International Conference on Recent Trends in Science, Engineering & Technology 2.0
Khandesh Bahuuddeshiya Sanstha's College of Engineering & Technology, Jalgaon
ICRTSET-2.0
Date: 15th October 2025
ISBN: 978-93-48954-26-8

Integrating Environmental Sustainability into Solid Waste Management Practices in Developing Regions

Mahadeva M[1*], Varshani V R[2]

[1]Assistant Professor, [2]Undergraduate Students, Department of Civil Engineering,

RNS Institute of Technology, Channasandra, Bengaluru, India

**Corresponding Author: mahadevm10@gmail.com*

Abstract

Solid waste management (SWM) is one of the key responsibilities of city administrators and one of the effective proxies for good governance. Effective SWM mitigates adverse health and environmental impacts, conserves resources, and improves the livability of cities. However, unsustainable SWM practices, exacerbated by rapid urbanization and financial and institutional limitations, negatively impact public health and environmental sustainability. This review article assesses the human and environmental health impacts of SWM practices in the Global South cities that are the future of global urbanization. The study employs desktop research methodology based on in-depth analysis of secondary data and literature, including official documents and published articles. It finds that the commonplace SWM practices include mixing household and commercial garbage with hazardous waste during storage and handling. While waste storage is largely in old or poorly managed facilities such as storage containers, the transportation system is often deficient and informal. The disposal methods are predominantly via uncontrolled dumping, open-air incinerators, and landfills. The negative impacts of such practices include air and water pollution, land degradation, emissions of methane and hazardous leachate, and climate change. These impacts impose significant environmental and public health costs on residents with marginalized social groups mostly affected. The paper concludes with recommendations for mitigating the public and environmental health risks associated with the existing SWM practices in the Global South.

Keywords: *Climate Change, Environmental Pollution, Health Effects, Landfilling, Land Degradation, Solid Waste Management, Storage And Handling, Recycling, Risk Exposure.*

1. Introduction

Environmental sustainability has become a global concern as nations grapple with the growing challenge of solid waste management. In the Global South—comprising developing regions in Asia, Africa, and Latin America—rapid urbanization, population growth, and industrial expansion have intensified the generation of solid waste. However, limited infrastructure, inadequate funding, and weak policy enforcement have led to poor waste management practices that pose severe threats to the environment and public health.

The improper disposal and open dumping of waste in these regions contribute to soil and water contamination, greenhouse gas emissions, and the spread of diseases. Unlike developed nations that utilize advanced technologies for waste segregation, recycling, and energy recovery, many countries in the Global South rely on unsustainable

DOI: 10.5281/zenodo.17542183

ISBN: 978-93-48954-26-8

methods such as landfilling and open burning. These practices not only degrade ecosystems but also undermine climate resilience and hinder progress toward the United Nations Sustainable Development Goals (SDGs), especially Goal 11 (Sustainable Cities and Communities) and Goal 13 (Climate Action).

To achieve environmental sustainability, the Global South must adopt integrated solid waste management strategies that emphasize waste reduction, reuse, recycling, and recovery. Strengthening policy frameworks, investing in green technologies, and promoting community awareness are key to transforming waste from a burden into a resource. Sustainable waste management practices can significantly reduce environmental impacts, create green jobs, and foster a circular economy—paving the way for a cleaner and healthier future.

