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SYSTEMATIC REVIEW Open Access

A SYSTEMATIC REVIEW OF SOLID WASTE MANAGEMENT IN INDONESIA: GENERATION, CHARACTERISTICS, TREATMENT, AND REGULATION

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Abstract

Introduction: *Research on solid waste in Indonesia remains relatively fragmented, with many studies still focusing on the development of solid waste management in urban areas. This study seeks to address the information gap by reviewing the development of solid waste management in Indonesia.* ***Discussion:*** *This systematic review was conducted through literature searches in Scopus, PubMed, and Google Scholar, selecting 38 articles that specifically examined solid waste in Indonesia in terms of its generation, characteristics, management, and regulatory frameworks. Collective evidence showed that household waste generation in Indonesia is strongly influenced by various factors such as income level, residential location, season, and public awareness of waste management. Waste banks and the 3R approach are the main pillars of community-based strategies, with composting applied to organic waste. Waste processing facilities play a supporting role within the community, such as WTE and incineration. Landfills remain necessary as a final solution for residual waste that cannot be further processed. Law No. 18 of 2008 on Waste Management serves as the primary regulatory framework in Indonesia. This law shifts the traditional paradigm of "collect-transport-dispose" toward a more sustainable approach through the 3R principles.* ***Conclusion:*** *Solid waste generation in Indonesia is determined by socio-economic factors, urbanization, and consumption patterns. Management strategies emphasize community-based approaches such as waste banks, composting, and the 3R principle, supported by small-scale processing facilities, while landfills remain necessary for residual waste. The Law on Waste Management requires revision to align with current developments and emerging challenges in solid waste management.*

INTRODUCTION

In numerous urban areas, particularly in developing nations, insufficient solid waste management systems create significant threats to public health, the environment, livelihoods, and natural resource preservation. The decades-long accumulation of unmanaged and improperly disposed waste due to economic growth demands urgent and comprehensive intervention across all societal levels (1). Indonesia's Coordinating Minister for Maritime Affairs and Investment has emphasized that solid waste management is an increasingly important component of the national development agenda (2). Comprehensive solid waste collection is a target in the national medium-term development plan, and it is becoming even more critical with the continued growth of Indonesia's urban population (3). More than half of Indonesia's population now lives in urban areas. Meanwhile, cities generate approximately 105,000 tons of waste per day, a figure projected to increase to 150,000 tons per day by 2025. However, 40 percent of the 142 million urban residents in Indonesia still lack access to basic waste collection services (4).

Uncollected waste constitutes a major source of pollution and poses significant health risks to communities

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in various regions (5). Open dumping remains the most common practice of solid waste disposal in Indonesia (6). The impact of uncollected waste is most evident along rivers, which have been declared as national strategic areas (7). Solid waste management is essential for the well-being of Indonesia's rapidly growing urban population and for the national economy, including the tourism sector. As Indonesia is one of the world's largest contributors to marine debris, improving solid waste management in coastal and riverine cities is increasingly vital to address marine pollution (2).

This systematic review is presented to address the gap in solid waste research in Indonesia, which remains relatively fragmented. Most existing studies tend to focus on specific regions and highlight only particular aspects, such as waste generation, waste characteristics, household waste management practices, or regulatory frameworks (8–12). Although some studies have reported the progress of waste management over the past three years, they did not provide detailed insights into the characteristics, management practices, or government regulations related to solid waste (13). To date, no comprehensive study has integrated the four key aspects—generation, characteristics, treatment, and regulation—into a single national-level review to provide a holistic overview of solid waste management in Indonesia. In addition, this review also explores the timeline of waste management regulations in Indonesia, several programs to address solid waste problems, and the achievement of national waste management targets.

Therefore, there is a need for comprehensive research that reviews the development of solid waste management in Indonesia, enriched with supporting data from various sectors, to present a comprehensive view of the current situation. This study seeks to address the information gap and to inform the formulation of more effective solid waste regulations in Indonesia.

