

ANALYSIS OF ENVIRONMENTAL LITERACY OF THE COMMUNITY IN WASTE PROCESSING

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Abstract

Waste management is an increasingly complex global issue due to urbanization, population growth, and changing consumption patterns. This study aims to map the research landscape of environmental literacy in waste management during the period 2016–2025 through bibliometric analysis using the Scopus database, with the assistance of VOSviewer, Excel, and Tableau software. The screening results yielded 33 relevant publications. Trend analysis shows a significant increase in the number of publications since 2018, with the highest spike in 2024. The distribution of publications is dominated by Asian countries, particularly Indonesia and India, which face serious challenges in urban waste management. These findings confirm that environmental literacy in waste management is a multidimensional issue that connects technical, social, health, educational, and global sustainability aspects. This study makes an important contribution by mapping the direction and conceptual structure of research, while also providing a basis for developing educational strategies, public policies, and community-based interventions to support sustainable waste management.

Keywords: environmental literacy; waste management

1. INTRODUCTION

Waste management is a pressing issue facing nearly every country, driven by increasing urbanization, population growth, and changing consumption patterns. The World Bank estimates that more than 2 billion tons of municipal solid waste (MSW) are produced annually, with projections suggesting this figure could rise to 2.2 billion tons by 2025 (Zavolokina, L., & Diesperova, N., 2024). This is in line with Bagustiandi (2024) who stated that annual population growth of 1.09% leads to increased waste generation, with projections estimating daily waste to reach 1.24 tons by 2033. Furthermore, a study in Malaysia found a correlation between population growth and waste generation, indicating that each additional person contributes significantly to waste volume (Nopiah et al., 2023).

According to the World Bank report (2020), every year the world produces more than 2 billion tons of solid waste, and this figure is expected to continue to rise to reach 3.4 billion tons or an increase of around 70% by 2050. Developed countries produce around 572 million tons of waste every year, accounting for almost half of the global total. (Kirti, 2024).

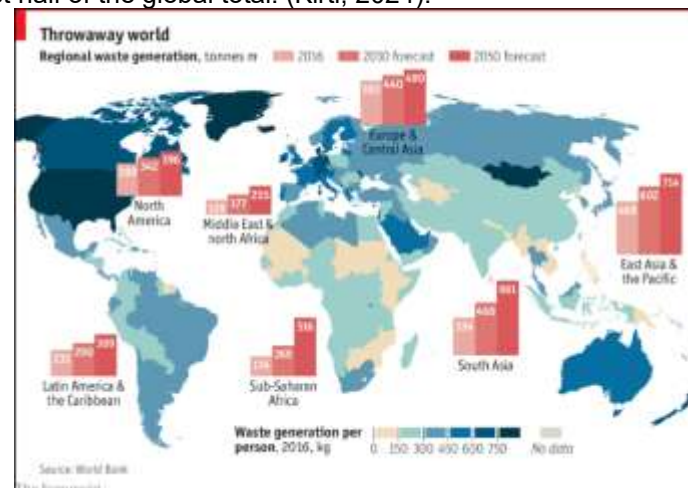


Figure 1. Waste Generation and Estimates Worldwide

Poor waste management causes environmental problems such as health risks, unpleasant odors, and air pollution. This complicates recycling efforts by mixing organic and inorganic waste, exacerbating the waste problem in the community and requiring innovative solutions such as smart trash bins (Abidin, A. R., et.al, 2022; Murugadhas, J. (2023). Then, Axmalia, A., & Mulasari, (2020) stated that the accumulation of waste in residential areas increases the risk of infectious diseases such as dengue fever and leptospirosis.

Furthermore, according to the World Bank (2018), of the total global waste generation of 2.01 billion tons per year, only around 19% is recycled and 11% is processed through incineration, while more than 70% of the remainder is still buried in landfills or left unmanaged. A 2023 Ministry of Health survey showed that only 37.8% of households in Indonesia managed their waste properly, while 62.2% were categorized as poor. The majority of households in Indonesia managed waste by burning, with a proportion of 57.2% in 2018. 2023. Waste management by being transported by officers was 27.6%, disposed of independently at TPS 8.7%, disposed of into rivers/drains/sea 2.8%, disposed of carelessly 2.3%, buried 0.7%, composted 0.3%, and deposited at waste banks 0.3%.

