

Solid Waste Management (SWM) in India and Their Resolving Strategies

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Abstract:- Every year, India produces 62 million tons of waste, of which less than 60% is collected and just 15% is treated while the rest around 31 million is treated as landfills. With landfills ranked third in India in terms of greenhouse gas emissions and mounting public pressure, the Indian government amended its solid waste management policy after 16 years. India is plagued by a massive garbage problem. According to projections, India will require a territory the size of Singapore to dump its rubbish by 2030. India is in a race against time to create appropriate urban waste management techniques as its urban population grows. This article provides an institutional framework for addressing this serious environmental and public health issue and bringing about systemic change in the industry and effective alternative sources to recycle and reuse the generated non-biodegradable wastes. There are also other startups working unnoticed to lessen the buildup of created waste, which, with adequate public recognition, can reduce the waste piled up.

Keywords:- Solid Waste Management, Start-ups for SWM, Alternatives for Non-Biodegradable Waste.

I. INTRODUCTION

There are several environmental issues in India. India's problems include contamination of the natural environment, garbage, domestically prohibited commodities, and air, water, and waste pollution. In India, natural catastrophes are also causing devastation. There was a far worse condition from 1947 and 1995. According to data gathered and environmental assessments assessed by World Bank experts, India made some of the world's fastest progress between 1995 and 2010 in resolving its environmental problems and improving its environmental quality [1,2].

Even yet, India still has a long way to go before it reaches environmental standards on par with other nations. Pollution is both a difficulty and an opportunity for India. Environmental issues are one of the main contributors to disease, health issues, and long-term effects on livelihood in India. Some have said that economic development is to blame for environmental problems. The fundamental cause of India's environmental degradation is thought to be the country's expanding population. Empirical evidence from nations like Japan, England, and Singapore, all of which have population densities equivalent to or higher than India's yet have considerably superior environmental quality, suggests that population density may not be the main factor affecting India's problems [3]. The primary sources of pollution in India include the rapid burning of fuelwood and biomass, such as dried animal waste, as well as the absence of organized garbage and waste removal services, sewage treatment facilities, flood control, monsoon water drainage systems, the diversion of consumer waste into rivers, the use of large land areas for burial, and cremation [4,5].

All three components of waste management - collection, transportation, and disposal - require infrastructural, maintenance, and upgrade [6], which on poor maintenance, garbage can be found in abundance all over the place. India is plagued by a massive garbage problem. By 2030, it is predicted that India will need a region the size of Singapore to dump its waste. India is rushing to develop effective urban waste management strategies due to the country's expanding urban population. The Bhandewadi dump, which has already exceeded its intended capacity, is the only source of waste for Nagpur, the thirteenth-largest city in India. The Nagpur Smart & Sustainable City Development Corporation, according to Ramnath Sonawane, Chief Executive Officer, is a pioneer in smart waste management systems, "offering an end-to-end solution for solid waste management from collection to disposal of garbage"[7].

