as presented in Table 4. A total of 18 keywords are accepted as indicators, including anaerobic digestion, biowaste, developing countries, extended producer responsibility, incineration, industrial ecology, landfill, LCA, material flow analysis, packaging, plastic recycling, plastic waste, resource recovery, reverse logistics, sorting, sustainability, waste electrical and electronic equipment, and waste-to-energy. These indicators are considered critical in the MSWM and CE study topics and are listed and numbered in Table 5.

Table 2
List of co-occurrences of author keywords.

Keyword	Occurrences weight	Keyword	Occurrences weight
Anaerobic digestion	8	Packaging	6
Biogas	5	Plastic	6
Biowaste	5	Plastic recycling	6
China	15	Plastic waste	10
Circular economy	226	Plastics	5
Construction and demolition waste	8	Pyrolysis	8
Developing countries	6	Recovery	8
E-waste	25	Recycling	63
Environment	6	Resource recovery	9
Extended producer responsibility	6	Reuse	6
Food waste	7	Reverse logistics	6
Heavy metals	5	Solid waste	11
Incineration	6	Solid waste management	6
Industrial ecology	13	Sorting	5
Landfill	7	Sustainability	22
Landfill mining	7	Waste	20
LCA	6	Waste electrical and electronic equipment	8
Life cycle assessment	17	Waste management	36
Material flow analysis	9	Waste-to-energy	10
Municipal solid waste	32	WEEE	16
Organic fraction of municipal solid waste	6		

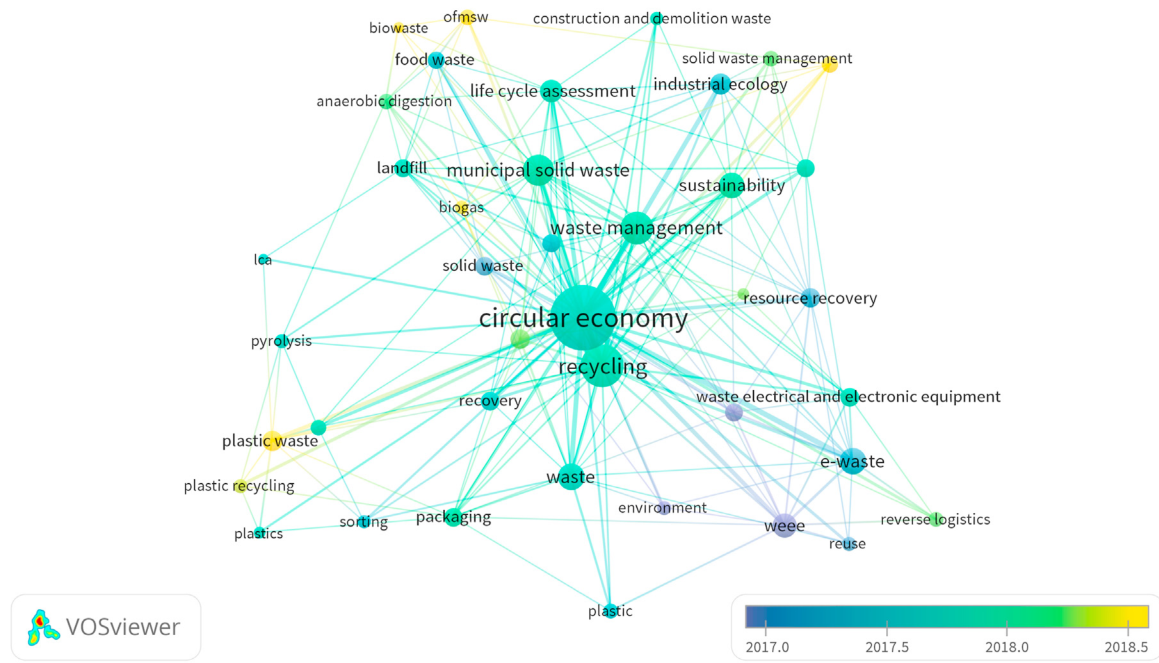


Fig. 2. Co-occurrence of author keywords by publication year.

