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Environmental sustainability and solid waste management in Guwahati, India: Issues and Solutions

Dr. Jayashri Roy[1]

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Abstract

The city's waste profile, high in organic content, coupled with unorganized recycling efforts, exacerbates landfill overuse and open burning of waste. This paper explores the specific SWM challenges in Guwahati, including policy gaps, financial constraints, and the need for public engagement. It proposes multi-faceted solutions: communitydriven waste segregation, decentralized composting and biogas facilities, wastetoenergy technologiesand enhanced recycling initiatives. Emphasizing policy reforms, public-private partnerships, and capacity-building, the proposed strategies aim to foster a resilient and sustainable SWM system in Guwahati, protecting environmental and community health. This paper explores the city's main challenges in waste management, examines their impacts on the environment and presents possible solutions that could lead to a more sustainable system. The study draws on current data, case studies from other cities and policy analysis to propose an integrated approach to address the MSW challenge in Guwahati.

Keywords: Solid Waste Management, Environment, Guwahati, Challenges and Solutions

Introduction

Between 2001 and 2010 India's urbanization rate increased significantly. Between 2001 and 2010(Census of India : 2011), India saw the expansion of numerous megacities(Jha, et.al.: 2011). Megacities are proliferating due to economic globalisation, shifting cultural norms, and technological advancements.

Guwahati a rapidly growing metropolitan area faces significant challenges today in managing the waste generated by its approx1 million+ population. These challenges pose threats to the environment (Zaman, &Lehmann :2013). This paper aims to evaluate the existing MSWM framework of Guwahati and suggest solutions to improve environmental sustainability. Guwahati, the largest city in Assam and the gateway to Northeast India, grapples with the growing challenges of solid waste management. However, by improving waste segregation, improving infrastructure, encouraging public-private partnerships, and engaging the community through education. As the largest city in Assam and a vital hub of north-eastern India, Guwahati has seen a surge in population and economic activity(Ghosh, &Sinha: 2019). This growth while fostering economic development has led to a significant increase in environmental pressures. The unplanned expansion of the city has overwhelmed existing waste management infrastructure, leading to challenges such as excessive landfill dependency.

Guwahati's challenges in SWM are compounded by limited public awareness, weak policy enforcement, and a lack of resources to address the growing waste problem. This complex situation requires multifaceted solutions that include government intervention, community engagement, and technological innovation(Nag, &Chakraborty: 2020).Through sustainable SWM practices, Guwahati can pave the way toward a healthier environment, making the city more resilient to future waste challenges and contributing to India's overall sustainability goals (Sarkar, &Mohapatra: 2018).

Guwahati the largest city in Assamwhich faces significant challenges due to rapid urbanization and inadequate infrastructure. Effective waste management is crucial for environmental sustainability and urban development(Nag, &Chakraborty: 2020).

This article explores the challenges of MSW management in Guwahati and aims to propose solutions to enhance environmental sustainability.

Objectives

- To explores the major challenges
- To challenges in Safe and Sustainable Disposal
- To Understand Policy and Regulatory Gaps
- To develop Policy and Funding Recommendations
- To solutions for developing Waste Processing Infrastructure

[1] Asst. Prof, Department of Geography, Vidyasagar Teachers' Training College, Midnapore, Paschim Medinipur, West Bengal, 9434663639, jayashriroy19@gmail.com

Methodology

Reports have been worked on and help of various books, journals and internet has been taken. By analyzing this data it becomes easier to understand the root causes and opportunities to improve waste management practices.

Waste Types

Waste can be categorised as either biodegradable or non-biodegradable in addition to being categorised according to its sources of materials.

Waste Management

According to UNEP (2015) this includes waste or garbage from homes, businesses, schools, offices, and cafés. It includes items like food scraps, used plastic bags, soft drink containers, and plastic water bottles, as well as damaged furniture and shattered homes. Equipment, apparel this covers radioactive, biomedical, urban and rural waste. Three categories are typically used to segregate solid waste:

(i) Organic or biodegradable garbage such as food scraps, kitchen scraps, green waste, flowers, leaves, fruits, and paper.