DISCUSSION

Research Methods for Systematic Review

This study followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (14) to conduct a systematic review. PRISMA provides a standardized methodology that contributes to the quality of the revision and replication process. In general, the PRISMA method consists of several steps: a) determining eligibility criteria; b) identifying sources of information; c) conducting data collection process; and d) selecting relevant data items.

Research Eligibility Criteria

Studies were selected according to specific inclusion and exclusion criteria as follows: a) all original research articles written in English; b) studies focusing on solid waste generation or trends, characteristics, management or treatment, and regulations in Indonesia, specifically municipal, household, or domestic solid waste; c) research employing quantitative, qualitative, or mixed-methods approaches; d) articles published between January 2015 and June 2025; e) full text and open-access availability. Studies were excluded if: a) they are duplicates (i.e., articles collected from three different electronic databases); and b) they were not primary research articles such as literature reviews, systematic reviews, and meta-analyses.

Resources and Study Selection

The literature search were carried out across three major online databases with large academic repositories, namely SCOPUS, PubMed, and Google Scholar. Articles that were not fully accessible were excluded from this study. The search covered all literature published between 2015 and 2025. The final selection and eligibility criteria are illustrated in Figure 1. Study selection was conducted in three stages. First, advanced search queries were formulated based on the study's focus on solid waste in Indonesia, including aspects of generation, characteristics, management, and regulation. The search keywords entered were ("Domestic" OR "Municipal" OR "Household") AND "Solid" AND "Waste" AND ("Generation" OR "Trend" OR "Characteristic" OR "Treatment" OR "Management" OR "Regulation") AND "Indonesia". The search included articles published between 2015 and 2025. These keywords must appear in the title, abstract, and keywords of the articles. The step-by-step keyword search process is presented in Table 1. Second, titles, abstracts, and keywords were reviewed based on the eligibility criteria to ensure relevance to the research topic. Third, all articles that passed initial screening underwent a full-text assessment. All assessments were conducted by more than one reviewer.

Tabel 1. The Keywords Used for the Literature Search

Keywords
Solid AND Waste AND Indonesia
Domestic AND Solid AND Waste AND Indonesia
(Domestic OR Municipal) AND Solid AND Waste AND Indonesia
(Domestic OR Municipal OR Household) AND Solid AND Waste AND Indonesia
(Domestic OR Municipal OR Household) AND Solid AND Waste AND Generation AND Indonesia
(Domestic OR Municipal OR Household) AND Solid AND Waste AND (Generation OR Trend) AND Indonesia
(Domestic OR Municipal OR Household) AND Solid AND Waste AND (Generation OR Trend OR Characteristic) AND Indonesia
(Domestic OR Municipal OR Household) AND Solid AND Waste AND (Generation OR Trend OR Characteristic OR Treatment) AND Indonesia
(Domestic OR Municipal OR Household) AND Solid AND Waste AND (Generation OR Trend OR Characteristic OR Treatment OR Management) AND Indonesia
(Domestic OR Municipal OR Household) AND Solid AND Waste AND (Generation OR Trend OR Characteristic OR Treatment OR Management OR Regulation) AND Indonesia

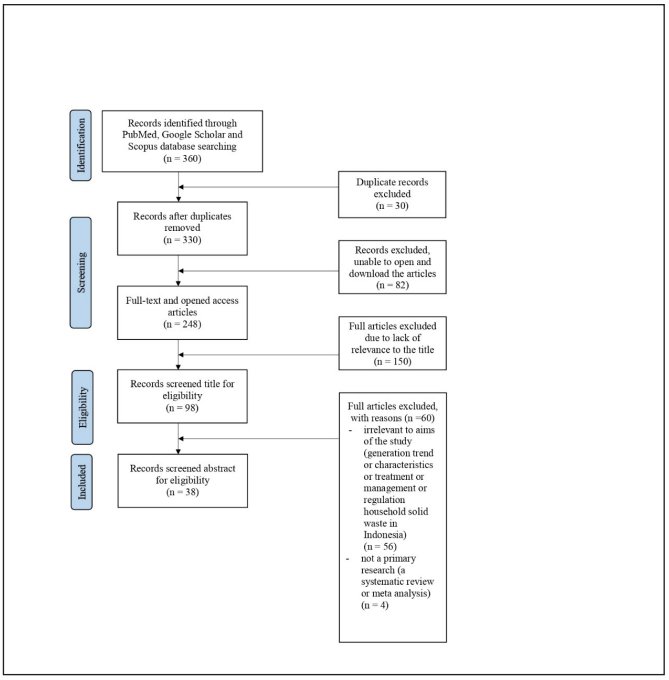

Figure 1. Flowchart Showing the Selection Process of Research Evaluating Solid Waste Management in Indonesia