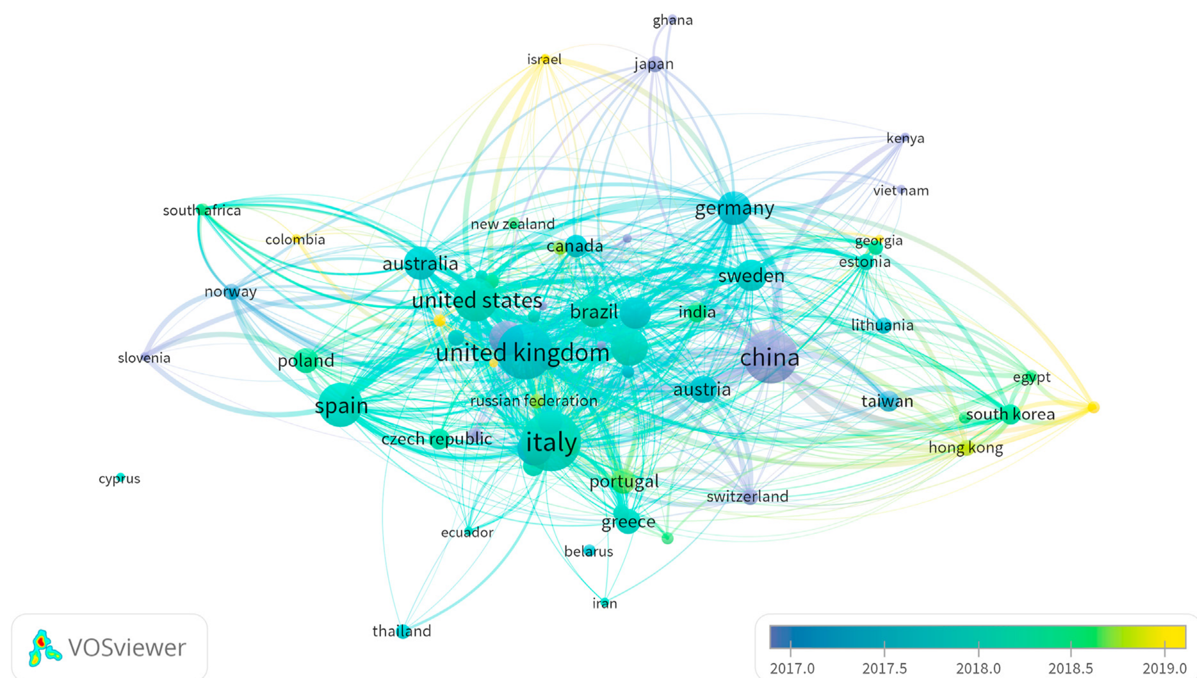


Fig. 3. Bibliographic coupling of countries/territories by year.

4.3. Entropy weight method results

Table 6 presents the comparable entropy weights of the indicators for each region (Equations (3)–(5)). The entropy weight method is used to reflect the utility value of an indicator and gives reliable weights when reviewing imperfect data. The entropy weight method uses entropy to represent the size of information. Entropy is a measure of how disorganized a system is when weighting an indicator; an indicator with a large entropy means that it has a great diversity of responses and a more significant influence on the system (Tseng et al., 2013). The greater the value of an indicator is, the more information that it contains. This means that the larger the entropy value is, the smaller the entropy weight (He et al., 2016). The smaller the entropy weight is, the more information that is contained in the indicator. Hence, this study uses the weighted average method to identify the level of information contained in the indicators for each region. If the weight is greater than the average, the indicator shows a need for improvement.

Table 3
List of bibliographic coupling of productive countries/territories according to region (United Nations, 2019).

Region	Asia and Oceania	North America	Latin-America And Caribbean	Europe	Africa
Countries/Territories	Australia	Canada	Argentina	Austria	Cote D'ivoire
	Bangladesh	United States	Bolivia	Belarus	Egypt
	China		Brazil	Belgium	Ghana
	Hong Kong		Chile	Croatia	Kenya
	India		Colombia	Cyprus	South Africa
	Iran		Ecuador	Czech Republic	Tanzania
	Israel		Mexico	Denmark	Uganda
	Japan			Estonia	
	Jordan			Finland	
	Macau			France	
	Malaysia			Georgia	
	New Zealand			Germany	
	Pakistan			Greece	
	Qatar			Hungary	
	Saudi Arabia			Ireland	
	Singapore			Italy	
	South Korea			Latvia	
	Sri Lanka			Lithuania	
	Taiwan			Netherlands	
	Thailand			Norway	
	Turkey			Poland	
	Viet Nam			Portugal	
				Romania	
				Russian Federation	
				Serbia	
				Slovenia	
				Spain	
				Sweden	
				Switzerland	
				United Kingdom	

Table 7 shows that Europe has provided the highest amount of information in the field of MSWM in a CE, followed by Asia and Oceania and Latin America and the Caribbean. In contrast, Africa and North America show less information. According to the fuzzy Delphi method, the most important weight of each indicator is converted to the global weight. The critical indicators for future challenges are identified by subtracting the global weight of the fuzzy Delphi method from the entropy weight.

Table 8 shows the indicator rank scores. The top five indicators are chosen for further discussion, with plastic waste (I12) ranked first in the indicator list, showing its urgent need for development as an MSWM and CE study topic. Incineration (I5) and sustainability (I16) rank second and third, followed by sorting solid waste (I15) and LCA (I8) in the fourth and fifth positions, respectively, representing potential research fields in the future.

5. Discussion

This section provides a discussion of future study challenges and implications for the status of different regions.

5.1. Future challenges and directions

This subsection discusses challenges and future study gaps based on the top five indicators, which were determined to be incineration, LCA, plastic waste, sorting solid waste, and sustainability.