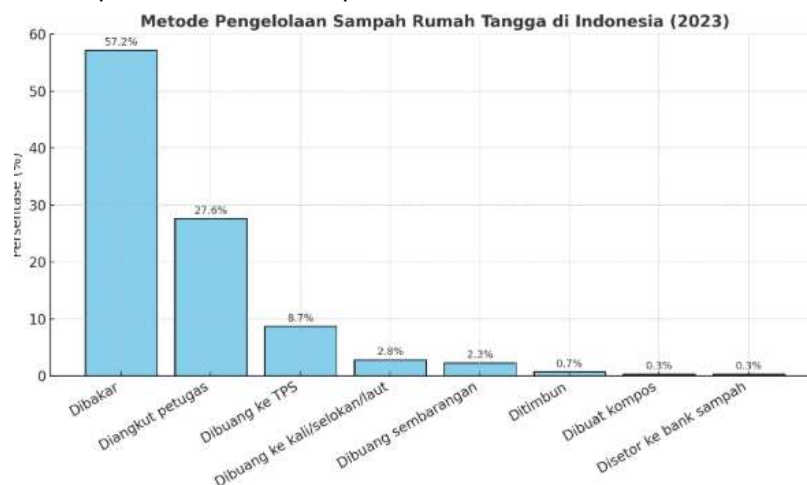


Diagram 1. Waste Management in Indonesia

The data in the graph shows that the majority of people still choose a practical but environmentally unfriendly method of managing waste, namely burning (57.2%). This reflects the low level of implementation of the 3R principles (reduce, reuse, recycle) and the circular economy, especially in developing countries that still rely on conventional disposal methods. This situation demonstrates the crucial role of the community in fostering environmentally conscious behavior, as successful waste management depends not only on infrastructure, government policies, and technical aspects, but also on social and educational aspects, particularly community environmental literacy (Sudarmadji, 2019). This lack of literacy results in low environmental awareness and a lack of practical skills in waste management, such as sorting, recycling, and reducing the use of single-use plastics.

Environmental literacy is key to building public awareness, knowledge, and attitudes towards waste issues. Environmental literacy extends beyond conceptual understanding to encompass the ability to make decisions and engage in pro-environmental behavior in everyday life (Ardoin, Bowers, & Gaillard, 2020). Through environmental literacy, the public is expected to be more active in waste sorting, reducing plastic waste, and supporting recycling programs run by the government and local communities. Environmental literacy encompasses environmental values, environmental responsibility, perceptions of environmental problems, and environmental behavioral skills (Wang, J.H., Tou, L.L., 2021; Liu, L., & Tobias, 2024).

The study of environmental literacy in waste management is highly relevant. This research is not only academically important but also makes practical contributions to achieving the Sustainable Development Goals (SDGs), particularly SDG 12 on sustainable consumption and production. Although research in the field of waste management has grown rapidly, there has been no comprehensive study mapping the research landscape of community environmental literacy in waste management using a bibliometric approach. This is consistent with the results of a keyword search using the Scopus database, which yielded one publication on environmental literacy, while articles on waste management yielded 199,626 publications from 1910 to 2025. Filtering the results for the past decade revealed

103,255 publications on waste management. Furthermore, the Scopus database retrieved 39 publications from 1982 to 2025. After filtering based on temporal criteria (2016-2025), 33 journal publications relevant to this research were identified.

To achieve this objective, we formulated three specific research questions (RQs): RQ1 (Revised): What are the publication trends and conceptual maps of research related to community environmental literacy in waste management over the past decade (2016-2025) based on bibliometric analysis? RQ2 (Alternative): What is the conceptual network structure and evolution of research themes on community environmental literacy in waste management identified through keyword co-occurrence analysis?

By addressing this RQ, our research seeks to offer an explicit and comprehensive overview of the current status and evolution of community environmental literacy research in waste management. Furthermore, through the integration of bibliometric analysis, the results are explained using VOSviewer, followed by a discussion and deduction session drawn from the literature based on the bibliometric analysis that has been conducted.

2.1 METHOD

This study employed bibliometric analysis following the framework developed by (Garza-Reyes, 2015), utilizing a systematic methodology and well-defined procedures for reproducibility. Bibliometric methodology helps visualize concepts with comparable interpretations. Data analysis was performed using VOSviewer 1.6.18 software, and the data were analyzed in several stages. Figure 1 illustrates these stages.

