Review

Assessing Global Waste Management: Alternatives to Landfilling in Different Waste Streams - A Scoping Review

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Assessing Global Waste Management: Alternatives to Landfilling in Different Waste Streams—A Scoping Review

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Abstract: This scoping review examines global strategies and enterprises for sustainable solid waste management, with a focus on alternative landfilling approaches. The study collected and analyzed a significant number of documents from different regions, revealing Asia as the major contributor (for the collected documents) (48.7%), followed by North America (24.3%) and Europe (15.8%). Recycling emerged as the most effective alternative waste treatment method, representing 52.3% of the documented approaches, with industrial recycling (22.6%) and residential/non-residential recycling (20.2%) as prominent categories. Food waste was a significant concern across regions, constituting 21.4% of the collected documents. Composting was widely adopted (15.4%) due to its simplicity and benefits for gardening and soil improvement. Other methods like biogas extraction, reusing, raising awareness, incinerating, redistributing, reducing, and fermentation accounted for 13.1% cumulatively. The study highlights the need for tailored waste management solutions based on regional challenges and successful practices. Promoting recycling infrastructure, composting, and waste reduction approaches are crucial to achieving sustainable waste management aligned with SDGs. Collaboration and knowledge-sharing between regions are essential to improve inefficient waste management mechanisms. Integrating the findings into policymaking and industry practices can lead to a more sustainable future with reduced environmental impact.

Keywords: sustainable solid waste management; recycling; composting

1. Introduction and literature review

The United Nations (UN) Conference, also known as the "Earth Summit", was the starting point in designing a comprehensive sustainable development plan [1]. After 23 years, in 2015, the UN summit proposed a reshaped universal sustainable development agenda with 17 sustainable development goals, also called the SDGs, which can be better adopted, revised, monitored, and measured in different countries [2].

It is believed that addressing some challenges in populated areas will cover multiple SDGs and thus have a greater contribution to the communities. For example, establishing composting plants in metropolitan areas can i) generate biogas as a source of energy [3] which is aligned with SDG7; affordable and clean energy, ii) increase employment [4] which is aligned with SDG8; decent work and economic growth, iii) establish a sustainable industry [5] which is aligned with SDG9; industry, innovation, and infrastructure and SDG11; sustainable cities and communities, iv) reduce the greenhouse gas emission by around 40% [6] which is aligned with SDG13; Climate action, and v) restore degraded agricultural lands by composting products [7] which is aligned with SDG15; life on land. Thus, seeking innovative ways to address the SDGs in urban areas might be of practical importance from municipalities' perspective.

Taking advantage of this opportunity, current review began to explore alternative methods for landfilling by amplifying the effectiveness of 3R policies (reduce, recycle, and reuse). The objective of this paper is to enhance awareness and encourage the implementation of sustainable practices such as recovery, recycling, and composting. The results of this review can assist municipalities in

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identifying practical solutions and integrating potential microenterprises for waste management before resorting to landfill disposal.

A report from the world bank indicates that over 40% of generated solid waste is being buried in either landfills or open dumps while compromising the potential benefits of alternative waste treatment methods [8]. While developed countries often possess better resources and strategic management plans to implement advanced treatment facilities, it is important to acknowledge that landfilling continues to be a prominent method for the disposal of various products globally. For example, Canadians select landfills to permanently dispose of the majority of their waste without integrating any other treatment methods and practices for recycling and materials recovery [9–11]. It is noteworthy to mention that the total diversion rate (waste being diverted over waste being landfilled) for all sources of waste, including both residential and non-residential, was slightly over 30% in 2018 for Canada [12]. Similarly, the average recycling rate for municipal waste in Europe in 2017 was reported to be 46% [13]. The factors contributing to the prevalence of frequent landfilling practices and the existence of numerous landfills can be attributed to urban growth, population expansion, available land resources, and public attitudes, such as the "Not In My Backyard" (NIMBY) approach [14–16].

Operating a landfill can have negative impacts on the surrounding environment, including but not limited to air pollution such as methane gas emission (global warming effects), underground water resource pollution, soil destruction, and vegetation cover degradation [17–19]. For example, Delkash et al. [20] indicated that the released methane and carbon dioxide from landfills can be carried by the wind and harm nearby areas. Karimi et al. [11] showed that the increased land surface temperature from methane gas release in eight Canadian landfills lowered the normalized difference vegetation index (NDVI), an index for measuring the health level of vegetation cover, for the neighboring lands.

Setting environmental effects aside, landfilling (and or open dumping) can also threaten public health. For example, Siddiqua et al. [19] showed that people living in the vicinity of a landfill might be susceptible to carcinogenic and non-carcinogenic effects of polluted water resources and toxic emissions. Similarly, Vinti et al. [21] showed that the closer proximity of populations to open dumpsites, landfills, and incinerations is associated with a greater number of neonatal outcomes, cancers, respiratory deficiencies, and cardiovascular disorders. Additionally, the presence of illegal disposal sites in the absence of nearby landfills has been identified as a potential threat to neighboring water resources in almost all remote communities in Canadian prairies [22].