5.1.1. Incineration

Municipal solid waste is disposed of either by landfilling or through incineration. In fact, waste incineration has recently become a fascinating treatment method. Continuous increases in waste generation, the absence of funding for landfills and their environmental and public health impacts have prompted an increased interest in incineration (Sebastian et al., 2019). Incineration is a process of burning municipal solid waste to sterile ash with little environmental impact. In optimal energy recovery and ecological sustainability, incineration decreases the amount of waste by 90% and the volume of mass by 70%; it also provides a possibility of recovering energy in the form of electricity (Joseph et al., 2018; Sebastian et al., 2018). Ashraf et al. (2019) proposed a clean closed-loop incineration procedure that utilizes municipal solid waste residues and helps reduce expensive landfill taxes. The feasibility of municipal solid waste incineration is determined by the composition of the municipal solid waste, which is the most crucial criterion; in contrast, the sustainable MSWM selections that are made pose a threat to the environment (Al-Salem et al., 2014). Although incineration is supposed to be a pathway to sustainable MSWM, it may not always be a feasible discarding technique, as it largely depends on the waste characteristics, which are dependent on the indigenous demography, sociocultural differences, seasonal changeability and landscape (Rajaeifar et al., 2017). Incineration is a multifaceted, complicated process with trade-offs among numerous dimensions with a cost-intensive requirement for an extensive practicability assessment of implementation.

In practice, the possibility of using incineration outputs such as ash, carbon dioxide, and energy to make cementing material through novel production stages allows a reproduction process within incinerator facilities (Ghouleh and Shao, 2018). Eco-cement production is based exclusively on municipal solid waste incineration residues to maximize the recycling potential. A simulation of solid waste incineration on an advanced technology-driven packaging bed with corrected boundary circumstances, homogeneous responses and control methods for pyrolysis products has been introduced (Gu et al., 2019). Knowledge of changes in the amount of feed waste and waste characteristics is a tool to determine the economic and environmental feasibility of incineration technology (Milbrandt et al., 2018). However, this process remains unpopular

Table 4
Fuzzy Delphi method screening out for indicators.

Indicators	l_b	u_b	D_b	Decision
Anaerobic digestion	(0.034)	0.909	0.689	Accepted
Biogas	(0.385)	0.885	0.590	Unaccepted
Biowaste	0.007	0.868	0.662	Accepted
China	(0.393)	0.893	0.595	Unaccepted
Circular economy	(0.266)	0.766	0.511	Unaccepted
Construction and demolition waste	(0.416)	0.916	0.610	Unaccepted
Developing countries	(0.054)	0.929	0.702	Accepted
E-waste	(0.340)	0.840	0.560	Unaccepted
Environment	(0.354)	0.854	0.570	Unaccepted
Extended producer responsibility	(0.027)	0.902	0.685	Accepted
Food waste	(0.348)	0.848	0.565	Unaccepted
Heavy metals	(0.356)	0.856	0.571	Unaccepted
Incineration	0.060	0.815	0.627	Accepted
Industrial ecology	0.273	0.977	0.818	Accepted
Landfill	(0.009)	0.884	0.672	Accepted
Landfill mining	0.000	0.500	0.333	Unaccepted
Lca	0.083	0.792	0.611	Unaccepted
Life cycle assessment	0.031	0.844	0.646	Accepted
Material flow analysis	0.031	0.844	0.646	Accepted
Municipal solid waste	(0.380)	0.880	0.587	Unaccepted
Organic fraction of municipal solid waste	(0.337)	0.837	0.558	Unaccepted
Packaging	(0.006)	0.881	0.670	Accepted
Plastic	0.000	0.500	0.333	Unaccepted
Plastic recycling	(0.004)	0.879	0.669	Accepted
Plastic waste	(0.425)	0.925	0.616	Accepted
Plastics	(0.389)	0.889	0.592	Unaccepted
Pyrolysis	(0.353)	0.853	0.569	Unaccepted
Recovery	(0.330)	0.830	0.553	Unaccepted
Recycling	(0.276)	0.776	0.518	Unaccepted
Resource recovery	(0.016)	0.891	0.677	Accepted
Reuse	0.118	0.757	0.588	Unaccepted
Reverse logistics	0.341	0.909	0.773	Accepted
Solid waste	0.103	0.772	0.598	Unaccepted
Solid waste management	(0.392)	0.892	0.595	Unaccepted
Sorting	0.041	0.834	0.639	Accepted
Sustainability	(0.453)	0.953	0.636	Accepted
Waste	0.089	0.786	0.607	Unaccepted
Waste electrical and electronic equipment	(0.042)	0.917	0.694	Accepted
Waste management	(0.352)	0.852	0.568	Unaccepted
Waste-to-energy	0.625	1.000	0.917	Accepted
Weee	(0.254)	0.754	0.503	Unaccepted
		Thresholds	0.613	

Table 5
List of fuzzy Delphi method indicator result.