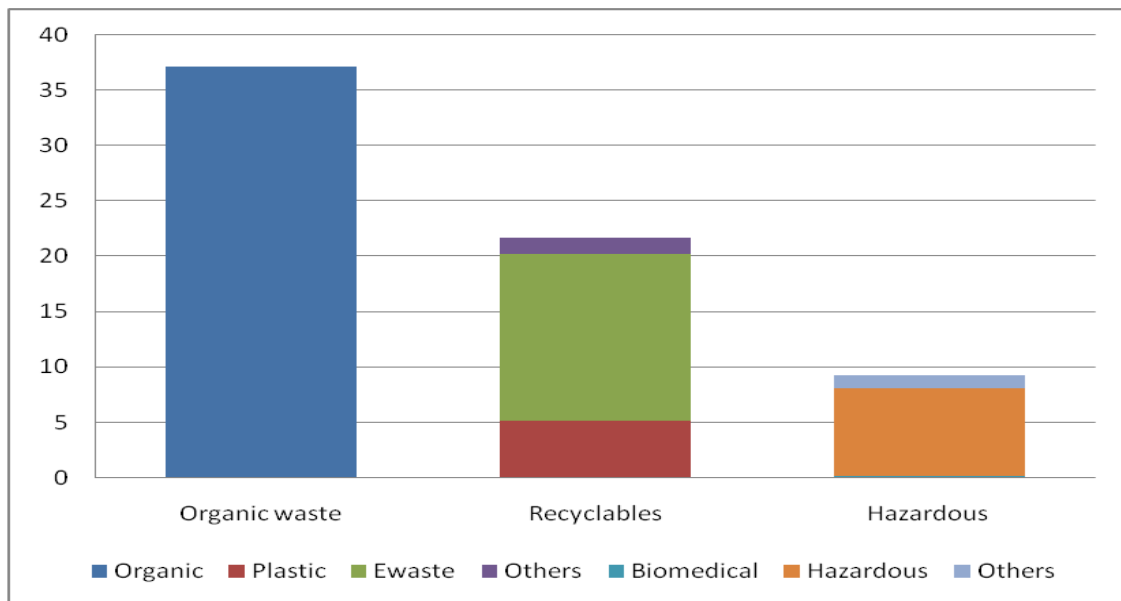


Fig. 1. Waste Composition of India, in Million Metric Tonnes per annum (Source: PIB 2016).

According to the Central Pollution Control Board, India will have around 21 million automobiles that have reached the end of their useful lives by 2025. (CPCB). In 2015, more than 8.7 million automobiles have reached the end of their useful lives. Currently, these vehicles are frequently dismantled at unorganized dismantling centers to recover working spare components. The action plan includes a section on the use of plastic, which has been on the national agenda for some time. Currently, the majority of Indian states have enacted some form of plastic prohibition. The CPCB recently informed the National Green Tribunal (NGT) that 18 Indian states have outright banned the use of plastic carry bags, while five more have a partial ban in some areas.

By 2025, the proposed plan calls for 100% recycling and reuse of PET plastic, as well as 100% recycling and reuse of PET plastic and 75% recycling and reuse of other plastic packaging materials. It also proposed a prohibition on the “disposal of recyclable garbage (plastics, metals, glass, and other materials)”. Several Indian cities began waste-to-energy initiatives in 2011, similar to those in Germany, Switzerland, and Japan. New Delhi, for example, is implementing two incinerator projects intended to convert the city's rubbish problem into a source of electricity [8]. These facilities are being hailed as a solution to the city's long-standing issues with untreated garbage and a lack of electricity. They are also welcomed by those working to reduce water contamination, sanitary issues, and the production of the potent greenhouse gas methane by rotting waste. Waste collection workers and local unions reject the initiatives, fearing that changing technology will rob them of their jobs [9].

A. Effects of Solid Waste

➤ Effect on Human Health

The US Public Health Service reports that improper solid waste disposal has been connected to 22 human illnesses (MIT Urban Development Sector Unit 1999). Burning trash has been linked in several studies to emphysema, asthma, and heart attacks. Municipal trash frequently contains human feces, which attracts additional rats and spreads illnesses like dengue fever and malaria together with poorly handled decomposing rubbish [10]. The Deonar fire in 2016 burned plastic, leather, and other materials for three months, releasing tonnes of cancer-causing smoke into the atmosphere. Mumbai is India's most populous metropolitan area, with a population of over 11.5 million (Census Department, Government of India, 2017). According to data from the System of Air Quality and Weather Forecasting and Research (SAFAR), Deonar is the city's most polluted suburb and has a dump that is the height of an 18-foot tower (Times of India 2015).

➤ Effect on Environment

In addition to its effects on human health, pollution of the land, water, and food supply also contributes significantly to India's emissions of greenhouse gases. Apart from particulate matter, burning releases carcinogenic hydrocarbons, carbon monoxide, nitrogen oxide, sulfur dioxide, and other gases into the atmosphere; as a result, India emits 6% more methane from trash than the global average of 3% (Planning Commission, 2014).

There will be a need for 1,400 sq km of landfill space in India by 2047, which is about the same size as the combined area of the top three most populous cities in India: Hyderabad, Mumbai, and Chennai [11].

Leachate from decaying waste contains heavy metals and toxic substances; because these emissions are currently absorbed into the soil or flow into water bodies (12), the entire food chain may be harmed if this contaminated water is used for farming, human consumption, or animal consumption.

B. Strategies for Waste Management

Reducing trash creation would be a key element in limiting future waste issues. By recycling, reusing, and decreasing their trash, businesses, industries, and the general

people can all play an important part in the solution. Reusing bags and containers, choosing your purchases carefully, using less throwaway goods, and using less packaging are a few examples of feasible reductions that may be made at the conceptual level. Additionally, other technologies that can influence source Reduction, for instance, would encourage communication and information distribution through electronic media instead of printed material, resulting in a significant decrease in paper waste percentage [13]. The many parts of solid waste are represented in the chart below for understanding.