The first stage involved downloading keywords from the Scopus database using the terms "environmental literacy" and "waste management." These terms were found in journal article titles, abstracts, and keywords, resulting in one publication on environmental literacy, while articles on waste management identified 199,626 publications from 1910 to 2025. Then, filtering for the last decade revealed 103,255 publications on waste management. Furthermore, 39 publications were obtained from the Scopus database from 1982 to 2025. After filtering based on temporal criteria (2016-2025), 33 journal publications relevant to this research were obtained.

The second stage described data related to publication year, field of study, leading journal, publications by country, and publications by affiliation. The third stage used OpenRefine to clean the data related to keywords and citation counts. The fourth stage analyzed the data using VOSviewer to examine the relationship between publications by country and affiliation, as well as citations by source, document, and author. VOSviewer was also used to explore co-occurrence based on author keywords. The fifth stage presented the data using Excel, Tableau, and VOSviewer software.



Figure 2. Bibliometric Analysis Stage

RESULTS AND DISCUSSION

3.2 Publication Trends in Environmental Literacy and Waste Management Based on Bibliometric Analysis

Bibliometric analysis of the Scopus database identified one publication on environmental literacy in 2020, while articles on waste management identified 199,626 publications from 1910 to 2025. Further filtering for the last decade revealed 103,255 publications on waste management. Meanwhile, for community environmental literacy in waste management, 39 publications were obtained from the Scopus database from 1982 to 2025. After filtering based on temporal criteria (2016-2025), 33 journal publications relevant to this research were identified. This number is relatively small compared to larger domains such as sustainability studies, but reflects the growing focus on environmental literacy in the context of waste management. Of the 39 documents, the majority are journal articles published in the fields of social sciences and environmental studies. The concentration of publications in the 2018–2023

period indicates that this issue has received significant attention in the last decade, in line with the increasing urgency of achieving the SDGs, particularly SDG 12 concerning sustainable consumption and production.

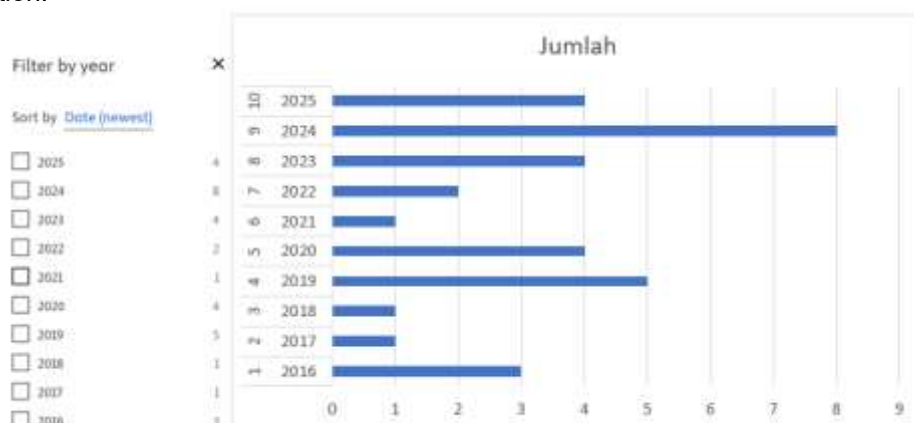


Diagram 2. Publication Trends on Community Environmental Literacy in Waste Management Globally, 2016-2025

Based on bibliometric results of publications in Scopus for the 2016–2025 period, the topic of community literacy in waste management shows a fluctuating but increasing trend. At the beginning of the period (2016–2017), the number of publications was still very limited, with only one to three articles per year. This situation indicates that environmental literacy issues, particularly related to waste management, were not yet a primary focus of academic research. However, from 2018 to 2020, there was a more significant growth in the number of publications, peaking at five articles in 2019. This increase aligns with the strengthening global discourse on the circular economy and the Sustainable Development Goals (SDGs), where community literacy is seen as a crucial element in supporting effective waste management systems (Mukherjee & Jha, 2022).

However, from 2021 to 2022, the number of publications decreased, with only one to two articles. This phenomenon was likely influenced by the COVID-19 pandemic, which shifted global research focus toward public health issues. However, during this period, there was a significant increase in the problem of medical waste, as noted by Patrício Silva et al. (2021). Entering 2023, the number of publications increased again, with a significant spike in 2024, reaching eight documents—the highest number during the analysis period. This positive trend continued into 2025, with four publications recorded by mid-year, and this number is expected to increase.