2. Literature Review

This work often involves studying existing reports from government agencies, consultants, and NGOs to provide deep knowledge about various national efforts. The underlying conclusion is typically that while formal sectors play an important role, there is significant scope for improving waste management practices to better serve the welfare of society. Agarwal et al. (2015) [1], Findings from such studies often highlight inefficiencies, such as irregular waste collection frequency, and confirm that a considerable amount of waste goes uncollected or improperly disposed of, thereby posing substantial risks to the environment and public health. Furthermore, this research often details waste composition (e.g., compostable matter, ash, and recyclables) and underscores the vital, though informal, role of ragpickers in reintegrating discarded plastic into the value chain. Dubey et al. (2025) [2], The literature comprehensively addresses the multifaceted challenges and necessary reforms within the municipal solid waste (MSW) management sector in India. Overall, the issue remains a major concern, prompting several recent reviews to establish the "State of Art" concerning current practices .Sahu et al. (2014) [9] and Kadam (2023) [3], Research indicates that the growth in solid waste generation is intricately linked to economic development, with studies exploring the relationship between MSW generation and environmental economic curves in the Indian context. Khajuria et al. (2012) [4], Supporting this systemic shift, research has identified the current status, primary challenges, and future potential of various technologies critical for improving MSW processes, highlighting the necessity of modernization to enhance operational efficiency Khan et al. (2022) [5], Furthermore, practical implementation demands a clear understanding of the waste characteristics at the local level. Detailed studies focusing on specific urban areas, such as the characterization of MSW and the proposal of a management plan for Kharagpur, have provided essential, granular data on waste composition and volume, which is crucial for designing locally tailored and effective waste treatment systems Kumar and Goel, (2009) [6], Effective municipal solid waste (MSW) management in India requires a multi-pronged approach that addresses both technical and structural challenges, with a growing emphasis on sustainable practices and technological adoption. At the foundational level, the need for comprehensive and implementable sustainable waste management strategies has been clearly articulated in the literature, which advocates for utilizing a robust Waste Management Hierarchy to guide decision-making toward long-term sustainability. Mehta et al. (2018) [7], This local issue aligns with global research that systematically reviews the broader spectrum of gaseous emissions arising from solid waste management activities worldwide, stressing the universal environmental risk associated

DOI: 10.5281/zenodo.17542183

ISBN: 978-93-48954-26-8

with inadequate practices. Pardo et al. (2015) [8], The literature on solid waste management (SWM) in India highlights two interconnected issues: the need for comprehensive strategic overviews and the critical environmental consequences of current practices. Systematic reviews have been crucial in synthesizing the existing knowledge on SWM practices in India, establishing the "State of Art" and defining the characteristics, collection, transportation, and disposal methods currently employed across the country. Sahu et al. (2014) [9], This foundational work provides the necessary context for identifying deficiencies in the current system. Addressing a major consequence of these deficiencies, other studies have focused specifically on the environmental impact of improper disposal, particularly quantifying the emissions from landfill sites. Research conducted on municipal solid waste disposal in major cities like Delhi demonstrated the need to quantify methane emission rates, which are significant contributors to climate change and localized air quality issues Talyan et al.(2007) [10].

3. Research Gap

The current literature on Solid Waste Management (SWM) in India, while robust in diagnosing challenges and proposing theoretical solutions, reveals a critical research gap centered on the viability and scalability of practical, decentralized models. Research successfully outlines the need for a shift towards a Sustainable Waste Management Hierarchy and identifies the crucial role of advanced technologies . Furthermore, papers establish the major environmental liabilities, such as methane emissions from disposal sites in metropolitan areas and provide essential background through comprehensive "State of Art" reviews). This collective body of work forms a strong foundation for understanding *what* the problem is, but less so for *how* to solve it consistently across diverse urban settings.

The most significant gap is the lack of integrated techno-economic feasibility studies for SWM systems in smaller Indian cities (Tier II and Tier III). While case studies exist for specific locations detailing waste characteristics there is a shortage of quantitative models that conduct cost-benefit analyses comparing different locally appropriate technologies (like decentralized composting versus bio-methanation) in environments with limited capital. This gap means policy makers often lack the evidence-based methodology required to select and fund effective, replicable solutions that are financially viable outside of the largest metropolitan areas. A related deficiency is the insufficient research into how to formally and effectively scale up successful micro-level interventions, particularly those involving the essential informal recycling sector into city-wide, sustainable frameworks.

Finally, the existing literature suffers from a deficit in longitudinal, localized data on public behavior and source segregation. The success of any modern SWM technology or policy hinges on source segregation, which remains a principal failure point in India The research has yet to rigorously apply behavioral science and economic modeling to design and test effective incentives or regulatory mechanisms that can achieve sustained, high-compliance source segregation rates across varying socio-economic and cultural groups. Addressing this gap would move the field beyond merely identifying "lack of segregation" as a challenge toward generating implementable strategies for citizen engagement and compliance.