Indicators	
I1	Anaerobic digestion
I2	Biowaste
I3	Developing countries
I4	Extended producer responsibility
I5	Incineration
I6	Industrial ecology
I7	Landfill
I8	Life cycle assessment
I9	Material flow analysis
I10	Packaging
I11	Plastic recycling
I12	Plastic waste
I13	Resource recovery
I14	Reverse logistics
I15	Sorting
I16	Sustainability
I17	Waste electrical and electronic equipment
I18	Waste-to-energy

because municipal solid waste incineration residues involve many pollution control standards, such as bottom ash, fly ash, and hazardous emission lime. Most previous viability studies have not assigned the appropriate weights to factors such as the environmental impact, energy recovery and economic operation in decision-making processes (Sebastian et al., 2019). With the intensification of incineration as a waste treatment technique, an increased emphasis on the demand for all-inclusive instruments for assessing municipal solid waste incinerability has been exploited by both researchers and practitioners. Composite indicators to quantify municipal solid waste incinerability are needed, and methods to measure the fundamental effects are required.

5.1.2. Life cycle assessment

LCA is an effective instrument to assess environmental sustainability by measuring the resources used and environmental effects related to a product or service with an extensive set of influencing quantification categories (Yeo et al., 2019). The ISO standards of LCA involve principles, frameworks, requirements and guidelines (International Organization for Standardization, 2006a, 2006b). This indicator is used to capture the causal relationships between resource consumption and the environmental effects of a precise service or manufacturing process and to assess unified MSWM systems. (Hellweg & Milà i Canals, 2014; Liu et al., 2017; Yay, 2015). LCA is employed to assist in the adoption of environmental sustainability of advanced regionalized waste treatment technology for greater environmental benefits (Yeo et al., 2019). In the sustainable management of solid waste, LCA has flaws with regard to the specificity of a particular location, rendering its use questionable in certain cases (Pereira and Fernandino, 2019).

Table 6
Regional entropy weights.

Indicators		Average	Asia and Oceania	Europe	North America	Africa	Latin-America and Caribbean
I1	Anaerobic digestion	**0.055596**	0.055584	0.055564	0.055611	0.055611	0.055611
I2	Biowaste	**0.055593**	0.055584	0.055546	0.055611	0.055611	0.055611
I3	Developing countries	**0.055554**	0.055557	0.055592	0.055611	0.055611	0.055400
I4	Extended producer responsibility	**0.055577**	0.055530	0.055574	0.055611	0.055611	0.055558
I5	Incineration	**0.055590**	0.055584	0.055583	0.055611	0.055611	0.055558
I6	Industrial ecology	**0.055545**	0.055530	0.055583	0.055389	0.055611	0.055611
I7	Landfill	**0.055500**	0.055530	0.055499	0.055500	0.055361	0.055611
I8	Life cycle assessment	**0.055570**	0.055584	0.055536	0.055611	0.055611	0.055506
I9	Material flow analysis	**0.055535**	0.055530	0.055527	0.055500	0.055611	0.055506
I10	Packaging	**0.055569**	0.055611	0.055564	0.055500	0.055611	0.055558
I11	Plastic recycling	**0.055556**	0.055584	0.055583	0.055389	0.055611	0.055611
I12	Plastic waste	**0.055538**	0.055503	0.055602	0.055611	0.055361	0.055611
I13	Resource recovery	**0.055584**	0.055584	0.055555	0.055611	0.055611	0.055558
I14	Reverse logistics	**0.055581**	0.055584	0.055592	0.055611	0.055611	0.055506
I15	Sorting	**0.055600**	0.055611	0.055555	0.055611	0.055611	0.055611
I16	Sustainability	**0.055365**	0.055395	0.055480	0.055389	0.055110	0.055453
I17	Waste electrical and electronic equipment	**0.055566**	0.055530	0.055518	0.055611	0.055611	0.055558
I18	Waste-to-energy	**0.055582**	0.055584	0.055546	0.055611	0.055611	0.055558

Table 7
Region Entropy weight comparison.

Indicators		Asia and Oceania	Europe	North America	Africa	Latin-America and Caribbean
I1	Anaerobic digestion	↓	↓	↑	↑	↑
I2	Bio-waste	↓	↓	↑	↑	↑
I3	Developing countries	↑	↑	↑	↑	↓
I4	Extended producer responsibility	↓	↓	↑	↑	↓
I5	Incineration	↓	↓	↑	↑	↓
I6	Industrial ecology	↓	↑	↓	↑	↑
I7	Landfill	↑	↓	↓	↓	↑
I8	Life cycle assessment	↑	↓	↑	↑	↓
I9	Material flow analysis	↓	↓	↓	↑	↓
I10	Packaging	↑	↓	↓	↑	↓
I11	Plastic recycling	↑	↑	↓	↑	↑
I12	Plastic waste	↓	↑	↑	↓	↑
I13	Resource recovery	↑	↓	↑	↑	↓
I14	Reverse logistics	↑	↑	↑	↑	↓
I15	Sorting	↑	↓	↑	↑	↑
I16	Sustainability	↑	↑	↑	↓	↑
I17	Waste electrical and electronic equipment	↓	↓	↑	↑	↓
I18	Waste-to-energy	↑	↓	↑	↑	↓

Note: ↑: above average value - need for improvement.
↓: below average value.