(ii) Non-biodegradable and inert waste such as debris, soil and garbage

(iii) Waste that can be recycled, such as paper, plastic, bottles, glasses, etc.

The following activities are included in solid waste activities:

- NGO employs 450 people in total who drive 64 auto tippers and 480 tricycles throughout the city.
- Guwahati has two operational transfer stations. One at GMCH, Bhangagarh and the other at RGB Road, next to Nursery, Ganeshguri. Every day 85 to 90 percent of the waste is taken to Baragaon (GMC, Website).

Sources of wastes

Source	Type of solid waste
Residential	Bulky waste
Industrial	Chemicals, plastics, and solid rocks. It can be hazardous or nonhazardous, and can pollute the environment, water resources, and farmlands.
Construction	packaging material and land-clearing debris
Commercial	Waste from businesses and offices,Waste from market cleansing
Agriculture	any unwanted or unsalable material that results from agricultural operations,plant residues from agriculture

Source: GMC, Website

>. Explores the major challenges:

Category	Percentage Contribution/Status	Remarks
Lack of segregation at source	60-70%	Most waste is mixed, making processing harder.
Inadequate waste collection infrastructure	50-60%	Limited coverage of collection services.
Inadequate recycling and composting	20-30%	Minimal efforts in segregation and processing.
Limited public awareness and participation	40-50%	Awareness campaigns are sporadic or ineffective.
Unscientific landfill and open dumping	70-80%	Dominant practice for waste disposal.
Insufficient Processing Facilities	30-40%	Few functional composting or recycling units.
Environmental Impact on Water Bodies	High	Waste runoff severely impacts local water bodies.

Overburdened and Unscientific Landfills	80-90%	Landfills are saturated and poorly managed.
Inefficient Organic Waste Management	50-60%	Large amounts of organic waste remain untreated.
Rising Waste Generation in Urban Centers	Growing Rapidly	Increasing population and urbanization.
Limited Recycling Infrastructure	20-30%	
Current Status of Waste Segregation	Significant	
Financial Constraints & Lack of Investment	Significant	
Technological Gaps	Significant	Dependence on outdated methods and tools.

Guwahati most of the waste is mixed at source, leading to inefficient processing and increased landfill dependence.Many neighbourhoods, especially slums and peri-urban areas, lack regular waste collection services. These results in illegal dumping blocked drainage systems and unsanitary conditions(Sarkar, &Mohapatra: 2018).A large portion of Guwahati's waste is recyclable or compostable, but due to lack of infrastructure and awareness, only a small percentage is processed. Most are sent to landfills, which contribute to pollution and greenhouse gas emissions.Around 78% of the waste is organic, with minimal composting or processing infrastructure operational.Limited, leading to the recycling of only 6-14% of waste (plastics, paper, and glass).

Guwahati's Boragaon Landfill, which handles most of the city's waste, is unsanitary, leading to pollution in nearby water bodies such as the Dipore Bill. Open dumping of waste further increases pollution and health hazards.Develop Infrastructure for Waste Processing(Sarkar, &Mohapatra: 2018).Guwahati has a limited number of waste processing facilities, leading to a heavy reliance on landfills. Improper disposal of waste often results in runoff into the Brahmaputra River and other local water bodies. This contaminates drinking water sources, harms aquatic life, and disrupts local ecosystems (Central Water Commission Report, 2022)The Boragaon landfill, the city's primary waste disposal site, is unscientifically managed. It faces frequent overflows, leading to leachate pollution, methane emissions, and harmful impacts on nearby ecosystems like DeeporBeel a Ramsar Wetland site.A large portion of Guwahati's waste is organic yet the city lacks adequate composting facilities. Organic waste that could be processed into compost or biogas is often mixed with non-biodegradable materials, making it unsuitable for processing and leading to increased greenhouse gas emissions when dumped in landfills (CPCB Report, 2020).The city has insufficient infrastructure to support large-scale recycling operations. There are few recycling plants, and most recyclable materials are processed informally by waste pickers, leading to inefficiencies and low recovery rates of valuable materials like plastics, metals and paper.Segregation of waste at the source remains a challenge due to low public awareness and limited government initiatives in Guwahati. Effective segregation is essential for recycling and composting yet only a fraction of households practice it(Guwahati Municipal Corporation , Annual Report: 2021). The lack of public-private partnerships (PPP) &external funding further exacerbates this challenge(Nag, &Chakraborty: 2020).