DOI: 10.5281/zenodo.17542183

ISBN: 978-93-48954-26-8

4. Advantages Of Solid Waste Management

i. Environmental Protection

Proper waste management reduces pollution of air, water, and soil, protecting ecosystems and biodiversity. It helps prevent open dumping and burning, which release harmful gases and toxins into the environment.

ii. Resource Conservation

Recycling and reusing materials conserve natural resources like metals, paper, and water, reducing the need for raw material extraction. Composting organic waste enriches soil fertility, supporting agriculture.

iii. Public Health Improvement

Effective waste management minimizes the spread of diseases caused by waste accumulation, such as malaria, cholera, and respiratory problems. Cleaner surroundings contribute to better overall community health.

iv. Economic Benefits

Recycling and composting create employment opportunities and promote small-scale industries. Energy recovery from waste (like biogas) can also reduce energy costs and support local economies.

v. Climate Change Mitigation

Sustainable practices like composting and reduced landfill usage help lower greenhouse gas emissions, contributing to climate change mitigation efforts.

vi. Enhanced Quality of Life

Cleaner cities and communities improve living standards, make urban areas more attractive, and promote social well-being.

5. Implementation

To address the environmental sustainability impacts of solid waste management in the Global South, a systematic and community-based approach can be implemented. The first step is to establish proper waste segregation at the source. Households, commercial establishments, and institutions should be encouraged to separate biodegradable, recyclable, and non-recyclable wastes through awareness campaigns and simple collection systems. Secondly, waste recycling and composting units can be developed at the community or municipal level. Organic waste from households and markets can be converted into compost or biogas, reducing landfill waste and generating useful by-products for agriculture or energy use. Lastly, the implementation of strict regulations and monitoring systems is essential to minimize illegal dumping and open burning of waste.

DOI: 10.5281/zenodo.17542183

ISBN: 978-93-48954-26-8

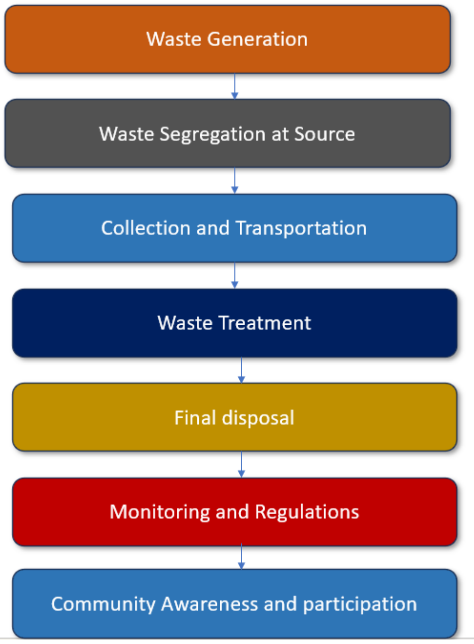

Fig.1: Flowchart for Solid waste management

Step 1: Waste generation

Waste generation is simply the process by which materials are deemed unusable or unwanted and are subsequently discarded by their source. It is driven purely by human activity—residential consumption, industrial manufacturing, and commercial operations—which produces diverse waste streams like municipal solid waste (MSW) from homes, construction and demolition debris (C&D) from building sites, and hazardous waste from specific industrial processes. The volume and composition of this waste are directly influenced by factors such as population size, economic activity (how much is bought and produced), and consumption patterns (the reliance on single-use items), all of which determine the burden placed on collection and treatment systems.

Step 2: Waste segregation at source

Waste segregation at source is a manual, non-mechanized practice where the person generating the waste separates it into distinct, designated streams before it is collected. This is done using different colored or labelled bins for categories like wet/organic waste (food scraps, yard trimmings), dry/recyclable waste (paper, plastics, metals, glass), and reject/non-recyclable waste (sanitary items, contaminated material). The fundamental purpose of this simple, human-driven process is to keep valuable, recyclable materials clean and uncontaminated by liquids or decomposing organics, thereby making the subsequent recycling and composting stages simpler, cheaper, and more effective.