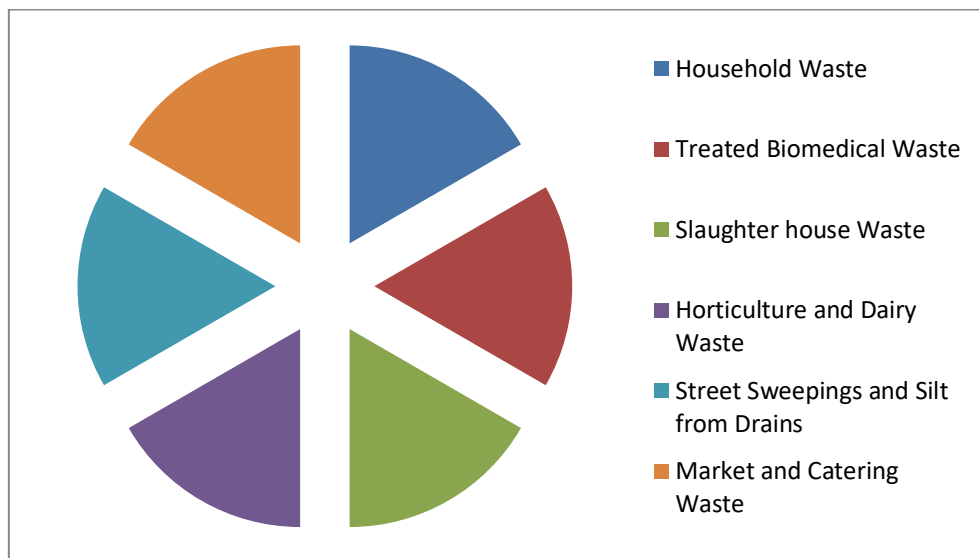


Fig. 2 – Types of Solid Wastes produced in India.

Mandatory requirements may force businesses to take responsibility for the garbage they produce. The vendor of a consumer commodity should theoretically be required to take back all packaging trash created under Germany's mandated recycling program [14]. Even though German law emphasizes recycling and lacks precise targets for source production, source reduction was nonetheless a consequence of the additional burden that the law placed on businesses. By creating useful byproducts (compost in the case of composting, energy in the case of WTE plants, and fuel in the case of RDF plants), proper waste management creates a circular economy. Due to heavy subsidies for artificial fertilizers, farmers are deterred from switching to organic farming, which significantly shrinks the market for compost [15]. Although the Department of Fertilizers must sell compost as part of the new SWM legislation, which aims to solve inefficiencies, there is still more to be done to develop a market for compost and encourage farmers to transition to organic farming.

➤ Management From Home

Similarly, recycling companies now compete on an equal footing with industries that use new raw materials (virgin products). Buyers of recycled plastic pellets, for example, have little financial motivation to support sustainable activities unless they can save money [15]. Facts like these underline the importance of more people using the recycling center rather than throwing everything in the garbage can. According to Lakeshore Recycling Systems, if

one is concerned about the carbon footprint from our day-to-day waste generated, the following ten items go to the recycling center rather than the trash includes;

- Newspapers and Glossy Magazines and Ads are some of the most straightforward recyclable materials. This can assist to save up to 60% of the energy necessary to produce fresh newspaper.
- Paper makes up a third of all municipal waste in the United States, according to the Environmental Protection Agency. It's also one of the most straightforward materials to recycle. Make sure all of your waste paper goes to the recycling facility, from outdated documents to junk mail and everything in between.
- One tonne of cardboard and paperboard may be sent to the recycling facility, which can save the amount of energy needed to produce new cardboard by 24 percent and over 9 cubic yards of landfill space. To save space, flatten the cardboard thoroughly.
- Polyethylene Terephthalate (PET) is the material used to make bottles for beverages including juice, soda, and water. In the US, almost 2.5 million plastic bottles are thrown every hour. The environment benefits from their recycling. Shampoo, detergent, and other like goods are packaged in thicker recyclable plastic bottles. These bottles should be rinsed thoroughly, and then the plastic tops should be taken off and thrown away.
- Aluminum is a great option for recycling because it retains its qualities indefinitely. It takes 95 percent less energy to do so than it does to make brand-new cans.

Recycling aluminum reduces the need for fresh aluminum mining, which helps to protect the environment. Many canned goods, including fruits, vegetables, soups, and coffee, are still packaged in steel ("tin") cans. They're also recyclable. Before recycling them, make sure they're clean.

- Food and beverage containers made of glass are completely recyclable. They can replace up to 95% of raw materials in the production of new glass products, making glass recycling extremely environmentally benign.