LCA is utilized to investigate the inclusive ecological performance of substitute systems or products, as it accounts for the environmental influences during the whole life cycle of a product or service (Papadaskalopoulou et al., 2019). Through LCA, the social cost of waste polyester recycling has been confirmed to have environmental effects on climate change, fossil resource shortages, noxiousness and poisonousness to humans, water consumption and global ecotoxicity (Wang et al., 2019). For instance, the environmental effects related to two distinct scenarios of waste management in olive oil production were determined through an LCA comparison between anaerobic digestion and disposal in soil (Batuecas et al., 2019). An attritional LCA of divergent recycling technologies was conducted for postindustrial and postconsumer polylactic acid waste treatment along with chemical recycling and solvent-based recycling (Maga et al., 2019). Plastic waste management options were determined through an LCA of plastic waste recovery for recycled materials, fuel and energy. Using LCA for MSWM in a CE, previous studies have attempted to take a technological system perspective on waste resources (Huysman et al., 2017; Mik et al., 2016; Nainggolan et al., 2019; Scheepens et al., 2016).

Although LCA contributes to investigating a waste life cycle, it

Table 8
Indicators ranking.

Indicators		Fuzzy Delphi method global weight (A)	Entropy Weight (B)	(B)-(A)	Need for future (Ranking)
I1	Anaerobic digestion	0.055398	0.055596	0.000198	13
I2	Biowaste	0.053206	0.055593	0.002387	7
I3	Developing countries	0.056474	0.055554	−0.000919	15
I4	Extended producer responsibility	0.055067	0.055577	0.000510	12
I5	Incineration	0.050380	0.055590	0.005210	**2**
I6	Industrial ecology	0.065741	0.055545	−0.010196	17
I7	Landfill	0.054057	0.055500	0.001443	10
I8	Life cycle assessment	0.051910	0.055570	0.003660	**5**
I9	Material flow analysis	0.051950	0.055535	0.003585	6
I10	Packaging	0.053896	0.055569	0.001673	9
I11	Plastic recycling	0.053816	0.055556	0.001739	8
I12	Plastic waste	0.049555	0.055538	0.005983	**1**
I13	Resource recovery	0.054446	0.055584	0.001138	11
I14	Reverse logistics	0.062108	0.055581	−0.006527	16
I15	Sorting	0.051387	0.055600	0.004212	**4**
I16	Sustainability	0.051093	0.055365	0.004272	**3**
I17	Waste electrical and electronic equipment	0.055822	0.055566	−0.000257	14
I18	Waste-to-energy	0.073695	0.055582	−0.018113	18

has various deficiencies (Das et al., 2019). Although this indicator helps to evaluate ecological effects, there is a scarcity of information about how, where, and to what extent it is applicable to MSWM (Laurent et al., 2014a). As a result, some specific worst practices have arisen in isolated stages of LCA, such as repeated neglect in performing the primary objectives of LCA at a substantiated level and a lack of transparency among system possibilities (Laurent et al., 2014a). Another deficiency is that LCA is strongly dependent on local site situations, which have diverse system boundaries, curtailing influencing factors and causing difficulties in inventory performance because of a lack of information on the local waste composition and a failure to perform sensitivity and uncertainty evaluation (Laurent et al., 2014b). Furthermore, this method has not been extensively adopted for waste prevention and is limited to solid waste categories such as household and construction waste (Das et al., 2019). There is still potential to improve LCA in the context of MSWM in a CE. An amended LCA approach that integrates environmental, economic, social, legal, institutional, and technological aspects is still necessary for the sustainable management of solid waste (Pereira and Fernandino, 2019).

5.1.3. *Plastic waste*

Plastic waste exists in the construction, packaging, and automotive sectors as well as in other sectors. It is one of the most prevalent types of waste as a consequence of its popular use and short lifetime (Ragaert et al., 2017). Most plastic wastes are non-biodegradable and take dozens of decades to degrade naturally. All kinds of this waste can begin to degrade by breaking down the chemical bonds, thus releasing free radicals and speeding up polymer chain degradation, causing unsanitary landfills and aggregating environmental influences (Singh et al., 2017). In terms of the consumption of large plastic products, minimizing the impacts of plastic waste generation on the environment through recycling, reuse and applications in new products is necessary (Barnes, 2019).

