Policy Implications on Evolution of Solid Waste Management in India: A Comprehensive Study

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Abstract

The increasing population has significant influence on rapid urbanization and industrialization, which leads to higher density of waste generation, putting additional pressure on its management. Solid Waste Management (SWM) refers to the process of collecting, transporting, processing, disposing, and monitoring solid waste materials generated by human activities. This includes waste from households, commercial establishments, and industrial processes. The objective of SWM is to minimize the amount of waste that ends up in landfills or open dumps, as well as to reduce the negative impact of waste on the environment and public health. This paper presents a comprehensive review of government policies that that promote sustainability, efficiency, and environmental protection. The findings suggests that SWM can be improved by setting penalties, providing incentives, and creating public-private partnerships. Effective solid waste management is essential for sustainable development, as it helps to conserve natural resources, reduce pollution, and protect public health.

Keywords— Waste management, Policy, Sustainable, Segregation, Recycle.

1. Introduction

Prior to India's independence in 1947, waste management was largely the responsibility of local communities, who disposed of waste in nearby landfills or dumped it in open areas. In the years following independence, the Indian government began to take a more active role in waste management. The first solid waste management rules were introduced in 1957, which required local authorities to collect and dispose of waste in a safe and sanitary manner. In the 1960s, the government established a number of waste treatment facilities across the country, including landfills and incinerators. In the 1970s and 1980s, the Indian government began to place greater emphasis on waste reduction and recycling. The concept of the "3Rs" - reduce, reuse, and recycle - was introduced, and a number of recycling programs were launched in major cities. Afterwards, in the 1990s and 2000s, waste management in India faced a number of challenges, including rapid urbanization, population growth, and inadequate infrastructure. Many waste treatment facilities were poorly maintained and operated, and waste collection and disposal were often inadequate in many parts of the country. In response, the government introduced a number of reforms, including the launch of the National Urban Sanitation Policy in 2008, which aimed to improve waste management in urban areas. Today, solid waste

management is a complex and multifaceted field that encompasses a wide range of practices and approaches. These include source reduction, recycling and composting, waste-to-energy technologies, and the use of advanced waste treatment facilities to reduce the environmental impact of waste disposal.

Being the most populated country on the globe, India generates a massive amount of waste. According to an estimate, our country produced 68.8 million tonnes of municipal solid waste (MSW) in 2019-20, which is expected to increase to 165 million tonnes by 2030 and 436 million tonnes by 2050 [1]. As per the Central Pollution Control Board (CPCB), the northern region of India generates the maximum amount of municipal solid waste, accounting for 37% of the total waste generated in the country, followed by the western region (24%), southern region (23%), eastern region (11%), and northeastern region (5%) [2]. A symbolic representation of regional waste generation ratio is depicted on Indian map in Fig. 1 for better interpretation. Moreover, it is third-largest e-waste generator in the world after China and the United States, as it generates approximately 3.2 million tonnes of e-waste per year. However, the formal recycling rate is estimated to be only around 5-10% for e-waste and 20-25% for solid waste. The most common methods of waste disposal in India were landfilling (53%), composting (31%), and waste-to-energy (15%) [3].

The lack of proper waste management infrastructure and practices has resulted in environmental degradation and public health hazards. But there are numerous challenges for effective solid waste management (SWM) including inadequate infrastructure, limited funding, and a lack of public awareness and participation. So, improving waste collection and transportation systems, establishing efficient waste processing and recycling facilities, and promoting public participation and awareness are crucial steps towards sustainable solid waste management in India. Here, the government plays an important role to address these challenges through a combination of policy interventions, investment in infrastructure, and so on. In the context of India, such strategies have resulted in a number of positive developments in recent years, such as the launch of the Swachh Bharat Abhiyan (Clean India Campaign) in 2014, which aims to promote cleanliness and sanitation across the country. Additionally, there has been growing interest in innovative waste management solutions, such as the use of biogas plants and decentralized waste management systems [4], which could help to address some of the challenges faced by the sector.

Despite these efforts, the challenges of solid waste management persist, and more needs to be done to address the issue. Therefore, the topic of solid waste management in India is essential, and this review paper aims to analyze the current state of solid waste management in India, government policies, and initiatives to address the issue, and the way forward.