Step 3: Collection and transportation

Collection and transportation in waste management are essential, non-digital logistical processes driven by traditional labor and established routes. Collection involves the manual loading of waste, previously segregated at the source, into specialized vehicles. Transportation then moves this accumulated waste from the point of generation (homes, businesses) to the centralized treatment facilities (like Material Recovery Facilities, transfer

DOI: 10.5281/zenodo.17542183

ISBN: 978-93-48954-26-8

stations, or landfills). This process relies on fixed scheduling, optimized routing based on population density and road networks, and mechanical equipment—such as compaction mechanisms within trucks—to minimize the volume of the waste during transit and ensure cost-effective movement to its final processing location.

Step 4: Waste treatment

Waste treatment is a multi-step, physical, chemical, and biological process designed to neutralize hazards, reduce volume, and prepare waste for safe disposal or resource recovery. This process varies significantly between waste types: for wastewater, it involves sequential stages like primary settling (physical removal of solids), secondary aeration (where natural bacteria consume organic matter), and final disinfection (using chlorine or UV light). For solid waste, treatment may involve composting (controlled biological decomposition of organics), or incineration (controlled burning) to drastically reduce volume, with the resulting ash requiring careful final disposal. All these methods rely on established mechanical engineering, chemistry, and microbiology principles to transform harmful waste into benign forms or useful resources

Step 5: Final treatment

Final disposal represents the crucial last stage in waste management for materials that cannot be recycled, treated, or recovered for energy. The primary conventional method is the Sanitary Landfill, an engineered site where residual waste is systematically buried: it is spread in thin layers, compacted by heavy machinery, and covered daily with soil to minimize odor and pests. These facilities are built with multi-layered liners and systems to collect and treat contaminated liquids (leachate) and safely manage gases (primarily methane) generated by decomposition. A secondary method involves the secure disposal of ash residue from incineration, which requires specific protocols to stabilize any concentrated toxins before final placement, ensuring the waste is contained and its environmental impact is permanently minimized.

Step 6: Monitoring and regulations

Monitoring and regulations are the essential, non-digital oversight systems that enforce environmental responsibility in waste management. Regulations are the legal rules established by governments that define what is acceptable, such as setting standards for the maximum levels of pollutants allowed in treated wastewater or specifying the design requirements for a sanitary landfill (e.g., mandatory protective liners and gas collection systems). Monitoring is the physical and chemical process of checking compliance. This involves using specialized, hard-wired equipment and manual sampling techniques, such as drilling groundwater monitoring wells around a landfill to test for contamination, installing continuous measurement devices in incinerator smokestacks to track air emissions, and regularly sampling the final effluent (treated water) from a treatment plant for laboratory analysis. Together, these systems provide the data and legal authority needed to ensure waste facilities operate safely, protecting public health and preventing long-term environmental degradation.

Step 7: Communication awareness and participation

Communication, awareness, and public participation are foundational human activities in waste management that operate entirely through conventional means, without the need for sophisticated technology. Communication involves distributing clear, simple messages—such as public service announcements, door-to-door flyers, or signage on bins—explaining the specific rules for sorting and collection schedules. Awareness is built through

DOI: 10.5281/zenodo.17542183

ISBN: 978-93-48954-26-8

basic educational outreach, including school programs and community meetings, designed to shift social norms and motivate individuals to comply with source separation and reduction goals. Finally, Participation is the actual physical act of the public following these instructions, such as sorting their waste into designated containers, taking organic material to a local composting site, or physically returning recyclable items to a drop-off center, thereby making the entire waste system workable at its grassroots level.This begins with waste segregation at the source, where people separate biodegradable waste (like food and leaves) from recyclable and non-recyclable materials. Segregation helps in easier recycling and reduces the burden on landfills. Collection and transportation systems should be efficient and supported by local governments to ensure that waste is not dumped in open spaces or water bodies.

Summary

Proper solid waste management is an important part of achieving environmental sustainability, especially in the Global South where rapid urbanization and population growth have led to increased waste generation. Many developing countries face challenges such as inadequate waste collection, open dumping, and burning, which cause soil, air, and water pollution. Sustainable waste management focuses on reducing waste at the source, promoting segregation, recycling, composting, and using sanitary landfills instead of open dumps. These practices help in conserving natural resources and minimizing environmental damage.