This results in inefficient waste handling and increased pressure on existing landfills (Kumar &Samadder:2017).

Challenges in Safe and Sustainable Disposal

Guwahati's waste is predominantly dumped in open, unscientific landfills like the Boragaon landfill. This improper disposal leads to serious environmental hazards, including groundwater contamination. The Boragaon landfill, located near DeeporBeel a Ramsar Wetland site, leaks harmful leachate into surrounding water bodies, affecting aquatic ecosystems and local biodiversity. Leachate pollution also poses health risks to nearby communities(Sarkar, &Mohapatra: 2018).Hazardous materials, including biomedical and electronic waste, are often mixed with general municipal waste(Nag, &Chakraborty: 2020).

Although waste management policies exist, there is poor enforcement of regulations regarding waste segregation, collection, and disposal. The absence of penalties for illegal dumping or non-compliance further aggravates the situation(Central Pollution Control Board: 2021). Guwahati should upgrade its landfills to meet scientific standards by constructing engineered landfill cells, installing leachate treatment systems, and implementing gas collection mechanisms to capture methane emissions. Properly designed landfills will reduce pollution and enable safe waste containment(Sarkar, &Mohapatra: 2018).Ensure that WTE plants use eco-friendly technologies, such as gasification or incineration with pollution control, to minimize emissions and environmental impacts(Anand:2010). Establish decentralized composting units in residential areas, markets, and institutions to manage organic waste

locally. Composting reduces the amount of waste transported to landfills & generates compost that can be used for agricultural purposes(Rajpal, Ramsey &Nagendra: 2021).

Guwahati faces challenges in achieving full waste collection coverage due to limited transportation resources and personnel shortages. The city lacks adequate landfill space, leading to overburdening of existing sites and potential health risks(GMC Solid Waste Management Report: 2021).Conduct regular audits and inspections of waste disposal sites, hospitals, and industries to ensure compliance with environmental and waste disposal standards. (Sarkar,&Mohapatra: 2018).

Challenges in SWM and Environmental Sustainability

Unplanned Urbanization:

Guwahati's rapid urban growth has led to increased waste generation without corresponding infrastructure, making collection and disposal inefficient (Mukherjee, & Bhattacharya: 2014).

Inadequate Disposal Infrastructure:

Guwahati lacks efficient waste treatment facilities, relying heavily on open dumping and landfills. These landfills not only occupy valuable land but also contribute to leachate, greenhouse gases, and other pollutants that harm the environment.

Lack of Awareness and Community Involvement:

Public awareness around waste segregation, recycling, and reducing waste is limited, with low community participation in sustainable waste practices(Sharma, &Kanwar: 2018).

Insufficient Policy Implementation:

Although India has regulations enforcement and compliance remain weak in Guwahati. Resource constraints, regulatory delays, and lack of monitoring hinder progress.

Environmental Pollution:

Poor waste management practices result in air, water, and soil pollution. Open burning of waste contributes to air pollution, while improper landfill management results in toxic leachate seeping into groundwater(Kumar, et.al.: 2017).