Hence, the integration of novel practices prior to the disposal of generated waste in landfills can yield various advantages as i) the provision of cost-effective materials for emerging businesses through recycling efforts [23,24]; ii) the introduction of new practices at the community level, such as gardening and composting, for households [25,26]; iii) the extension of the lifespan of landfills by reducing the amount of waste being sent to them [27,28]; iv) the creation of income and employment opportunities through recycling-focused enterprises [29,30]; and v) the preservation of the environment by mitigating the negative impacts of landfilled waste, including methane gas emissions, toxic leachate, disruption of vegetation cover, and health-related consequences [31,32].

This study conducts a scoping review to assess global alternative practices and micro-enterprises for reducing landfill waste. It collects a wide range of waste treatment and recycling practices from around the world, providing original insights. The findings have implications for policymakers at local, regional, and international scales, aiding in the design of effective waste generation and management solutions.

2. Materials and Methods

A scoping review is adopted to broadly include the related literature from different resources. To ensure that the outcomes were inclusive, both academic and grey literature were reviewed. The purpose of scoping reviews is to define a framework for screening the available database around a subject that can be replicable and transparent.

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2.1. Searching method

The Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) diagram is shown in Figure 1 for the collected databases. It shows both the collection of different resources and the screening method, which is adopted in the current study. PRISMA designed a 27-item checklist to assist in the reporting of systematic reviews [33].

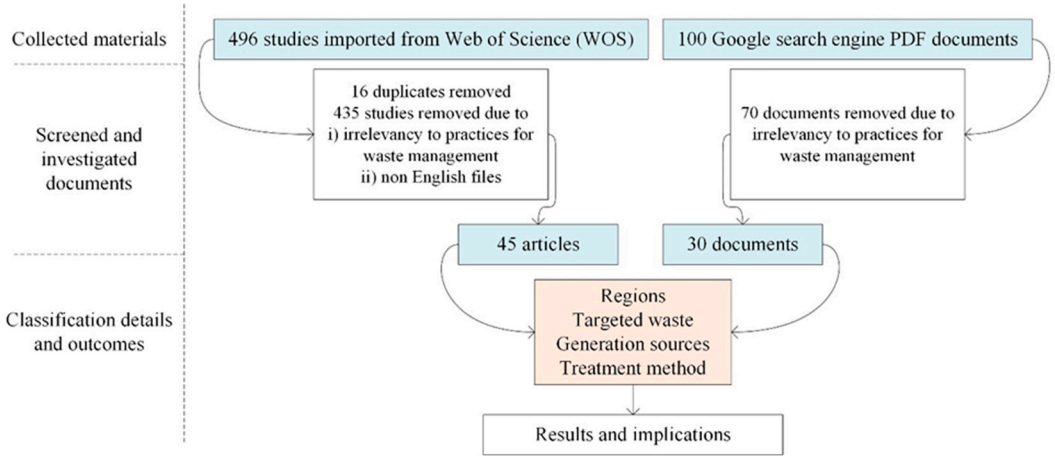

Figure 1. Incorporation of different resources in current study using Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) diagram.

2.2. Academic database

A total of 496 journal articles were gathered from the Web of Science (WOS) database, excluding conference papers, as depicted in Figure 1. The selection process for these articles involved utilizing a combination of boolean strings and field tags, aligning with the objective of the current review as below;

(TS=(recycl* OR reus* OR waste?restor* OR alternative* NEAR/10 landfill*)) AND TS=(*micro?enterprise* OR enterprise* OR startup*)

Where "TS" stands for topic. Following the set of Boolean strings and field tags, it is expected that the screened documents include at least one of the terms "recycle," "reuse," "waste," "restore," or "alternative landfill" in combination with another term such as "microenterprise," "enterprise," or "startup" in their topic. Topics include title, abstract, and keywords. In order to solely collect the relevant articles, the topics were further limited to sustainable science, management, design and manufacturing, bioengineering, knowledge engineering and representation, energy and fuels, mineral and metal processing, paper and wood material science, soil science, contamination and phytoremediation, polymer science, economic, climate change, environmental sciences, membrane science, forestry, ceramics, nuclear engineering, catalysts, combustion, metallurgical engineering, and asphalt. The search period is narrowed down to the previous 10 years, ranging from January 2012 to December 2021. It is believed that targeting the recent decade can better highlight the state-of-the-art alternatives to landfilling around the globe. After evaluating all 496 journal articles, 451 journals were eliminated due to duplication, irrelevance, and the inclusion of non-English files. Consequently, only 45 articles, as depicted in Figure 1, were chosen for further examination.

2.3. Google search engine

Google search is identified as one of the methods to collect grey literature around a topic. Thus, Google's search engine is adopted in the current study to highlight the associated documents. For consistency purposes, the timeline is set to 2012–2021. Filetype is defined as PDF, and only the first 10 pages were picked. Similar to academic search, a set of Boolean strings were used as below:

(Waste recycling* reuse* waste restore* micro enterprise* startup* business* entrepreneur*)

Among all 100 collected PDF documents, only 30 were picked, while the rest were screened due to their irrelevancy to the scope of the current review.