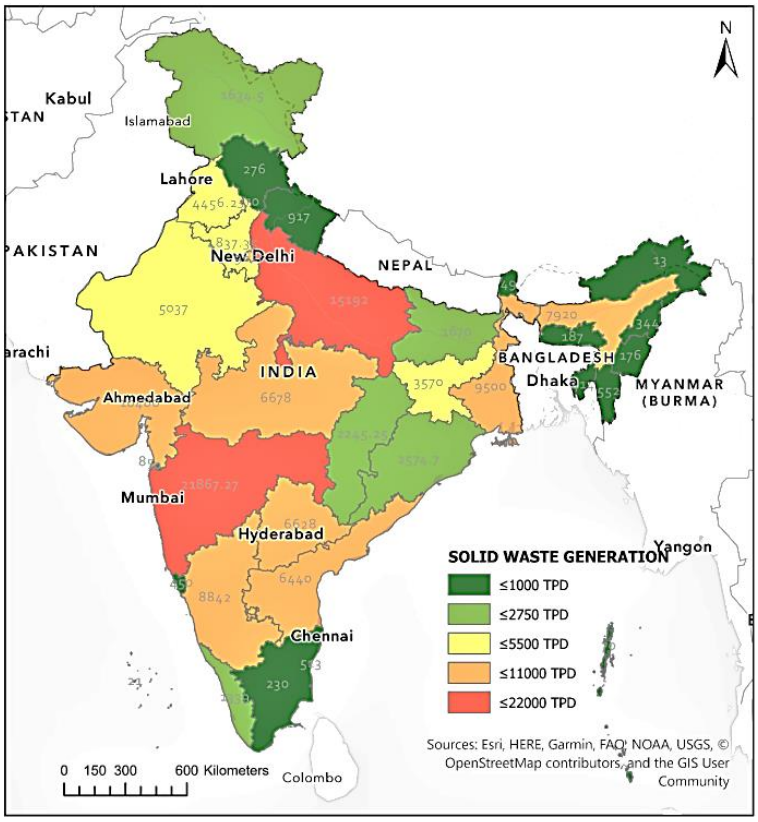


Fig. 1. Regional participation for waste generation [2]

Rest of the paper starts with a brief review of existing efforts in the similar research area. Then a generic framework of solid waste management is presented in Section III. Next section lists important policies of Indian Government for having a sustainable SWM, whose implication is discussed in subsequent section. Finally, the paper concludes in Section VI.

2. Literature Review

This section provides valuable insights into solid waste management and their policy implications. They can be used as a resource for policymakers, researchers, and practitioners to develop effective policies and strategies for sustainable solid waste management.

An in-depth analysis of the policy and institutional issues related to solid waste management in India is presented by K. Mandal [5]. The author describes the existing policy framework for solid waste management in India and analyze the gaps and challenges in the system. The paper emphasizes the urgent need for a comprehensive policy and institutional framework for solid waste management in India, which is sustainable, inclusive, and participatory. A policy framework for community-based solid waste management (CBSWM) in Indian scenario has been analyzed for identifying the challenges and opportunities for its implementation by Alinejad et al. [6]. The authors argue that CBSWM can be an effective way of addressing the solid waste management challenges in India, particularly in urban areas. Soni et al. [7] present a case study of a successful solid waste management initiative in Pune, India, highlighting the key factors contributing to its success. The authors recommend better implementation strategies and enforcement of existing policies and regulations in order to promote community participation along with the development of innovative and sustainable waste management technologies. Pal and Bhatia [8] examine the policy interventions

implemented under the Swachh Bharat Mission and the impact of these interventions on the source segregation of municipal solid waste (MSW). The authors find that policy interventions can be effective in promoting source segregation of MSW in India, but their success depends on the design and implementation of the interventions. For better interpretations, different case studies of various Indian cities can be observed, that are conducted in Kolkata [9], Chandigarh [10], Delhi [11] and Mumbai [12].