- **Understanding Policy and Regulatory Gaps**

Aspect	Current Status	Gap Identified	Recommendations
Waste Segregation	Limited awareness and implementation of source segregation.	Lack of enforcement mechanisms and awareness campaigns.	Conduct awareness drives and impose penalties for non-compliance.
Collection & Transport	Door-to-door collection services are irregular and insufficient, particularly in peri-urban areas.	Inadequate coverage and lack of monitoring systems.	Implement GPS-based tracking for waste vehicles and expand coverage to all areas.
Processing & Recycling	Limited waste processing facilities; most waste ends up in open dumping grounds.	Lack of investment in recycling and composting infrastructure.	Establish more Material Recovery Facilities (MRFs) and incentivize recycling industries.
Legislation	Existing policies such as SWM Rules 2016 are poorly enforced at the local level.	Weak enforcement and lack of localized policy adaptations.	Strengthen enforcement capacity and develop city-specific bylaws.
Funding Mechanisms	Insufficient budget allocation for SWM activities.	Over-reliance on government funds; minimal private sector participation.	Explore Public-Private Partnerships (PPP) and increase budgetary provisions.
Public Participation	Low levels of citizen engagement in SWM activities.	Minimal stakeholder involvement in planning and implementation.	Foster community participation through Resident Welfare Associations (RWAs) and NGOs.

Disposal Practices	Reliance on open dumping and non-scientific landfills.	Absence of engineered landfills and leachate management systems.	Develop scientifically engineered landfills and ensure proper leachate treatment.
Plastic Waste Management	Inefficient management of plastic waste despite Plastic Waste Management Rules 2016.	Poor monitoring and lack of alternatives to single-use plastics.	Promote biodegradable alternatives and enforce plastic bans effectively.
Capacity Building	Municipal staff lacks adequate training in modern SWM techniques.	Insufficient capacity-building programs for local authorities.	Organize regular training and workshops for municipal staff.

Source : GMC, 2023

National rules require due to weak monitoring and limited public awareness. Waste segregation rates remain low, which hinders recycling and resource recovery efforts and leads to increased landfill use. Effective enforcement of these regulations is vital to improve segregation practices at the household and community levels (GMC: 2021 & CPCB : 2020). Guwahati's SWM is constrained by limited municipal budgets and dependency on central government fundswhich limits investment in modern infrastructure, collection vehiclesand treatment technologies. Additionallysustainable financial mechanismssuch as user fees, recycling incentivesPPPmodelsremain underutilized(World Bank,2018).Although public-private partnerships have been successful in other Indian cities for SWMGuwahati has yet to fully leverage this model. The absence of clear policies or incentives for private investment results in lost opportunities for bringing in advanced technologies, management expertise, and funding, which could enhance waste management practices (NITI Aayog, 2020).Guwahati has limited formal recycling programs and lacks the infrastructure needed for effective wastetoenergy initiatives. Without strong policies to incentivize recycling and energy recovery from wasterecyclable materials often end up in landfillsand potential energy sources are wasted. Policy gaps here reduce the potential for a circular economy that could lessen landfill dependence and environmental pollution. (National Green Tribunal NGT, 2021).Addressing the policy and regulatory gaps in Guwahatiis critical to achieving environmental sustainability. Implementing a multistakeholder approach, fostering innovation, and strengthening governance mechanisms, the city can transition towards a cleaner and greener future.

Policy and Funding Recommendations

The challenges in managing solid waste effectively are often exacerbated by rapid urbanization, poor infrastructure, and insufficient public awareness. These issues are pressing in urban centres, where unplanned growth leads to inefficiencies in waste collection, segregation, and disposal.Guwahati should adopt a comprehensive, city-specific SWM policy that addresses local waste characteristics, population density, and urbanization rate. This policy should prioritize waste segregation at the source, improve collection efficiency, and incorporate climate resilience into waste management practices. Localized policies can better address the unique waste composition and logistical challenges faced by Guwahati, making waste management more efficient and effective (MHUA, 2020).