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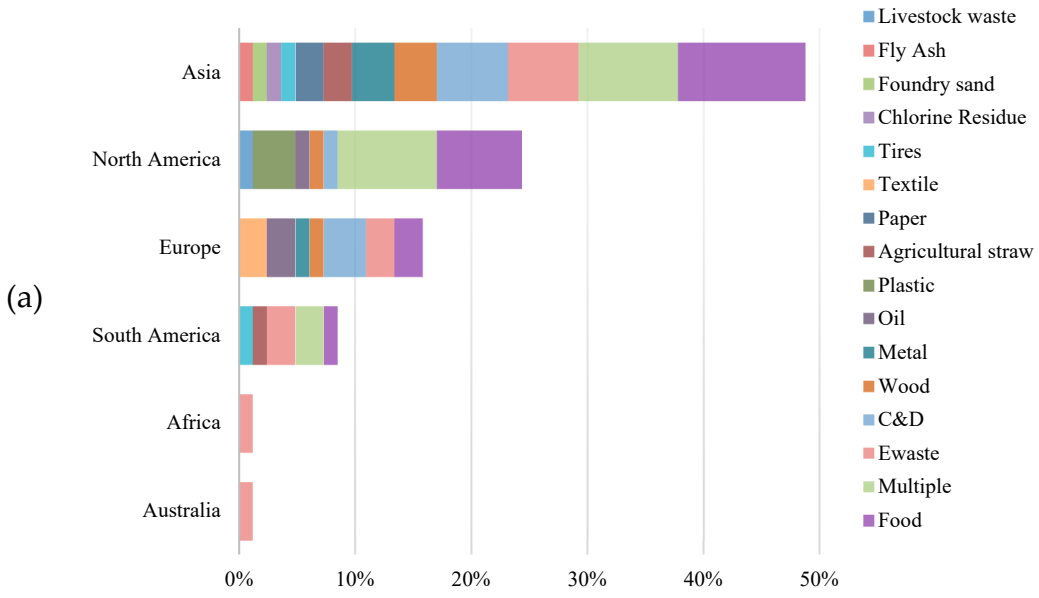
2.4. Combination and classification of documents

The current review utilized a combination of academic databases (45 studies from WOS) and grey literature (30 documents from Google search engine) to assess landfill alternatives and potential policy integrations. In order to emphasize the contribution of this review in addressing the existing knowledge gap, the collected materials were categorized based on the study region (e.g., North America, South America, Asia, Africa), targeted waste (e.g., wood, plastic, food), generation source (e.g., residential, non-residential, industrial), and treatment method (e.g., recycling, composting, incineration), as illustrated in Figure 1.

3. Results

3.1. Regions

As shown in Figure 2a, a significant portion of the collected documents, accounting for 48.7%, originated from Asia. This can be attributed to the presence of densely populated areas and rapid urbanization within the region. Asia currently holds 59.5% of the global population, with a high population density of approximately 150 people per km² [34]. Consequently, improved solid waste management practices, particularly in major metropolitan areas, have the potential to enhance resource recovery and create employment opportunities [35,36]. Furthermore, the lower costs associated with recycled products have fostered a market for recycled materials in certain Asian countries. This economic incentive has prompted these countries to implement and manage recycling programs. Notably, in 2017, Asia accounted for recycling approximately 98% of global plastic waste [37]. Even after China's ban on plastic waste imports in 2017, other Southeast Asian countries became the new recipients of such waste [38].



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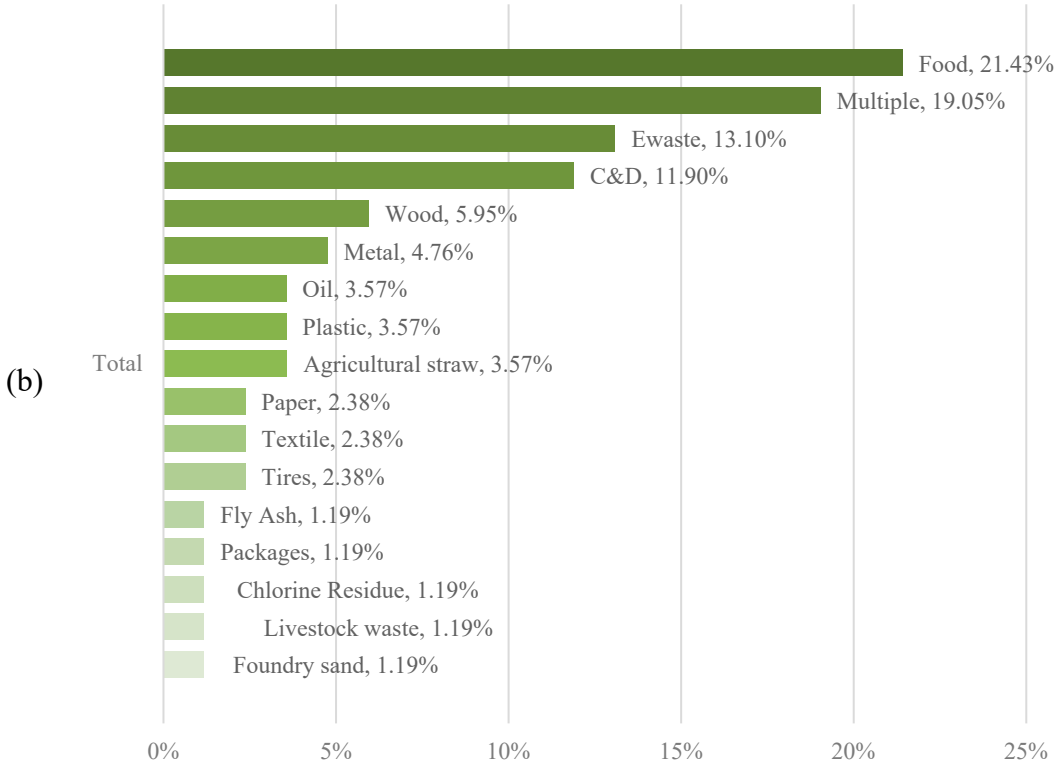