3. Methodology

An organized practice of solid waste management is essential to minimize the impact of waste on the environment and public health. So, it is important to ensure proper execution of the basic steps of solid waste management process, which are shown in Fig. 2. It starts with waste generation, which plays a crucial role in solid waste management (SWM). In order to design effective waste management strategies, it is important to understanding the factors that influence waste generation of different categories, broadly covered by two classes, hazardous and non-hazardous. They differ in their potential to harm human health and the environment due to their physical, chemical, or biological properties. Examples of hazardous waste include chemical waste, medical waste, radioactive waste, e-waste, etc., whereas household waste, construction and demolition waste, agricultural waste, etc., are considered as non-hazardous waste. After waste is generated, it is temporary stored at their place of generation, until it is ready for collection. This process is termed as on-site storage, that uses long-lasting containers of appropriate capacities. Their additional qualities of being leakproof and having tight lids prevent littering, pests, and odors, caused by the stored waste. Then systematically, this temporary stored waste is collected from households, commercial establishments, and public places by a waste collection truck for transporting it to a designated waste collection point for further processing. These trucks should be covered to prevent littering and odors.

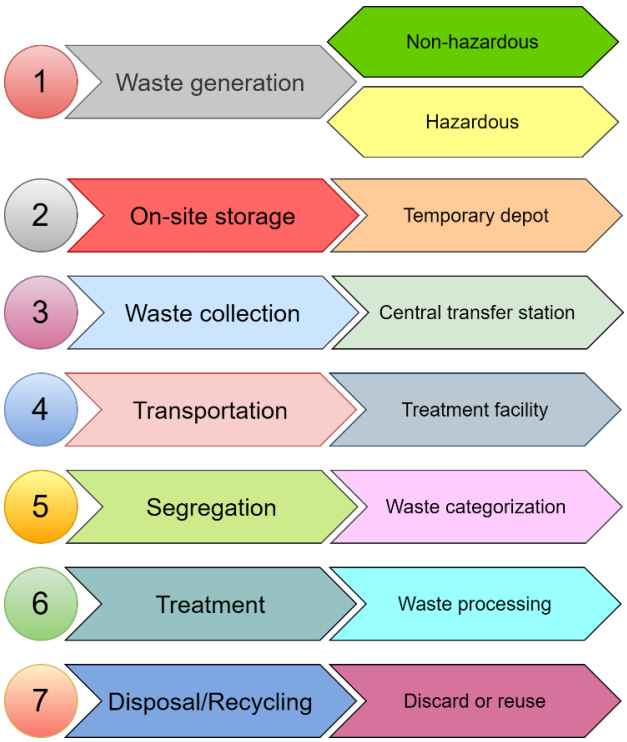


Fig. 2. Generic steps of solid waste management (SWM)

However, the frequency and mode of transportation may vary depending on the location and the amount of waste being transported. At the waste treatment facility, the waste is sorted and segregated based on its type. This is an important step as it helps in the efficient treatment and disposal of waste. The waste is usually segregated into biodegradable, non-biodegradable, hazardous, and recyclable waste. The sorting and segregation process can be done manually or using machines. It is important to ensure that the waste is sorted and segregated correctly to prevent contamination. Once the waste has been sorted, it is treated based on its type. Biodegradable waste is usually treated using composting or vermicomposting techniques. Composting involves the decomposition of organic waste by microorganisms, while vermicomposting involves the use of worms to decompose organic waste. Non-biodegradable waste is either incinerated or landfilled. Incineration involves burning waste at high temperatures to convert it into ash and gas. Landfilling involves burying waste in designated landfills. Hazardous waste is treated using special techniques such as chemical treatment, incineration, or neutralization to minimize its impact on the environment. Thus, the waste treatment majorly focuses on three Rs, first one being "reduction", which means keeping the production of waste to a minimum. Next comes "reuse", which simply means using something more than once. The third option in the hierarchy is "recovery", which includes several separate processes that enable material or energy resources to be recovered from the waste. These include recycling, composting and energy from waste. Finally, the least desirable waste management option is disposal of the waste that cannot be recycled or reused. It includes landfill, tipping and incineration (burning) without energy recovery.