Challenges	**Potential Solutions**
Unplanned Urbanization	Integrated urban planning with SWM systems, zoning laws, and green infrastructure.
Inefficient Collection and Segregation	Community awareness programs, improved collection mechanisms, and smart technologies.
Inadequate Disposal Infrastructure	Investment in sanitary landfills and modern processing facilities.
Lack of Awareness and Community Involvement	Educational campaigns and community-based waste management programs.
Insufficient Policy Implementation	Strengthen legal frameworks and create actionable local waste management policies.
Environmental Pollution	Adoption of environmentally friendly technologies and stricter enforcement of laws.
Lack of Comprehensive Localized SWM Policies	Develop region-specific SWM strategies tailored to local needs and waste types.

Inconsistent Enforcement of Waste Segregation Rules	Regular inspections, strict penalties, and incentivization of segregation at source.
Insufficient Funding and Financial Mechanisms	Establish dedicated funds and offer tax incentives to encourage private investments.
Lack of Public-Private Partnerships (PPP)	Encourage collaboration between governments and private firms for efficient systems.

Source: GMC, 2023

Ministry of Housing and Urban Affairs. (2020) Urban Solid Waste Management Guidelines. funds can be reinvested into SWM infrastructure and services, supporting long-term improvements without relying exclusively on government budgets (UNEP, 2019).Diversified funding sources provide consistent financial support for SWM, allowing for continuous improvements in waste collection, recycling, and landfill management.

Solutions for Sustainable SWM

Stronger enforcement of existing waste management policies along with incentives for compliance, such as reduced taxes or rewards for businesses and households practicing sustainable waste management, can foster a culture of responsibility. Engaging private enterprises in SWM infrastructure development, like setting up recycling plants or waste-to-energy facilities, can bring investment, innovation, and expertise, alleviating the government's resource constraints.

Solutions for Developing Waste Processing Infrastructure

Challenges	Solutions
Insufficient Processing Facilities	Build advanced waste processing plants with a focus on recycling, composting, and energy recovery.
Lack of Investment and Funding	Secure government subsidies, grants, and Public-Private Partnerships (PPP) for infrastructure projects.
Inadequate Land Availability	Promote vertical waste processing facilities and integrated processing zones to optimize space usage.
Environmental Concerns from Processing Plants	Invest in eco-friendly technologies and enforce strict environmental regulations for operations.
Limited Policy Support and Implementation	Develop region-specific policies and streamline approval processes for waste processing facilities.
Inconsistent Enforcement of Waste Segregation Rules	Regular inspections, strict penalties, and incentivization of segregation at source.
Insufficient Funding and Financial Mechanisms	Establish dedicated funds and offer tax incentives to encourage private investments.
Lack of Public-Private Partnerships (PPP)	Encourage collaboration between governments and private firms for efficient systems.
Gaps in Recycling and Waste-to-Energy Policies	Implement clear guidelines for recycling and promote waste-to-energy technologies.

Source: GMC, 2023

Set up decentralized composting units in residential areas, markets, and public parks to process organic waste locally. This reduces the burden on landfills and encourages community participation in waste management(World Bank: 2018).Invest in biogas plants to convert organic waste into renewable energy. These can be integrated into commercial areas like markets, where food waste is generated in large quantities. The biogas produced can be used for cooking or electricity generation, while the slurry can be used as organic fertilizer(Sharma, &Kanwar: 2018). Establish material recovery facilities across the city to sort recyclable materials like plastics, metals, and paper. These technologies can minimize air pollution and ensure efficient energy generation (Singh, &Tyagi: 2019). Implement scientific landfill management techniques at Boragaon and other waste disposal sites. This includes the use of engineered cells to contain waste, proper leachate treatment systems, and methane gas capture for energy generation (CWC, 2022). Introduce landfill mining to recover valuable materials from old landfills, while also creating space for additional waste. The extracted