Figure 2. Regions and their major treatment methods for generated waste in different classes.

North America constitutes the second-largest region, accounting for approximately 24.3% of the gathered documents. This notable contribution can be attributed to the adoption of novel waste treatment and management techniques in the United States and Canada. Furthermore, there is a growing recognition of the benefits associated with efficient waste management and treatment plans within communities and industries. An example of this recognition is evident in the initiatives undertaken by the United States Environmental Protection Agency (USEPA), which emphasizes the impact of recycling on national prosperity and environmental protection [39]. The USEPA reported a significant increase in recycling rates from 7% in the 1960s to around 30% in recent years, resulting in the creation of over 680,000 jobs in the US [39]. Additionally, mandatory environmental regulations compel companies in North America to mitigate their adverse environmental impacts. For instance, enterprises in the region are required to annually report their carbon footprint in tonnes of carbon dioxide equivalent (CO2e) across three emission scopes: direct emissions (e.g., company-owned boilers), indirect emissions (e.g., energy procured by the company), and other remaining emissions (e.g., waste, business, and travel) [40]. Consequently, cost-effective methods, such as implementing waste management policies that promote the use of reusable plates and mugs for employees and replacing paper towels in washrooms with high-efficiency hand dryers, are being introduced to help businesses reduce their carbon footprints [41]. These seemingly minor alterations can contribute to the overall enhancement of waste management practices in North America.

Europe ranked third with 15.8% of the collected documents, as is shown in Figure 2a. Europe actively implements waste-related laws, known as EU waste management laws, to protect its environment and population [42]. Within the EU waste management law, a waste hierarchy is identified with terms including prevention, preparation for reuse, recycling, recovery, and disposal. Amendments to EU waste management law focus on the possibilities for implementing "extended producer responsibility (EPR)" in EU member states. EPR shows how different enterprises can reduce total waste generation, produce more durable products, increase resource efficiency, and provide services for product repair without compromising the quality and safety of the products [42].

South America, Africa, and Australia collectively contribute approximately 10.9% of the total collected documents, with South America accounting for around 8.5%, and Africa and Australia each

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contributing 1.2%. This relatively modest representation could be attributed to the absence of efficient solid waste management mechanisms in these regions. For instance, a report focusing on paper and plastic recycling initiatives in Brazil (South America) revealed that despite the existence of various recycling programs, the selection of targeted waste collection programs among the country's over 5,500 municipalities is not adequately implemented [43]. Furthermore, Brazil faces challenges stemming from a lack of education regarding the adverse environmental impacts of waste [43]. Similarly, Matzembacher et al. [44] emphasized the necessity of establishing sustainable mechanisms to foster the development of new enterprises in Brazil. To achieve this, they suggested several measures including aligning educational goals related to sustainability with the concerns of neighboring communities, improving the distribution and implementation of sustainable practices, and fostering greater collaboration between universities and industrial sectors.

3.2. Targeted waste

Food waste is a significant concern in Asia, North America, Europe, and South America, as indicated by the purple bar in Figure 2a. However, approaches to addressing food-related issues vary across regions. In Asia, North America, and Europe, urban food waste (UFW) is relatively high due to distribution, handling, and consumption mismanagement [45]. In contrast, regions like Africa prioritize combating hunger and malnutrition caused by food shortages, frequently measuring the global hunger index (GHI) [46]. Figure 2b highlights that more than one fifth (21.4%) of the collected documents specifically focus on food waste. These documents cover various stages of the food waste lifecycle, including production, consumption, waste generation, treatment, and disposal. For instance, No Food Waste [47], an Indian company, collects excess untouched food from small communities and redistributes it to those in need, aligning with the United Nations Sustainable Development Goals (SDGs) 1 and 2, which target hunger elimination and reduced food waste. Similarly, a study in Brazil emphasizes the importance of addressing food production and distribution, suggesting that raising awareness among smaller enterprises about available food resources and developing sustainable distribution models can mitigate food loss [44]. Regarding food waste treatment, the Natural Resources Defense Council [48] identifies and maps composting and anaerobic digestion facilities in a small American city to assess their capacity for food waste acceptance. Another example is the Green Era Campus in Illinois, USA, which collects biodegradable food waste from neighboring communities at a remediated brownfield site, now operating as an anaerobic digester facility [49].