Data Items

Data extraction was carried out independently by five authors using standardized abstraction forms. The characteristics obtained from each eligible study included the authors' names, year of publication, country of the research, and publisher. Data items extracted from each article were summarized into the following categories: authors, year of publication, title, objective, research design, sample, and research findings consisting of solid waste generation or trends, solid waste characteristics, solid waste management or treatment, and solid waste regulations.

The initial search yielded 360 scientific articles based on the predetermined keywords. The number of articles retrieved was influenced by the variation in search coverage across Scopus, PubMed, and Google Scholar. Figure 1 shows that keyword searches in PubMed and Google Scholar referred only to titles, since unlike Scopus, these databases do not provide features to search within titles, keywords, and abstracts. After thoroughly reviewing their entire content based on the eligibility criteria, 38 empirical articles were selected and analyzed in this systematic review.

Solid Waste Generation in Indonesia

A total of 38 articles analyzed to examine waste generation in Indonesia. The analysis revealed that household waste generation varies widely across the country, influenced by socioeconomic characteristics, consumption patterns, and regional conditions. At the global level, China and the United States contributed approximately 37% and 12%, respectively, of the total increase in new municipal solid waste (MSW) capacity between 2014 and 2019 (1). Research shows that the majority of the municipal solid waste generated in developing countries such as Indonesia originates from households, accounting for approximately 55-80% (15). In Indonesia, the estimated potential for solid waste generation reaches 3.25 L/person/day, or 0.833 kg/person/day (16). Figure 2. Illustrates the trend of average household waste generation in Indonesia from 2015 to 2025. From 2015 to 2019, waste generation appears to have decreased, but in subsequent years, it shows a steady increase. This indicates that overall waste generation in Indonesia has shown an increasing trend in recent years.