To ensure long-term sustainability, public awareness and community involvement are essential. Governments, NGOs, and local authorities must work together to create effective policies, promote education on waste segregation, and enforce strict regulations against improper disposal. When these strategies are properly implemented, they not only reduce pollution but also create job opportunities and improve public health. Thus, sustainable solid waste management plays a vital role in protecting the environment and supporting a cleaner, healthier future for the Global South.

Conclusion

In conclusion, effective solid waste management is a key factor in achieving environmental sustainability in the Global South. The increasing population and urban growth have resulted in rising amounts of waste, which, if not managed properly, can cause serious pollution and health problems. Adopting sustainable practices such as waste segregation, recycling, composting, and proper landfill management can significantly reduce environmental damage and improve the overall quality of life. These methods not only help conserve natural resources but also support cleaner cities and healthier communities.

Furthermore, the success of waste management systems depends largely on government policies, public awareness, and community participation. Local authorities must enforce strict waste management rules, promote education about responsible disposal, and encourage active citizen involvement. By working together, societies in the Global South can move toward a cleaner and more sustainable future, ensuring that development goes hand in hand with environmental protection. sustainable solid waste management is crucial for protecting the

DOI: 10.5281/zenodo.17542183

ISBN: 978-93-48954-26-8

environment and improving living conditions in the Global South. By adopting proper waste segregation, recycling, composting, and safe disposal methods, communities can greatly reduce pollution and conserve natural resources. Government support, strict regulations, and active public participation are necessary to make these practices successful. When implemented effectively, sustainable waste management not only safeguards the environment but also promotes economic growth, public health, and a cleaner, greener future for all.

References

[1] Agarwal, R., Chaudhary, M. and Singh, J. (2015). Waste Management Initiatives in India for Human Well Being. European Scientific Journal, SPECIAL/ edition (June): ISSN: 1857-7881.

[2] Dubey, R., Rathore, D. and Dwivedi, A. (2025). Municipal Solid Waste Management in an Urban Setting in India: A Case Study of Prayagraj City. International Research Journal of Multidisciplinary Scope (IRJMS), Volume 6(1): 725-737

[3] Kadam, D. D. (2023). Solid Waste Management In India. International Journal of Creative Research Thoughts (IJCRT), Volume 11, Issue 4 (April): ISSN: 2320-2882.

[4] Khajuria, A., Matsui, T., Machimura, T and Morioka, T. (2012). Decoupling and environmental kuznets curve for municipal solid waste generation: Evidence from India. International Journal of Environmental Sciences, Volume 2: 1670-4

[5] Khan S, Anjum R, Raza ST, Ahmed Bazai N and Ihtisham M. Technologies for municipal solid waste management: Current status, challenges, and future perspectives. Chemosphere 2022; Volume 288:132403

[6] Kumar, K. N. and Goel, S. (2009). Characterization of Municipal Solid Waste (MSW) and a proposed management plan for Kharagpur, West Bengal, India. Resources, Conservation and Recycling, Volume 53: 166-174.

[7] Mehta, D., Paliwal, D., Tege, S and Sankhla, V. S. (2018). Sustainable Waste Management: An Approach Towards Sustainability. JETIR, Volume 5, Issue 9 (September): ISSN-2349-5162.

[8] Pardo G, Moral R, Aguilera E and Prado A. Gaseous emissions from management of solid waste: a systematic review. Glob. Chang. Biol. 2015; Volume 21:1313-27

[9] Sahu, S., Nair, S. J., Sharma, P. K. (2014). Review on Solid Waste Management Practice in India: A State of Art. International Journal of Innovative Research & Development, Volume 3, Issue 3 (March): ISSN 2278-0211.

[10] Talyan V, Dahiya RP, Anand S, Sreekrishnan TR. Quantification of methane emission from municipal solid waste disposal in Delhi. Resour. Conserv. Recycl. 2007; Volume 50: 240-59.

DOI: 10.5281/zenodo.17542183