Overall, this publication pattern demonstrates that public literacy has become a crucial component of public policy strategies, social innovation, and the achievement of the SDGs. These findings align with those of Ardoin et al. (2020), who emphasize the importance of environmental literacy for collective behavioral change, and Liu et al. (2023), who point to increased global collaboration in environmental research.

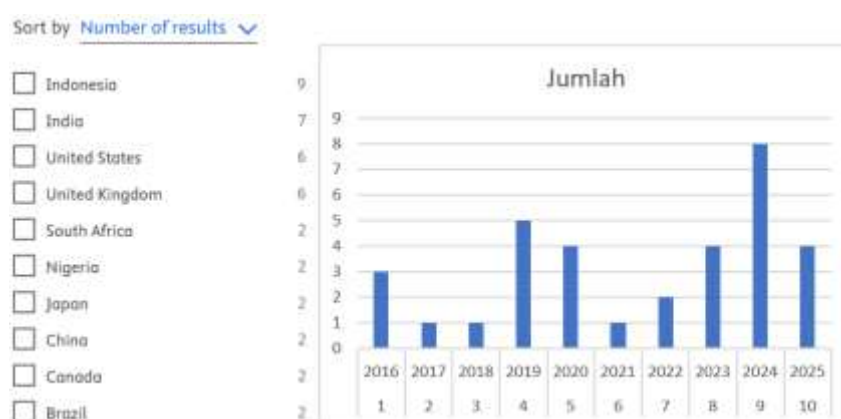


Diagram 3. Publication Trends on Community Environmental Literacy in Waste Management by Country, 2016-2025

The distribution of Scopus publications on community literacy in waste management for the 2016-2025 period shows an interesting pattern, with contributions from Asian countries, particularly Indonesia and India, dominating. Indonesia ranked first with nine publications. This number reflects the urgency of the increasingly complex waste management issue in Indonesia, particularly in urban areas. Research shows that low community literacy is a key factor in the success or failure of waste management systems (Pradana, Sutanto, & Rahayu, 2021). The Indonesian government, through its Jakstranas (National Waste Management Policy and Strategy) policy, also seeks to integrate environmental education into both formal and non-formal programs, thus encouraging academics to study this issue more deeply. Anuardo, R.G., et al. (2022) emphasized that community literacy is effective when supported by policies, infrastructure, and academic/industry involvement.

India ranked second with seven publications. Similar to Indonesia, India faces serious challenges in terms of urban waste volume and management. The Indian government's Swachh Bharat Abhiyan program places public literacy as a key aspect in creating behavioral change, as successful waste management depends on citizen participation (Gupta & Yadav, 2019). This explains why research in India has focused heavily on the relationship between environmental awareness, public education, and the success of national cleanliness programs.

Overall, the distribution of these publications demonstrates that public literacy in waste management is not merely a local issue but has emerged as a global agenda. The predominance of research from Asian countries demonstrates the urgent need to seek community-based solutions in regions with more complex waste management challenges. Meanwhile, contributions from developed countries enrich the conceptual landscape and provide a methodological foundation that can strengthen implementation in developing countries.

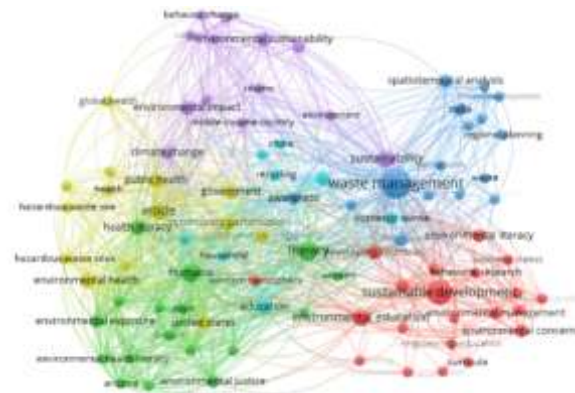


Figure 4. Visualization of the Scopus Database Keyword Network Using Vosviewer

Keyword map analysis shows that community environmental literacy occupies a central position in academic discourse related to waste management, with the network structure demonstrating a close relationship with waste management, sustainable development, and environmental education. This demonstrates that community literacy is not only understood as environmental knowledge but also encompasses awareness, attitudes, and practical skills in managing waste sustainably. In this context, environmental literacy serves as a foundation for behavioral change, which aligns with findings (Ardoin et al., 2020; Harmuningsih, D., & Saleky, S. R. J., 2017) that environmental education has a significant impact on shaping pro-environmental behavior.