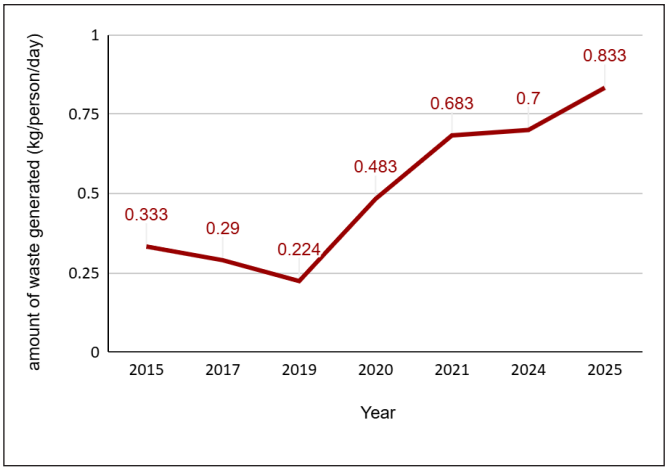

Figure 2. Average Annual Waste Generation

In general, household waste generation in Indonesia ranges from 0.14 kg/person/day to 0.833 kg/person/day. The lowest figure was recorded in Padang City at 0.14 kg/person/day, while the highest figure was recorded in Balikpapan City at 0.833 kg/person/day (17-18). Several studies show that the cities of Surabaya and Bali have relatively similar solid waste production, namely 0.33 kg/person/day (19–21). In Cimahi City, waste generation was recorded at 0.6 kg/person/day (22), while in Medan City, it ranged from 0.191 to 0.222 kg/person/day (23). On the other hand, other studies reported that waste generation in Padang City reached 11,875 tons/day per household unit and 598,966 kg/day in 2013 (17,23). These results suggest that the level of urbanization, economic activity, and population growth in each city have a greater influence on household waste generation than the geographical location between islands or regions. For example, large cities on Java Island, such as Surabaya and Cimahi, show moderate levels of waste generation. Meanwhile, cities with the highest and the lowest solid waste generation, namely Balikpapan and Padang, respectively, are located outside Java. This condition is similar to research in 2023 which stated that population growth, urbanization, and economic growth can increase the volume of solid waste (24). Furthermore, comparison between urban and suburban areas shows that urban communities tend to produce more waste compared to suburban communities. Research conducted in the city of Medan shows that the central area produces 0.295 kg of solid waste per person per day, compared to 0.180 kg of solid waste per person per day in the outskirts (25). Other findings noted that waste generation in suburban areas of Medan, such as Medan Labuhan and Medan Tuntungan, ranged from 0.233 kg per person per day to 0.254 kg per person per day (22). Another study reported that solid waste generation in the central area of Sleman Regency reaches 0.7 kg per person per day (26). In Malang City, it was reported that the urban center produces around 38,630 tons per day and 14.1 million tons of solid waste annually, while urban village areas generate an average of 0.5 kg/person/day (27-28). These findings indicate that proximity to urban activity centers correlates with higher volume of waste generated, in line with high population density, consumption patterns, and lifestyles of the people in those areas. This condition is similar to research conducted in 2022 in the city of Serang which found that densely populated areas with diverse consumption patterns, such as urban areas, tend to produce more waste (29).

Based on socioeconomics factors, high-income households produce more waste than low-income households. A study revealed that high-income households generated 0.587 kg of waste per person per day, whereas low-income households generated only around 0.256 kg per person per day (30). This indicates that higher income levels are associated with greater volumes of waste generated, in line with increasing consumption patterns, the use of packaged products, and lifestyle changes. This is supported by another study indicating that households with higher incomes tend to have greater purchasing power for food and other products, thereby potentially generating more waste (31). Several studies have also noted specific phenomena. For instance, in Piyungan City, waste generation during the dry season was recorded at 0.3 kg per person, but during the rainy season, it reached 0.38 kg per person (32) The increase in waste generation is likely caused by the increased water content in organic waste and disruptions to waste transportation systems during the rainy season. Another study also found that waste weight increases during the rainy season due to suboptimal waste management systems (33). Muddy soil conditions and standing water hamper the operation of trucks and heavy equipment, especially in the process of moving and compacting waste. A study during the COVID-19 pandemic in the city of Bandung noted an interesting trend in community behavior towards waste separation across economic groups: 78.16% of high-income households separated mask waste from domestic waste, whereas 90.35% of middle-income households and 100% of low-income households did not separate mask waste from domestic waste. This indicates a gap in waste management awareness and practices (34).

Solid Waste Characteristics in Indonesia

The review indicates that the most dominant type of waste generated by households is organic waste. A study found that the average daily generation of household organic waste was 1.8 kg, while the average daily generation of inorganic household waste was 1.31 kg (35). Another study reported that household waste composition consisted of food waste at 51.21% of the total waste, followed by plastic waste at 17.96%, paper waste

at 11.95%, and diaper waste at 8.69% (36). As illustrated in Figure 3 the largest share in terms of capacity of solid waste compositions is food waste (66.94%), followed by organic waste (about 59.75%) and the minimum is rubber waste (about 0.25%). Similar findings were reported in Bekasi City, where the highest composition of household waste was food waste, amounting to 261.60 kg or 82.67% of the total (37). A study in Balikpapan also showed that food waste was the most dominant type of waste generated (38).