Previous literature has discussed how to minimize the impact of plastic waste (Dahlbo et al., 2018; Hahladakis et al., 2018; Milios et al., 2018). A cleaner and more sustainable thermal separation process that converts metal plastic waste into high-quality aluminum and hydrocarbon fuel gas was presented (Yin et al., 2019). A preliminary assessment of the antimony concentrations in plastic fractions was made for different classifications of plastic waste derived from waste electrical and electronic equipment (Alassali et al., 2019). Plastic waste was taken from espresso coffee containers to study different categories of degradation and to determine the effect of exposure on material properties (de Bomfim et al., 2019). An LCA perspective on plastic waste treatment was provided by putting a plant's capacity into an LCA system to compare the environmental influences of plastic waste scenarios. Agricultural solid waste on land associated with different crops and plastic applications in rural zones was measured using a specific set of plastic waste indicators (Blanco et al., 2018).

However, the lack of information on the types of products and applications and the polymers and contamination in plastic waste limits the ability to identify the recycling potential, thus challenging the design of recovery facilities, system improvements and overall waste management systems (Faraca and Astrup, 2019). Although plastic waste recovery has been acknowledged, information about the composition and characteristics of problematic plastic waste is scarce and unavailable. There are still gaps that make it challenging to replace disposable plastic products with "environmentally friendly" products in an optimal solution. The result is an important turning point in the context of rising costs and a lack of recycling for developing real solutions to address the rapid rise of global plastic consumption (Barnes, 2019; Dauvergne, 2018). Plastic alternatives still face questions regarding the availability of raw materials, whether they will be inexpensive enough to be accepted by the market and their harm to the environment after being discharged. Furthermore, current legislation is not environmentally friendly.

5.1.4. *Sorting solid waste*

Municipal solid waste is rich in various valuable recyclable materials, such as plastic, glass, paper, and metal. Effective MSWM can facilitate valuable recyclable material recovery and reduce environmental damage. Waste sorting is a crucial stage in MSWM for material recycling and should receive more attention (Gundupalli et al., 2017; Minelgaitė and Liobikienė, 2019) to develop and test a sorting and quality assessment method. Thus, the general reason for studying the quantity and quality of solid waste is to reduce the number of items disposed (Hossain and Roy, 2019). The quality of waste sorting is insufficient, and different types of waste are mixed together; additional separation processes are always essential for waste recycling (Leeabai et al., 2019).

The role of social influence is particularly important for handling the uncertainty of personal recycling responsibility. It is essential to understand the factors that influence sorting behavior to suggest tools that can most effectively contribute to promoting waste separation and contribute to an enhanced and more operative application of recycling programs. The continuous rise in household solid waste has received significant global attention, and waste sorting is regarded as an effective tool to reduce the waste disposal volume. A comparison of motivation–intention–behavior in regard to household solid waste sorting has been carried out to enhance our understanding of the determinants of household solid waste sorting behavior (Fan et al., 2019). Win-win results in waste sorting behavior were suggested to identify differences in waste separation performance among handling systems (Nguyen and Watanabe, 2019). As a precondition for the cumulative circularity of resource flows in the economy, waste is preserved in discrete resource varieties to improve the effectiveness and cost of different waste treatment and sorting mechanisms (Nainggolan et al., 2019).

However, in developing and developed countries, low recycling levels of solid waste are evident. There is no clear concept of quality assessment, and the results of solid waste sorting are very uncertain (Nørup et al., 2018). It is necessary to identify processes that promote waste separation in effective ways, as well as proposed methods to identify precise waste; thus, the potential for enhancing collection is essential. There are still gaps for further study on the potential for minimizing and separating waste. Research on the completion of waste sorting equipment lines, the development of recycling, the minimization of waste at the source and at transfer points before sorting and treatment processes, and sorting without dedicated activities is needed to focus and deploy SWM at many levels to meet the requirements of daily life.

5.1.5. Sustainability

CE thinking highlights reduction, reuse, recycling, and recovery (including energy recovery through waste incineration), with a focus on the net environmental or sustainable output over the final discharge (Chen et al., 2017a, 2017b; Kirchherr et al., 2017; Malinauskaite et al., 2017; Silva et al., 2017). However, regional and local waste information systems are often not available or reliable and cannot be restricted to assist decision-making processes and to handle the challenges of integrated management. Although sustainability practices have been implemented, many regions and localities still present poor waste management. As unsustainable MSWM has increased, concerns over overconsumption and its consequences have grown significantly (da Silva et al., 2019). Nevertheless, less information has been obtained from the cultural perspective, and changes in the generation of socioenvironmental problems have been questioned in the field of MSWM (de Souza Melaré et al., 2017; Martinez-Alier, 2014; Pereira and Fernandino, 2019).