4. Policy Initiatives: Outline

In India, waste generation is primarily governed by the Municipal Solid Wastes (Management and Handling) Rules, 2000, which were revised in 2016 as the Solid Waste Management Rules (SWM), 2016. However, the policy interventions by the Government of India towards establishing SWM started just after the plague outbreak in 1994. Since then, various important reforms have been committed to provide clear guidelines for managing the solid waste from its generation to final disposal. All these rules apply to all urban and industrial areas in India and can be observed to be focused towards reducing waste generation and promoting sustainable waste management practices. Fig. 3 represents a chronological summary of key rules related to SWM. These rules apply to all urban and industrial areas in India and provide a framework for the management of solid waste from its generation to final disposal. To ensure effective coordination and cooperation between various departments and stakeholders involved in waste management, different nodal agencies are included. A brief introduction of each agency and its specific is given below:

- Ministry of Housing and Urban Affairs (MoHUA): This ministry is responsible for formulating policies, coordinating the activities of various agencies, and promoting sustainable urban development.
- Central Pollution Control Board (CPCB): The CPCB is responsible for monitoring and enforcing pollution control regulations, including those related to solid waste management.

Fig. 3. Timeline summary of SWM policies in India

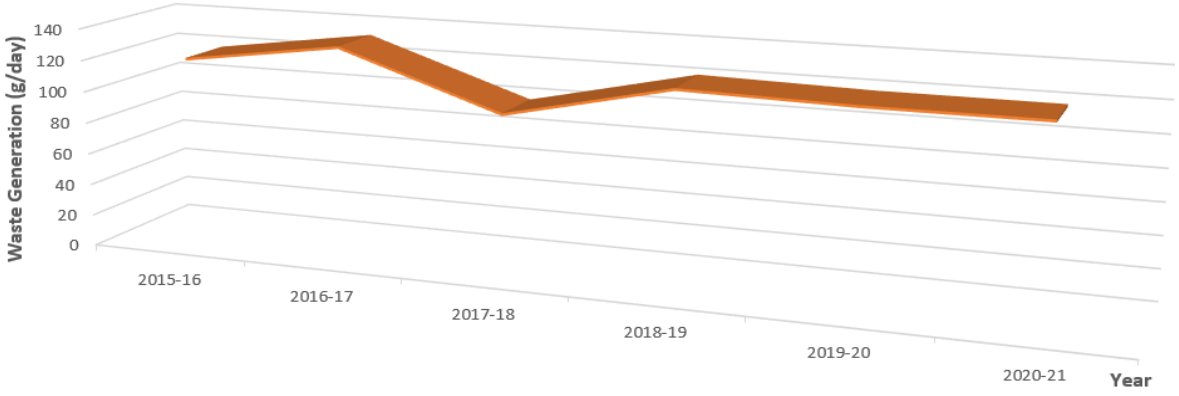
- State Pollution Control Boards (SPCBs): The SPCBs are responsible for enforcing pollution control regulations at the state level.
- Urban Local Bodies (ULBs): The ULBs are responsible for implementing solid waste management programs at the local level, including collection, transportation, and disposal of waste.
- National Environmental Engineering Research Institute (NEERI): NEERI is a premier research institute that provides technical expertise and advice on solid waste management to various government agencies.

- Central Public Health and Environmental Engineering Organisation (CPHEEO): CPHEEO provides technical support and guidance to ULBs on solid waste management and related issues.
- National Institute of Urban Affairs (NIUA): NIUA is a research institute that works on urban development issues, including solid waste management.
- Ministry of New and Renewable Energy (MNRE): The MNRE promotes the use of renewable energy technologies, including waste-to-energy, for solid waste management.