The network structure demonstrates a connection with public health, and environmental health literacy demonstrates that community literacy in waste management has direct implications for public health. (Patrício Silva et al., 2021; Hariati, J., 2025; Winursita, W., & Johan, R. C., 2024) emphasize that poor literacy in waste management can increase health risks, ranging from infectious diseases to air and water pollution. At the same time, environmental literacy is also related to global issues such as climate change and environmental sustainability, as demonstrated by Liu et al. (2023), who linked waste management to climate change mitigation. This indicates that public literacy in waste management is not only important in the local context but also has a global impact on achieving the Sustainable Development Goals (SDGs).

These findings provide a comprehensive answer to RQ1 by demonstrating that the trend of environmental literacy publications in the context of waste management over the past decade has been

characterized by a consistent increase, with significant acceleration in line with the increasing urgency of sustainability and waste management issues in the modern era. The distribution of findings reflects the involvement of both established research centers and emerging contributors from various local and global contexts. The complex conceptual structure visualized in the keyword network confirms that environmental literacy has become a research domain that has reached critical mass, with continued relevance to socio-ecological transformation and the application of innovative technologies, including the Internet of Things (IoT), in supporting sustainable waste management.

Conceptual Network Structure and Evolution of Research Themes on Environmental Literacy and Waste Management Identified Through Keyword Co-Occurrence Analysis

Keyword co-occurrence analysis using VOSviewer reveals a complex and multidimensional conceptual network structure in environmental literacy research on waste management. This network architecture demonstrates that the concept of environmental literacy occupies a strategic position as a central node connecting various research domains, such as waste management, sustainability, environmental education, and community participation. The conceptual centrality of environmental literacy not only reflects its popularity in academic literature but also confirms its role as a foundational concept that serves as the basis for designing educational strategies, environmental policies, and community-based interventions to achieve more sustainable waste management. Thus, environmental literacy serves as an epistemological bridge that unites the ecological, social, and educational dimensions within the modern waste management research landscape.

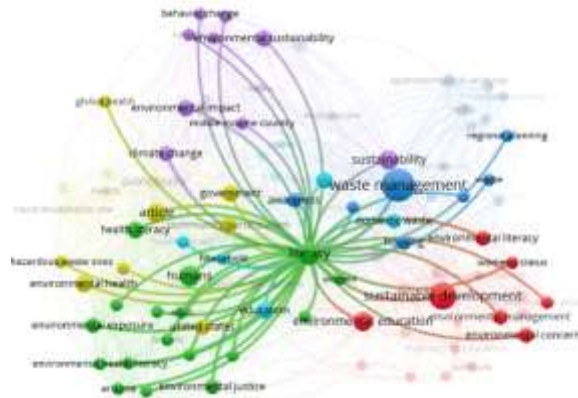


Figure 4. Visualization of the Scopus Database Keyword Network Using Vosviewer

Analysis of the co-occurrence map shows that research related to environmental literacy in waste management is structured into six main interconnected clusters. The green cluster emphasizes the role of literacy, human rights, environmental justice, and health, indicating that environmental literacy is deeply rooted in public awareness of health risks and collective responsibility. This aligns with Nutbeam's (2000) argument that health literacy is the foundation for encouraging environmentally friendly behavior. The blue cluster focuses on waste management, domestic waste, recycling, and awareness, indicating that the technical aspects of waste management can only be optimal if the public has high awareness and involvement. Wilson et al. (2012) emphasized that sustainable waste management depends on the public's understanding of their role in the system.

Furthermore, the red cluster highlights sustainable development, environmental education, and environmental literacy, with their curricular connections demonstrating the importance of integrating environmental literacy into both formal and non-formal education. Tilbury (2011) argues that environmental education is a transformative instrument that equips communities with the values, skills, and motivation to behave sustainably. The purple cluster addresses environmental sustainability, environmental impact, behavior change, and sustainability, emphasizing that environmental literacy in waste management is part of the global sustainability agenda. Rockström et al. (2009) emphasize that changing public behavior is key to maintaining planetary sustainability.