In addition, the continuous escalation of MSWM has brought serious global attention to management of waste in a sustainable manner and to SWM decisions (Pujara et al., 2019). MSWM is a cross-cutting problem that affects all sustainability domains (triple bottom line) and emphasizes the position of combining its political precedence (Rodić and Wilson, 2017). The use of sustainability indicators for calculations by public administrators and metropolitan employees is also common. Pereira and Fernandino (2019) evaluated the MSWM quality in a coastal metropolis and tested the implementation of a system of indicators. A relevant set of sustainability indicators was selected to investigate MSWM in large and medium-sized cities worldwide and was applied in three municipalities (da Silva et al., 2019). An overview has been provided to an extensive range of existing MSWM strategies with the main purposes of designating present technologies, innovative strategies, and monitoring assessments that prevail in waste management situations in different regions as well as possible approaches to sustainable solid waste recycling and utilization (Das et al., 2019). Based on existing studies, holistic approaches to monitoring MSWM on a global scale are still lacking. The major challenges, such as waste generation, collection, transportation and logistics, treatment and disposal, remain gaps for further investigation (Baawain et al., 2017; Hietala et al., 2018; Hassan et al., 2016; Loan et al., 2019; Mmereki et al., 2016).

5.2. Regional discussion on MSWM in a CE

This study shows that Europe has the highest number of publications in the field of MSWM in a CE, followed by Asia and Oceania and Latin America and the Caribbean. In contrast, Africa and North America currently have fewer studies, indicating that there is still plenty of room for further exploration.

Africa addresses wide-ranging and multifaceted MSWM problems. Municipal solid waste is normally disposed of without any consideration of its ecological and human health effects. Dumpsites are basically uncontrolled or poorly managed. However, current waste treatment technologies are incapable of being applied in this region due to their high cost (Hietala et al., 2018). Most African cities are now facing challenges from poor public service management due to insufficient and failing infrastructure caused by underinvestment. Furthermore, even adequate MSWM infrastructure cannot cope with the excess waste, leading to excessive leakage of plastic waste into the natural environment, including through some on-site plastic waste locations, especially along the coastlines (Das et al., 2019). This situation has contributed to common unsanitary events, such as poor solid waste and wastewater disposal, resulting in heavy pollution of heavy metals, persistent organic contaminants and biological effluence in water resources.

North America has fewer articles even though the region is composed of rich and developed countries. The region's approach to SWM has evolved over time from open discarding to integrated waste management moving in the direction of a proactive approach (Hettiaratchi, 2007). In North America, effective waste reduction is largely driven by policies and legislation combined with suitable technologies and economic procedures. Hence, the status quo is not necessarily improved. High living standards and income per capita are connected to high rejection rates, resulting in very large amounts of waste (Mmereki et al., 2016). Indeed, cities have stopped recycling municipal waste due to its high cost and the low profits from recycling activities. The region sends its waste to other regions and often achieves extremely poor waste management performance (Barnes, 2019). The result is an important crisis that requires reconsidering the policy of exporting waste over long distances to develop real solutions under the situation of escalating global consumption (Dauvergne, 2018). Under such circumstances, difficult challenges still endure. Elements of ecological superiority, municipal well-being and consciousness, resource crises, and alternative energy in sustainable waste systems should receive more attention.

Overall, the concept of MSWM in a CE has received extensive attention over the last decade and has become a principal point for progressing towards achieving regional sustainable development (Nainggolan et al., 2019; UNIDO, 2017). As a result, the uncertainties and complexities are growing deeper and faster than the extent to which decision makers are capable of responding. The improvements are inadequate in the face of such escalating challenges, and a lack of quality assessments is causing a large number of problems that need to be solved to exploit the potential of MSWM in a CE.

6. Concluding remarks

This study presents a review of a bibliometric analysis of MSWM in a CE, identifies indicators for improvement and provides a regional state-of-the-art comparison. This study proposes a hybrid approach to enhance traditional bibliometric analysis. The proposed hybrid method includes bibliometric analysis, the fuzzy

Delphi method and the entropy weight method. VOSviewer software is used in the bibliometric analysis to visualize an overview of the bibliometric status by applying data obtained from the Scopus database and presenting the results as visual information. The fuzzy Delphi method aims to screen out unnecessary indicators based on expert judgments. The entropy weight method transforms the indicator frequencies into comparable weights to determine the performance of different regions on the indicators and to identify the critical indicators. This study contributes to the literature as follows:

1. A data-driven systematic review is presented. Bibliographic coupling analysis identifies 41 keywords, and 18 indicators are accepted as critical concerns based on expert evaluation. The following top five indicators are chosen: incineration, LCA, plastic waste, sorting waste, and sustainability are potential avenues for further investigation and offer the opportunity to identify priorities for speculation.
2. A total of 69 countries/territories are included, which are then rearranged into 5 regions: Asia and Oceania, Europe, North America, Africa, and Latin America and the Caribbean. The results show that Europe has the highest number of publications in the field of MSWM in a CE, followed by Asia and Oceania and Latin America and the Caribbean. In contrast, Africa and North America have fewer publications than the other regions. The challenges and gaps among different geographical regions not only contribute local viewpoints for investigation but also offer the global state of the art of MSWM in a CE. Hence, this study can serve as a reference for the decision making of MSWM and CE actors.
3. The government and professionals can find useful information for policy design and practical planning from different regional perspectives to promote innovation. Africa and North America are confirmed to have fewer publications. In particular, Africa is in urgent need of improvement since current waste treatment technologies cannot be applied in this region due to their high cost.