Asia, North America, and South America exclusively focus on "Multiple" waste class (Figure 2a), constituting approximately 19.0% of the collected documents (Figure 2b). This waste class encompasses various waste types, indicating either the diverse nature of waste during processing or the adoption of inclusive waste treatment plans by certain enterprises. For instance, the USEPA developed comprehensive guidelines to facilitate recycling programs at airports [50]. These guidelines cover waste categories (e.g., cardboard, paper, glass, aluminum, plastic bottles, pallets, food waste), their sources (e.g., public terminals, ticketing, security gates, food service areas, offices, cargo shipping, maintenance areas, airfield ramps), and recycling methods [50]. The plan also encourages airports to promote the use of recycled content materials among customers [50]. Similarly, the city of Sioux Falls presented a solid waste management master plan in 2016, addressing different waste treatment approaches for various waste classes before disposal [51]. The plan suggests measures such as incentivizing plastic and paper recycling by private companies based on waste volume, establishing a food rescue committee to explore food waste recovery opportunities, supporting food donation programs, implementing energy recovery programs for hard-to-recycle plastics through incineration, imposing taxes on plastic bags or restricting their use by businesses, and promoting the purchase of refurbished and reusable items [51].

"Electronic" waste (E-waste) is only addressed in Asian, European, and South American regions (Figure 2a) and comprises 13.1% of the total documents (Figure 2b). The absence of e-waste as a target waste in some regions, such as North America, may be due to transboundary e-waste movements to other regions (e.g., to developing countries in Asia) [52]. Similarly, lack of proper regulations, absence of environmental awareness, and great transboundary movement of e-waste are identified as some

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of the issues in China that might put informal workers in danger of improper e-waste treatment (e.g., releases of toxins and heavy metals from e-waste burning) [53]. Furthermore, according to a Chinese study, there were approximately 22.7 million metric tonnes of e-waste in China in 2020, which is expected to increase to approximately 40 million metric tonnes by 2040 [54]. Consequently, substantial financial resources should be spent on establishing new e-waste treatment facilities (with a maximum travel distance of around 240 km from the waste generation point). It is expected that the profit rooted in e-waste treatment might not be significant (e.g., around US$2.5 per unit of TV) [54].

"Construction and demolition (C&D)" waste is addressed in Asia, North America, and Europe (as shown in Figure 2a). This could be due to the location of major C&D waste generators around the world. According to a study in 2012, China (Asian), India (Asian), the United States (North American), France (European), Germany (European), and the United Kingdom (European) are the top ranked C&D waste generators, with 1002, 530, 519, 246, 201, and 100 million tonnes of C&D waste generation, respectively [55]. It is also noteworthy to mention that EU waste management legislation introduces new recycling targets for construction and demolition (C&D) waste to be around 70% by 2020 [42]. Thus, they might seek new methods to efficiently recover a substantial part of C&D waste to meet the requirements. C&D waste comprised 11.9% of the collected documents, highlighting its recycling methods and applications for different purposes. For example, an American company applied a specific type of fungi, cultivated in a lab environment, to shredded waste material at the generation point [56]. The generated biomaterial was then used as a new commercial and industrial product [56]. They particularly target roofing, asphalt, and chemical manufacturers, as they might not be able to either attain higher recycling rates or implement zero waste policies [56]. Another study in China showed that governmental policies are playing a vital role in supporting downstream enterprises that supply recycled materials stemming from C&D waste [57]. The government is also thought to be responsible for changing the general approach to using recycled C&D waste in building materials from the perspective of contractors and building owners [57]. Similarly, Rodríguez et al. [58] found that managing C&D waste is complex in Spain, where manufacturers have access to low-cost natural aggregate. In addition, the presence of privately owned enterprises associated with recycled C&D waste is threatened by fluctuations in the construction industry [58].