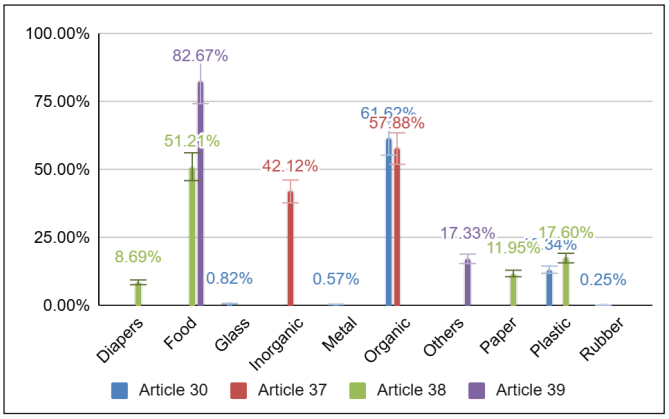

Figure 3. Average Composition of Solid Waste by Article Claim

The reviewed studies consistently show that municipal solid waste (MSW) in Indonesia is dominated by organic materials with high moisture and volatile content. A study found that on average, organic waste contains 79.4% water, 82.24% volatile matter, 56.33% C-organic, and 1.67% nitrogen (39). A study found that the moisture content of food waste specifically ranges from 80% to 90%, indicating a predominantly “wet” waste profile which is typical across various regions (26). Another study in Malang City showed that the organic fraction of MSW reaches 64.9%, with moisture content varying between 60.6% and 66.8% (27). Similarly, another study reported an average moisture level of 49.94% and a high volatile matter content averaging 53.34%, while the ash content was relatively low at 6.12%, meeting criteria for combustibility (38). On the other hand, plastic waste and disaggregated paper waste exhibit significantly lower water content, typically ranging from 0.2% to 14%, and volatile matter content in the range of 75% to 99%, typical of inorganic waste (39). Another study reported that daily waste streams are compositionally dominated by organic waste (61.62%) and plastic (13.34%), whereas rubber, metal, and glass are present only in small proportions: 0.25%, 0.57%, and 0.82%, respectively (28). Another study found that the low ash content and substantial carbon content found in MSW samples suggest a favorable profile for thermal treatment. Moreover, the nitrogen (N) and sulfur (S) content in the waste remains below 5%, implying a reduced risk of harmful emissions from N- or S-based compounds in fuel gas during incineration (40).

Solid Waste Management in Indonesia

Waste management in developing countries is carried out using locally relevant alternatives. For example, waste is disposed of in landfills equipped with sanitation and landfill gas collection systems, a small portion is processed through incineration, and some waste is utilized through recycling and composting. In 2016, according to World Bank data for developing countries producing plastic waste, most single-use plastic waste was processed through incineration or disposed of in landfills, which are sources of pollution, occupy valuable land, and contaminate important natural resources (1). Meanwhile, in Indonesia, the most common waste management approach applied to household waste in various regions of Indonesia is the waste bank model. Numerous studies indicate that this model is highly attractive because it integrates economic, social, and environmental aspects directly into daily waste management practices. For example, a study in Buleleng District noted that waste banks act as a key component of waste processing alongside landfills (39). Similar systems are implemented in the Riau Islands (41), Padang (17), Medan (25), and Pontianak (42). All of these demonstrate that waste banks not only reduce waste volume but also encourage education and promote the circular economy at the household level. A study specifically highlight that community participation in waste bank activities can foster behavioral changes in waste management while simultaneously providing economic benefits (41). As illustrated in Figure 4, waste banks account for the largest proportion of waste management strategies in Indonesia (31.25%), followed by the 3R approach and composting (12.5% each). This distribution confirms that waste banks remain the primary strategy adopted across regions.