This study provides overall insights into the complex study background and intensively broadens the scope of MSWM in a CE. Future studies need to align quality incentives for solid waste processing to CE practices as well as a focus linked to production and consumption perspectives and develop the gaps in MSWM in a CE to improve the roles of firms, governments and professionals in fostering innovative implementations. (1) Future studies should examine incineration intensification as a sustainable instrument for assessing sustainable development practices; (2) LCA approaches should be amended to integrate conceptual CE aspects for the sustainable management of solid waste; (3) Future studies correspondingly need to focus on and deploy SWM methods, including relevant differences regarding CE consumption behaviors to meet daily life requirements; (4) Plastic waste issues should be better emphasized in future research as a precedence to frame a clearer link between a CE and sustainability due to large-scale environmental disputes; and (5) Elaboration of MSWM and CE effects in terms of sustainability, such as a reduction in carbon emissions or the curbing of waste and pollution, should be given further consideration.

Nevertheless, this study entails certain limitations. Although Scopus has a broad scope with regard to indexing publications, there are some limitations in regard to the inclusion of low-impact sources and updating the latest articles (Shukla et al., 2019). This discussion may not be detailed enough to perform a quality assessment, and future research should employ more condensed data for better results. This study provides an in-depth technique for data-driven analysis, and future research should examine both academic and practical investigations in this field.

CRediT authorship contribution statement

Feng Ming Tsai: Writing - review & editing. **Tat-Dat Bui:** Writing - original draft, Writing - review & editing, final check. **Ming-Lang Tseng:** Writing - original draft, Writing - review & editing, final check. **Ming K. Lim:** Writing - review & editing, Methodology. **Jiayao Hu:** Writing - review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Literature reviews on CE or MSWM with a systematic approach

Authors	Databases	Years	Keywords	Number of revisited papers	Focus	Journal
Merli et al.,(2018)	Web of Science Scopus	No chronological	Circular economy	565	CE's academic research state-of-the-art	Journal of Cleaner Production
Kirchherr et al. (2017)	Scopus	2012–2016	Circular economy	148	CE definitions	Resources, Conservation & Recycling
Reike et al. (2018)	Google Scholar Scopus	2010–2016	Circular economy History Development Definition	69	CE's historical development Value retention options	Resources, Conservation & Recycling
Korhonen et al. (2018a)	Web of Science	2000 and 2017 (May, 30th)	Circular economy	407	Values Societal structures Cultures Worldviews	Journal of Cleaner Production

(continued on next page)

(*continued*)

Authors	Databases	Years	Keywords	Number of revisited papers	Focus	Journal
Sanjeevi and Shahabudeen (2015)	–	1960–2013	–	387	Potential paradigmatic of CE MSWM performance indicators Practical methods	Waste Management & Research
Deus et al. (2018)	Web of Science	No chronological	Municipal solid waste Urban solid waste Indicator Index	204	MSWM performance indicators	International Journal of Environmental Science and Technology
D'Amato et al. (2017)	Web of Science	1990–2017	Circular Economy Green Economy Bioeconomy	1949	Circular-Green-Bioeconomy relationship	Journal of Cleaner Production

Appendix B. Region search term

Region	Search terms
Asia and Oceania	TITLE-ABS-KEY ("Australia" or "Bangladesh" or "China" or "Hong Kong" or "India" or "Iran" or "Israel" or "Japan" or "Jordan" or "Macau" or "Malaysia" or "New Zealand" or "Pakistan" or "Qatar" or "Saudi Arabia" or "Singapore" or "South Korea" or "Sri Lanka" or "Taiwan" or "Thailand" or "Turkey" or "Viet Nam")
North America	TITLE-ABS-KEY ("Canada" or "United States")
Latin America and Caribbean	TITLE-ABS-KEY ("Argentina" or "Bolivia" or "Brazil" or "Chile" or "Colombia" or "Ecuador" or "Mexico")
Europe	TITLE-ABS-KEY ("Austria" or "Belarus" or "Belgium" or "Croatia" or "Cyprus" or "Czech Republic" or "Denmark" or "Estonia" or "Finland" or "France" or "Georgia" or "Germany" or "Greece" or "Hungary" or "Ireland" or "Italy" or "Latvia" or "Lithuania" or "Netherlands" or "Norway" or "Poland" or "Portugal" or "Romania" or "Russian Federation" or "Serbia" or "Slovenia" or "Spain" or "Sweden" or "Switzerland" or "United Kingdom")
Africa	TITLE-ABS-KEY ("Cote D'ivoire" or "Egypt" or "Kenya" or "Ghana" or "South Africa" or "Tanzania" or "Uganda")

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