materials can be recycled or processed for energy, and the reclaimed land can be repurposed for other uses, such as green spaces or solar farms. This will ensure that waste is properly processed at composting units, recycling centres, or WTE plants. The city can provide color-coded bins for households and commercial establishments to facilitate segregation(Singh, &Tyagi:2019). Guwahati's municipal body can create investment-friendly policies to attract private sector players for setting up waste processing infrastructure. Tax breaks, subsidies, and long-term contracts for private operators can help create a conductive environment for investment(Sarkar, &Mohapatra: 2018). Partner with international organizations and development agencies to secure funding and technical expertise for waste processing projects. Collaborating with global institutions like the World Bank, UNDP, or bilateral agencies can bring advanced waste management technologies to the city. Develop training programs for municipal staff and waste management professionals on advanced waste processing techniques, landfill management, and recycling technologies. These programs will ensure that waste processing infrastructure is operated and maintained efficiently (Sharma, &Kanwar: 2018).

Solid Waste Management activities

Processing and Disposal

GMC has started a scheme to buy dry garbage from the public in order to separate waste at the source. Tricycles and auto tippers ride up a ramp in the Transfer Station and unload the trash straight into a compactor and dumper. In addition to the provision of a leachate treatment facility, there is sufficient water for cleaning and sanitisation procedures inside the station. Since the transfer station opened, the surrounding areas have been designated as dustbin-free zones (GSCL: 2020).

With a 50 TPD installation capacity, the compost facility at Boragaon, Guwahati, was put into service in 2010 and uses wind row composting technology(Sarkar, &Mohapatra, 2018).At the moment, it generates five TPD of compost every day. It has been suggested that the compost facility be expanded from 50 TPD to 200 TPD shortly(Guwahati Municipal Corporation (2020, 2021).

Policy Recommendations for Sustainability:

Strengthening regulatory frameworks and incentivizing sustainable practices are essential for advancing SWM in Guwahati. Legislative support, along with education and awareness programs, is necessary to achieve long-term environmental sustainability (UNEP Guidelines on Sustainable SWM: 2019).

Monitoring Committee

1) Principal Secretary to the Govt of Assam, GDD – Chairman
2) L.R. & Secretary, Judicial Deptt. Or his representative – Member
3) Secretary, GDD - Member
4) Representative of Finance Deptt. - Member
5) Col. ManoranjanGoswami, Social Worker – Member
6) Mr.DhirenBarua, President Save Guwahati Build Guwahati – Member
7) Commissioner, GMC – Member Secretary (Guwahati Municipal Corporation (GMC, 2020&GMC Website)

The pilot project

- Drum composting is an on-site composting process that Guwahati Municipal Corporation has implemented at a number of bulk garbage sources, including vegetable markets, agricultural markets, hostels, messes, etc. AFCONS has been given the task.
- The State Mission Directorate has received an Swaach Bharat Mission (2019)Proposalfor the necessary machinery and equipment for about Rs. 29.31 crores.

Consultancy of IIT Kharagpur, West Bengal

A preliminary assessment of Guwahati City's waste management issue, encompassing international best practices for trash management, has been submitted by IIT Kharagpur. The IIT Kharagpur has recommended actions to address the waste management issues right now. In Guwahati, IIT Kharagpur has focused on a number of significant initiatives for Short, Medium& Long Term Solutions for sustainable solid waste management techniques at Gowhati Municipalities.

Conclusion

GMC has initiated a scheme to purchase dry waste from the public to segregate waste at source. Tricycles and auto tippers ride up a ramp at the transfer station and unload garbage directly into a compactor and dumper. Apart from provision of leachate treatment facilities, there is sufficient water inside the station for cleaning and sanitization procedures(Sarkar, &Mohapatra: 2018). The surrounding areas have been designated as dustbin-free areas since the transfer centre opened.

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