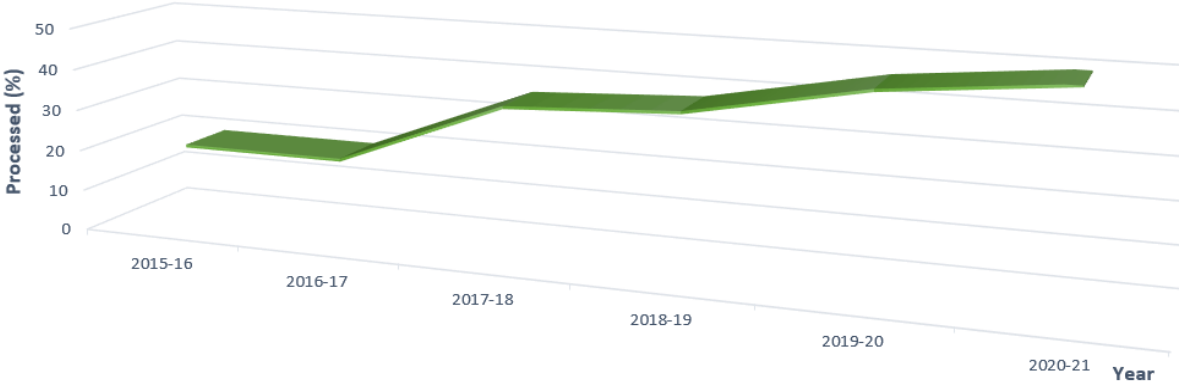
The collaborative effort of these agencies helps to create a comprehensive waste management system that meets the needs of the community while also protecting the environment.

5. Discussion

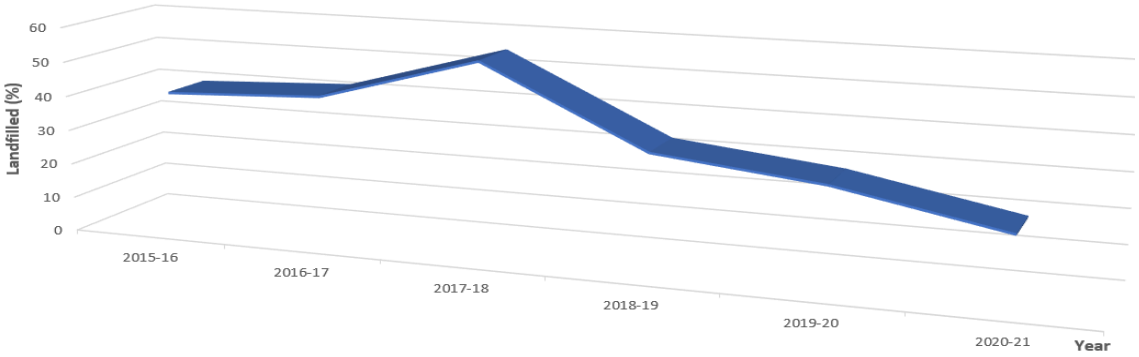
India has a long history of formulating policies and rules related to solid waste management (SWM), which are amended over the years to address the changing needs of the society and the environment. Their successful implementation is the responsibility of different agencies, like CPCB, ULB, NEERI, and so on. These policies and rules aim to address the issues related to waste generation, collection, segregation, treatment, and disposal. This section analyses the impact of Government involvement in SWM in terms of waste generation and their quantum of processing. Fig. 4 displays the conclusive observations, drawn on the basis of annual report provided by official website of CPCB [13].



(a) Year wise solid waste generation per capita (g/day)



(b) Year wise solid waste processed (%)



(c) Year wise solid waste landfilled (%)

Fig. 4. Trend observation of Government policies on SWM

The fist trend analysis, displayed in Fig. 4(a) is for the per capita waste generation, calculated in grams per day (g/day). It shows marginal decreasing trend over the last six years. Fig. 4(b) illustrates the trend of percentage solid waste processed during the year 2015-21. In comparison to 19% in 2015-16, the processing trend increased to 49.96% in 2020-21. On the other hand, solid waste landfilled has decreased from 54% to 18.4%, as shown in Fig. 4(c).

6. Conclusions and Future Scope

The Indian government has implemented various policies, rules, and guidelines to manage the increasing amount of solid waste in the country. The policies and rules have evolved over time, with a focus on waste reduction, segregation, recycling, and safe disposal. The government has established various nodal agencies and committees to oversee and implement these policies at the national, state, and local levels. These policies have had significant implications on the waste management industry, leading to the development of new technologies and practices. However, challenges still remain, such as inadequate infrastructure, lack of public awareness, and poor implementation of policies.

Also, in coming future, the Government bodies must think of including enforcement mechanisms in the form of penalties for reducing the non-compliance of the SWM policies and rules. Additionally, the use of artificial intelligence and machine learning in SWM practices may provide generic solution of critical use cases.

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