"Wood" waste is targeted by Asia, North America, and Europe (Figure 2a) and accounts for about 5.9% of the collected documents (Figure 2b). This could be due to the presence of wood products manufacturing companies in these regions, where sustainable solutions for wood waste should be sought. For example, North America is well known for using wooden construction frames for around two centuries [59]. Reports indicate that wooden frames are flexible, durable, fire-resistant, and environmentally friendly [59]. Thus, material recovery issues arise from wooden C&D waste, while the recovered wooden products can be used in composite materials, mulch, and animal bedding [59]. Similarly, from 1993 to 2007, Chinese wood manufacturers' exports expanded to more than 13 times of its initial size [60]. The exported products include wooden (i) office furniture, (ii) kitchen furniture, and (iii) bedroom furniture, and China captured the largest share of global wooden furniture exports of around 90% in 2006 [60]. In addition, another Chinese study of wooden furniture introduced recycling methods as energy utilization (e.g., wooden chips for incineration), renovation (e.g., slight change of former furniture, such as scraping away the outer layer and generating a retro feel), deconstruction and reorganization (e.g., using wooden pallets in combination with metal stands for desks), crushing and regeneration (e.g., using crushed wooden materials for artificial paper boards), and artistic sublimation (e.g., using discarded wooden materials with cement and plaster for sculptures) [61]. However, according to a report on wooden furniture manufacturers focusing on medium density fiberboard (MDF) in Turkey, approximately 96.9% of wooden waste is burned in combustion chambers for heating purposes [62].

"Metal" waste is reported in Asia, North America, and Europe (shown in Figure 2a) and contributes to 4.7% of collected documents (shown in Figure 2b). For example, a study is Taiwan showed that using Activity Based Standard Costing (ABSC) method can increase the recycling efficiency in steel-scrap associated industries [63]. Another Chinese study showed that huge size of iron scrap plates might not be directly used as charge materials since there is high chance of oxidation

due to the greater surface area and presence of fine particles [64]. Thus, a method is developed where iron scrap is compressed by hydraulic machines and provided iron cakes. It is believed that iron cakes can be adopted in foundry plants as it has lower costs, negligible environmental effects, and lower energy consumption [64].

"Oil" waste is reported in North America and Europe (shown in Figure 2a) and only covers 3.5% of the collected documents. The small percentage might be due to the presence of barriers and issues in the oil recycling industry. For example, an Indian review of cooking oil conversion to biodiesel production reported inaccessibility to used oil, absence of processing and recycling technology, irreconcilable supply chains, and a lack of planning and policy integration as barriers to efficient production of biodiesel from used cooking oil [65]. However, a Greek study showed how lipid-rich wastes can be incorporated with microorganisms through an anaerobic digestion process and result in producing biogas [66]. Biogas production can help with i) the reduction of GHG emissions, ii) the conservation of biomass, iii) the production of organic fertilizers, and iv) the reduction of overall treatment costs for waste materials handling [67].

"Plastic" waste is only shown for the North America region (for 3.5% of entire documents), as shown in Figures 2a,b, respectively (absent in other regions such as Europe). This might be related to the short market demand for recycled plastic waste. For example, a European study of the Nordic countries found that, despite the presence of European waste policies, they were not very successful in producing value-added materials from end-of-life plastic products [68]. This issue could stem from either smaller demand and market size for recycled plastic or significant plastic products' imports [69]. With regard to the collected documents, multiple methods for plastic waste treatment are found. For example, AmberCycle Industries in the USA, founded in 2012, used a particular enzyme for digesting the polyethylene terephthalate (PET) originated in plastic waste and converting it to terephthalic acid [70]. Terephthalic acid can be used for producing high-quality plastic products, including fibres and bottles [71]. Similarly, Apple's supplier's report in 2018 showed that display and enclosure protection films, made from PET, can be used as product trays later in the manufacturing line [72]. Plastic waste recycling at Apple is expected to eliminate over 200 tonnes of solid waste annually [72].

"Agricultural straw" waste is only addressed in Asia and South America (Figure 2a). This might be on behalf of the types of industries and their association with agricultural residues in Asian and South American countries. Agricultural straw can have multiple uses, including but not limited to producing ethanol [73], agricultural fertilizers [74], animal feeds [75], and paper [76]. Agricultural straws can also be used as a substitute for oil and natural gas as a source of energy [77]. China is identified as one of the greatest generators of agricultural straw [78]. However, inefficient straw (i) collection, (ii) transportation, (iii) storage, and (iv) marketing are known as some of the barriers to its recycling [79,80]. An environmental summary from a South American company that produces sugar and ethanol revealed that over 99% of the straw from its sugarcane fields is used for multiple purposes, including fuel (bagasse) and byproducts (food trays) [81].

Around 13.0% of collected studies are about paper, textiles, tires, fly ash, packages, chlorine residue, livestock waste, and foundry sand cumulatively, as shown in Figure 2a,b. Less interest in recycling these classes of waste might be due to the abundance of raw materials, the complexity of recycling methods, and lower demand for recycled products. For example, paper recycling is only possible if the paper treatment facilities collect the dry and clean papers, while a large amount of paper waste i) originates from oily food packages, ii) contains water-resistant, chemically changed paper containers, iii) contains printing materials and stickers, and iv) classifies as plastic waste due to the presence of plastic coatings (e.g., waxes and silicon oils)[82]. Similarly, a review of textile waste reported that i) absence of motivation and broadcasting; ii) absence of practical regulations and incentivization; iii) lack of public recognition; iv) absence of collection facilities; and v) diversified product materials and chemicals are some of the challenges that dampen the overall recycling rate of textile waste [83].