Conversely, the yellow cluster connects public health, government, climate change, and global health, demonstrating the crucial role of policy and its link to the global health agenda. This aligns with Zurbrugg et al. (2012), who stated that government intervention and public regulation play a crucial role in strengthening public environmental literacy. Meanwhile, the light blue cluster highlights aspects of regional planning, spatiotemporal analysis, and the context of developing countries, demonstrating that

waste management and environmental literacy require a spatial data-driven approach and sensitivity to local characteristics. Bai et al. (2018) emphasize that spatial-based strategies can encourage community participation while supporting more adaptive environmental management policies. Overall, this map illustrates that environmental literacy in waste management is not simply a technical issue, but a multidimensional one involving public health, education, sustainability, social participation, and spatial planning. These findings emphasize that strengthening environmental literacy in the community must be supported by a combination of educational and participatory strategies, public policy, and data-driven technology to more effectively address the global challenges of waste management.

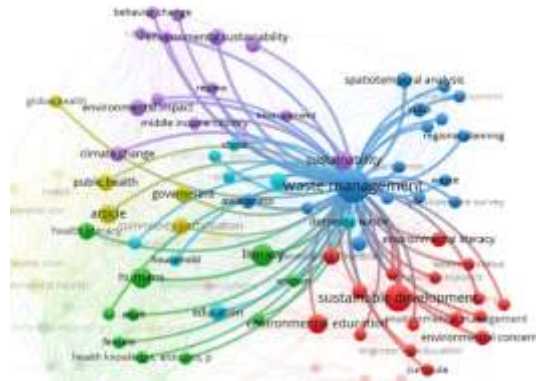


Figure 6. Visualization of the Scopus Database Keyword Network Using Vosviewer "overlay visualization" with the keyword "waste management" as the center.

The Vosviewer co-occurrence map above shows that research on environmental literacy in waste management is divided into six main, interconnected clusters. The blue cluster emphasizes waste management as the dominant keyword, with subthemes such as domestic waste, recycling, and awareness. This confirms that environmental literacy is closely related to household waste management practices and technical policies. Similarly, according to Wilson et al. (2012), effective waste management requires an integration of technical and social aspects, making public awareness and literacy key factors.

The red cluster focuses on sustainable development and environmental education, emphasizing environmental education, curriculum, and environmental management. This theme demonstrates that environmental literacy is not only cognitive but also normative and practical, related to sustainable development. Tilbury (2011) emphasized that environmental education plays a strategic role in shaping sustainable behavior and increasing community capacity to engage in responsible waste management.

The green cluster highlights literacy, human resources, and community engagement, emphasizing the social dimension of environmental literacy. Community involvement is a crucial element in raising collective awareness. According to Pretty (2003), community participation in environmental issues increases ownership and strengthens the sustainability of waste management programs. Thus, environmental literacy emphasizes not only knowledge but also collective action.

The purple cluster focuses on environmental sustainability and environmental impact, demonstrating that environmental literacy in waste management also relates to global issues such as climate change, sustainability, and ecological impact. This aligns with Rockström et al.'s (2009) argument on the importance of maintaining planetary boundaries through sustainable practices, of which waste management is a crucial instrument.

The yellow cluster emphasizes public health and government, linking waste management to public health and public policy. Poor waste management directly impacts health, so environmental literacy can strengthen public awareness in preventing health risks. Consistent with Zurbrugg et al.'s (2012) argument, government involvement and appropriate regulations can minimize the health impacts of ineffective waste management.

Finally, the light blue cluster shows links to regional planning, spatiotemporal analysis, and developing countries, emphasizing the role of regional planning and spatial data-driven research in supporting environmental literacy. According to Bai et al. (2018), sustainable urban planning, including data-driven

waste management, is crucial for improving public literacy and supporting sustainable development in developing countries.

Overall, this analysis demonstrates that environmental literacy in waste management is a multidimensional issue that connects technical, social, educational, health, and global sustainability aspects.

CONCLUSION

Waste management has become an increasingly pressing global issue due to population growth, urbanization, and changing consumption patterns. Research shows that the majority of the world's waste is still managed using conventional, less environmentally friendly methods, while in Indonesia, most households still burn waste. This situation reflects the low implementation of the 3R principles and environmental literacy among the public, even though public awareness, attitudes, and practical skills are crucial factors for the success of waste management systems.

A bibliometric analysis of publications from 2016–2025 shows that research on environmental literacy in waste management is relatively limited but shows an increasing trend, particularly in Asian countries such as Indonesia and India. Keyword visualization results reveal six main clusters, confirming that environmental literacy is multidimensional, linking technical, social, educational, health, and sustainability aspects. Thus, environmental literacy can be viewed as a strategic instrument in encouraging behavioral change, strengthening community participation, and supporting the achievement of sustainable development goals (SDG 12).

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