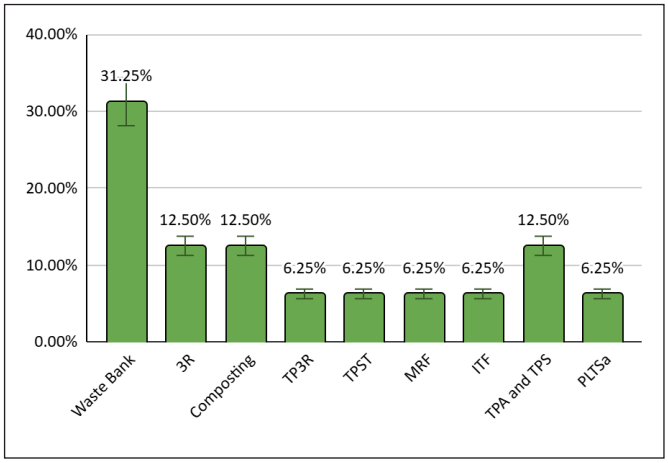

Figure 4. Implementation of Waste Management

Parallel to the role of waste banks, the 3R approach (Reduce, Reuse, and Recycle) consistently emerges in Indonesia's waste management strategies. These principles are formally implemented by local governments through processing facilities and informally adopted by community members as part of environmental stewardship. A 2020 study reported that residents in densely populated urban areas of two major cities actively practice waste sorting, reduction, and recycling through 3R programs at both the household and temporary collection point (*Tempat Pembuangan Sementara*/ TPS) levels (28). Similar initiatives are observed in Makassar (35), where the 3R approach is integrated with community-based waste collection systems, and in Padang (17) and Medan (25), where this approach is coordinated with local waste banks.

Another widely adopted strategy is composting, particularly for processing organic waste, which continues to make up the majority of household waste composition. A study in Surabaya found that composting is an effective method for reducing the volume of waste, particularly biodegradable materials such as food scraps and leaves (36). Another study also reported that composting, combined with waste sorting systems, serves as a primary strategy in areas such as Medan Tuntungan and Medan Labuhan (23).

Facility-based processing approaches are also employed in several regions. For example, Sleman has developed TPS3R and TPST as community-scale processing units that are efficient both economically and technically (26). The study also highlighted two community-based processing units in Sleman that handle waste at a medium scale, concluding that financial and operational sustainability are essential for the success of facilities including TPS3R. Meanwhile, in Balikpapan and Yogyakarta, Material Recovery Facilities (MRFs) and Intermediate Treatment Facilities (ITFs) are used to sort and process valuable inorganic waste (18). A 2020 study further highlighted the performance of the MRF facilities in Yogyakarta in sorting and recycling reusable materials (16).

Despite the prioritization of waste reduction and recycling strategies, the final disposal of waste in landfills remains an integral part of the waste management system in many areas. A study in Buleleng reported that the landfill system is used as the final processing stage after collection and waste bank activities (39). Similarly, another study showed that although there are efforts for recycling and composting, most residual waste still ends up in landfills at the end of the management chain (36). A study in Bondowoso mentioned that landfills are used alongside TPS as a basic technical waste management system at the district level (43). Additionally, in Malang, landfills are incorporated into waste management scenarios, which involve a combination of recycling, composting, and energy recovery through incineration before the disposal of residual waste (27).

Some regions are also integrating waste-to-energy (WTE) technologies. A study analyzed the WTE facility in Bantargebang, which utilizes incineration methods to reduce waste volume while simultaneously generating electricity from combustion (40). Although not yet widely implemented, this strategy shows significant potential, especially in metropolitan cities with high daily waste volumes.

Solid Waste Regulations in Indonesia

Various cities and regencies in Indonesia have implemented a range of regulations in an effort to address solid waste management issues. In general, the most widely applied regulation is Law No. 18 of 2008 on Waste Management. Research indicates that this regulation has been adopted in Bantul Regency (36), the Riau Islands (41), Padang City (17), Medan City (25), Jakarta City (44), and Bondowoso Regency (43). This law shifts the traditional paradigm of "collect-transport-dispose" toward a more sustainable approach through the 3R principles.

In addition to Law No. 18 of 2008, several regions have adopted supplementary local regulations to improve waste management. A study stated that in Buleleng Regency, Bali, solid waste management is regulated by Regional Regulation No. 6 of 2018 (39). A study in Sleman Regency reported that Sleman Regency implemented Presidential Regulation No. 97 of 2017 and Regulation of the Minister of Public Works and Public Housing No. 3 of 2013, which promotes 3R-based waste management through TPS3R (26). Similarly, a study reported that Yogyakarta City also implemented the Regulation of the Minister of Public Works and Public Housing No. 3 of 2013 as the basis for its waste management system (16). In Makassar City, a study noted that Regulation No. 13 of 2012 from the Ministry of Environment and Forestry serves as a guideline for community-based 3R activities supported by the World Bank (45). In Bandung City, waste management is regulated by Regional Regulation No. 9 of 2018 concerning Waste Management (46) and Ministerial Regulation No. 13 of 2012 concerning Waste Bank Management (34).