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3.3. Treatment method and waste origination

Documents are classified based on treatment methods like recycling, composting, raising awareness, reusing, incinerating, redistributing, reducing, biogas extraction, and fermenting. Some documents may fall into multiple categories, but specific details are considered to assign them to a particular class. For instance, composting can be seen as a recycling method, but having it as a separate class helps define a specific group of studies more effectively.

Recycling involves collecting, processing, and producing new materials to reduce waste and extend disposal site lifespan [50]. It is the most effective waste treatment method before landfilling, representing 52.3% of collected documents (Figure 3). It applies to industrial, residential, non-residential, and agricultural waste sources (Figure 3).

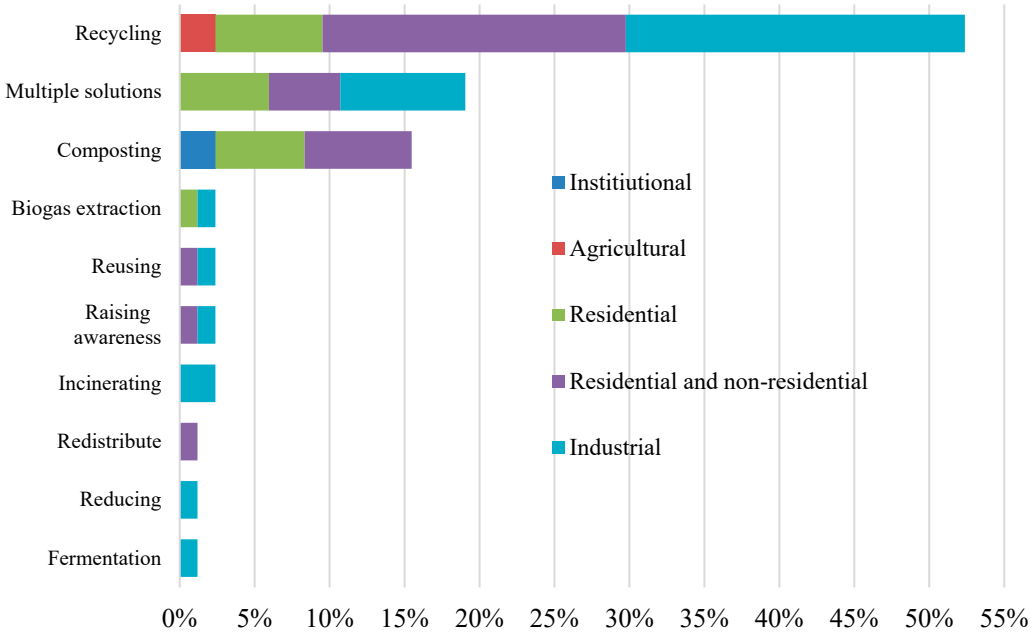

Figure 3. Waste treatment methods and generation sources.

Industrial recycling represents 22.6% of treatment methods, emphasizing the significance of innovative waste reduction approaches. For instance, a Chinese study demonstrated that fly ash residues from power plants can be used to create ash bricks with a fly ash content of over 50% and confirmed that the resulting bricks meet national building material standards [84].

Residential and non-residential recycling contributes 20.2% to treatment methods, highlighting the role of businesses collecting materials from both sources. For example, a Colombian study integrated tires from different origins with polyurethane resin, creating flexible rubber tiles with satisfactory density and tension levels. These tiles have versatile applications, including rubber wall and ceiling coverings [85]. On the contrary, residential recycling focuses only on residential sources, accounts for 7.1% of all collected documents. For example, a paper art workshop is designed to train participants about the possibilities of changing used papers into different products such as greeting cards, picture frames, calendars, and decorative pieces [86]. In addition, a Chinese study in 2021 reported that using maggots in combination with organic materials originated in household waste can generate organic fertilizers [87].

Agricultural recycling explains 2.3% of the collected documents. The conversion of agricultural straw to ethanol [73], agricultural fertilizers [74], animal feeds [75], and paper [76] are some of the examples. Furthermore, an Indian company only used agricultural straw such as banana fibre and bamboo to create baskets, trays, placemats, coasters, lamp shades, car seat covers, and colour pencils [88].

Multiple solutions, which make up 19.0% of all documents (as shown in Figure 3), encompass different methods that can be classified into various categories. They were found in documents addressing industrial waste (8.3%), mixed waste (4.7%), and residential waste (5.9%). For instance, in the 2020 annual report by a Japanese construction-focused company, they highlighted CO_2 reduction, waste reduction, and responsible use of natural resources as some of their management strategies for completed projects, ongoing initiatives, and future plans [89]. Another example is Enerkem, a Canadian company that specializes in producing biofuels and renewable chemicals from non-compostable and non-recyclable materials like textiles from both residential and non-residential sources [90].