A study showed that Padang City not only refers to Law No. 18 of 2008 but also reinforces its waste system through Government Regulation No. 81 of 2012 concerning Management of Household Waste and Household-Like Waste, Ministerial Regulation No. 13 of 2012 concerning Guidelines for Implementing Reduce, Reuse, and Recycle through Waste Banks, and Regional

Regulation No. 5 of 2012 concerning Waste Management (47). Similarly, another study reported that Bondowoso Regency complements its policy framework with Regional Regulation No. 82 of 2018 on Regional Policies and Strategies for Domestic Solid Waste and Domestic-Like Waste, and Regional Regulation No. 3 of 2011 on Solid Waste Management in Bondowoso Regency, as local policies to strengthen domestic waste management (43). At the national level, Indonesia has enacted a number of key regulations that serve as the legal foundation for waste management. These include Law No. 18 of 2008 on Waste Management, Government Regulation No. 81 of 2012 on Management of Household Waste and Waste Similar to Household Waste, Regulation of the Ministry of Environment and Forestry No. P.10/Menlhk/Setjen/PLB.0/4/2018 on Waste Management at Its Source, and Ministerial Regulation No. 75 of 2019 on the Roadmap for Waste Reduction by Producers. Furthermore, other studies emphasized the importance of Presidential Regulation No. 97 of 2017 concerning National Policy and Strategy for the Management of Household Waste and Household-Similar Waste (Jakstranas) (48) as well as Presidential Regulation No. 83 of 2018 concerning the Prevention of Marine Pollution by Waste (49-50).

Establishing waste management regulations at the regional level is crucial because it allows local governments to tailor policies to environmental challenges, socioeconomic conditions, and the characteristics of waste generation in their respective regions. According to data from the Ministry of Environment and Forestry of the Republic of Indonesia, as of January 2021, 41 local governments—consisting of two provinces and 39 regencies/cities—had enacted regulations or policies related to solid waste management, such as limiting or even banning the use of single-use plastics (48). These regulations demonstrate that waste management in Indonesia is implemented across multiple levels, from national to local, with an emphasis on sustainability, community involvement, and the strengthening of 3R-based systems as the core of the country's waste management transformation.

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CONCLUSION

Collective evidence from this systematic review of Indonesian studies shows that household waste generation in Indonesia is strongly influenced by various factors such as income level, residential location (city center or suburban), season, and public awareness of waste management. Geographical location is not the main factor for determining the amount of waste generation. Rather, socio-economic dynamics, urbanization, and consumption habits play a more significant role in determining the level of waste generation. Solid waste management practices in Indonesia tend to rely on a combination of approaches that are adapted to local conditions. Waste banks and the 3R approach are the main pillars of community-based strategies, with composting applied to organic waste. Waste processing facilities play a supporting role within the community, such as WTE and incineration. Finally, landfills remain necessary as a final solution, especially for residual waste that cannot be further processed. In general, the most widely implemented regulation is Law Number 18 of 2008 concerning Waste Management, specifically Article 20, which explicitly requires the implementation of the 3R principle (Reduce, Reuse, and Recycle). This law shifts the paradigm of the community as waste producers from previously only "collect-transport-dispose" to actively implementing the 3R principle of reduce, reuse, and recycle from the source of generation. This shift emphasizes that the responsibility for sustainable waste management begins with the community itself, not just at the final stage of disposal.

AUTHORS' CONTRIBUTION

All authors participated actively in the research and article writing and are partially responsible for the material, including conceptualization, design, analysis, and revision. All authors' contributions are as follows: AHZF: conceptualization, methodology, data curation, validation, original draft preparation, and supervision; KUNEM: resources, methodology, data curation, and validation; MI: resources, methodology, data curation, and validation; SFP: resources, software, data curation, validation, writing, reviewing, and editing; SASA: resources, data curation, validation, writing, reviewing, and visualization

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