Composting, the process of converting organic waste into nutrient-rich soil with the help of oxygen [91], is widely adopted by both residential and non-residential waste generators due to its simplicity, the abundance of organic waste in daily life, and the usefulness of the final products for gardening and soil improvement [91]. Composting represents 15.4% of the documented methods and is used for mixed waste (7.1%), residential waste (5.9%), and institutional waste (2.3%). For instance, Eco Energy, an Indian company, offers composting kits for residential waste and biodegradable materials like cotton and paper bags, paper straws, and wooden cutlery [92]. Additionally, Western University in Canada published a student guide in 2020 promoting environmental practices and sustainability, including institutional composting to achieve a zero-waste goal by 2022 [93].

The remaining methods, including biogas extraction, reusing, raising awareness, incinerating, redistributing, reducing, and fermentation, account for less than 2.3% of collected documents individually (13.1% cumulatively). The reason for their unpopularity might be rooted in unfavorable economic outcomes, complex processing methods, a lack of multiple stakeholders' involvement, and public conflict. For example, there should be proper reactors to capture and separate different types of biogases derived from anaerobic digestions, including CH_4 and CO_2 [94], and therefore, this might not be a feasible option for some classes, such as residential waste sources. Likewise, according to a report, it was found that communities living near incinerators do not hold a favorable opinion regarding incineration as a substitute for landfilling [95].

Redistribution of food surplus might also seem an alternative way to reduce the food waste. However, associated complexities might tighten redistribution's development. For example, a study about food donations by retailers in Britain showed that food distribution is comprised of a set of activities that include food storage accommodating, early distributing of perishable food, maximizing the total number of food recipients, and minimizing the leftover food waste [96]. Therefore, a logistical arrangement with the presence of charities and retailers might be necessary [96].

Reducing waste is also known as one of the options among the collected documents. However, it is associated with increased awareness about the methods for waste reduction before its generation [97].

4. Conclusion

This study delves into waste management practices across diverse regions and waste categories, unveiling crucial percentages, values, and trends that offer insights into the global landscape of waste management. Asia stands out as a significant contributor to waste generation, accounting for 48.7% of collected documents. This trend mirrors the region's high population density and rapid urbanization. With Asia hosting 59.5% of the world's population and around 150 people per km^2, the need for improved waste management practices is clear. Notably, Asia has been successful in recycling, reclaiming 98% of global plastic waste in 2017, even after China's plastic waste import ban. North America follows with 24.3% of documents, showcasing a strong focus on innovative waste treatment. Recycling rates have surged from 7% in the 1960s to approximately 30% today, yielding over 680,000 jobs. Mandatory environmental regulations necessitate carbon footprint reporting and encourage sustainable practices, driving changes such as the use of reusable plates and energy-efficient hand dryers. Europe accounts for 15.8% of documents, emphasizing the implementation of EU waste management laws and waste hierarchy principles. Measures like extended producer responsibility (EPR) are being explored to enhance resource efficiency and product durability. By

setting a recycling target of 70% for construction and demolition waste by 2020, Europe is poised to drive sustainable practices in this sector. Among all collected documents, South America, Africa, and Australia contribute 10.9% collectively, with South America holding 8.5%, and Africa and Australia each contributing 1.2%. These regions face challenges due to inadequate waste management mechanisms. Brazil, for instance, struggles with inefficient waste collection and a lack of education on environmental impacts. Collaborative efforts are essential to foster sustainable practices and develop new enterprises. Examining specific waste categories, food waste garners significant attention, encompassing 21.4% of documents. Strategies vary, with Asia, North America, and Europe addressing urban food waste mismanagement, while Africa focuses on reducing hunger and malnutrition. Innovative initiatives, such as surplus food redistribution and conversion to biogas, underline the potential for waste reduction and social impact.

The treatment methods employed exhibit intriguing trends. Recycling, constituting 52.3%, spans industrial (22.6%), residential and non-residential (20.2%), and agricultural (2.3%) sectors. Composting, accounting for 15.4%, is favored for organic waste diversion, with applications in mixed (7.1%), residential (5.9%), and institutional (2.3%) waste sources. While multiple methods encompass 19.0%, diverse approaches address specific waste categories. Biogas extraction, reusing, raising awareness, incinerating, redistributing, reducing, and fermentation collectively contribute less than 2.3%, each highlighting unique challenges and opportunities.

This study unveils a mosaic of waste management trends worldwide. The figures and percentages underscore the varying emphasis on different waste categories and treatment methods, driven by regional factors and environmental awareness. Collaborative efforts, innovative strategies, and targeted interventions are essential to harness the potential of waste management, promoting sustainable practices and global well-being.

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Abbreviations

ABSC	Activity Based Standard Costing
C&D	Construction and Demolition
EPR	Extended Producer Responsibility
GHG	Greenhouse Gas
GHI	Global Hunger Index
MDF	Medium Density Fiberboard
NDVI	Normalized Difference Vegetation Index
NIMBY	Not In My Backyard
PET	Polyethylene Terephthalic
PRISMA	Preferred Reporting Items for Systematic Review and Meta-Analysis
SDGs	Sustainable Development Goals
UFW	Urban Food Waste
UN	United Nations
USEPA	United States Environmental Protection Agency
WOS	Web of Science

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