➤ *Policies by the Government*

The first thorough solid waste management regulations were adopted in 2000. The Ministry of Environment revised the regulations in 2016 and released the most recent solid waste management rules in 2016 to regulate the efficient collection and disposal of municipal solid waste in India after poor implementation caused diseases and widespread protests in several Indian states (Hindustan Times 2016; Hindu 2012; Times of India 2016).

Since 1986, seventeen regulations have been issued or changed, each dealing with the management and processing of a specific sort of trash, such as the e-waste rules of 2011, the plastic waste rules of 2011, and the batterie rules of 2011. The most significant stumbling factor to efficient execution has been the lack of a single comprehensive strategy with an overarching framework of governing entities. Different requirements necessitate various certifications from the Central Pollution Control Boards (CPCB), making the process time-consuming. The following are the main characteristics of the 2016 solid waste management rules [15].

- All waste generators must segregate their garbage, however, there is no explicit penalty for non-compliance.
- Bulk producers (any institution with floor space greater than 5,000 square meters) are required to manage their trash, but there is no penalty for non-compliance.
- An expanded producer obligation on brand owners to establish a garbage collection program for waste generated during packaging.
- Promotion of waste-to-energy facilities, as well as a mandate to the Department of Fertilizers to sell compost alongside chemical fertilizers.
- There is a provision for local governments to charge garbage generators collection fees, with no penalties for non-compliance.

A web-based program was started in 2016 by the Ministry of Environment, Forests, and Climate Change (MoEFCC) to track and monitor waste management in India [16]. The Integrated Trash Management System program gathers information and helps government organizations, recyclers, owners of disposal facilities, and garbage generators work together.

In 2019, the parliamentary 'Standing Committee on Urban Development' released a report on 'Solid Waste Management Including Hazardous Waste, Medical Waste, And E-Waste,' which included a plethora of proposals to

enhance India's SWM. In March 2021, the parliament received a report on the actions done. The committee issued a total of 37 recommendations, 14 of which were accepted by the government, 21 of which were rejected by the committee, and two for which the committee was still waiting for a response.

Under the Swachh Bharat Abhiyan plan, the Ministry of Urban Development and the Central Pollution Control Board (CPCB) of India publish a National City Rating every year. Around 500 cities are included in the ranking, accounting for 72 percent of India's urban population. For this survey, India was divided into five zones until 2017, and each city was rated on 19 indicators. Green, blue, black, and red were used to categorize the cities, with green being the cleanest and red being the most polluted. None of the cities received a perfect score in the exercise's green category. By this plan, the Indore capital of Madhya Pradesh The Ministry of Housing & Urban Affairs [17] ranks cities based on the cleanliness index and was ranked first.

C. *Start-Ups and Their Role*

A startup is a company or initiative that an entrepreneur launches to identify, create, and validate a scalable business model. While self-employment and enterprises without ambitions to register are included in the definition of entrepreneurship, startups are defined as companies with plans to grow beyond the founder's sole location. Early on, startups face a lot of uncertainty and failure, but only a tiny portion of them go on to achieve success and significance.

Many firms with funding are currently talking up their revolution to reduce and reuse strategies to minimize various types of trash (18). Below are some examples of startups and their contributions to environmental conservation.

- Attero is a full-service electronics asset management company that aims to maximize the value of all electronic assets.
- Cashify. in is an e-commerce platform that allows you to resell unwanted electronics.
- Shakti Plastics Industries, situated in Mumbai, recycles various sorts of plastic waste and is one of India's largest polymer waste recyclers.
- Through technological advances across the value chain, Banyan Nation is unlocking the market for premium recycled plastics in India.
- Lohum Cleantech provides services on how used lithium-ion battery cells can be reused.
- Saahas Zero Trash is a social enterprise that provides waste management services from start to finish.
- ExtraCarbon offers a kabadiwala service that collects recyclable rubbish from households and businesses on demand. We'll buy your trash and old stuff for cash or store credit. Make money from the comfort of your own home. No, we're not joking; sell your trash to us and make a lot of money.
- The goal of Phool is to solve the problem of flower temple waste. Through its 'flowercycling' technique, it collects tonnes of floral waste from temples, which is

handmade into charcoal-free incense, organic vermicompost, and biodegradable packaging material.

- APChemi provides pyrolysis plants that are proven, patented, and reliable for converting waste plastic, tyres, and biomass into fuels.
- GEM Enviro Management collects polyethylene terephthalate (PET) waste from companies, offices, hotels, and educational institutions and recycles it into T-shirts, caps, and bags.

II. DISCUSSION

Mandating corporate enterprises to utilize a minimum percentage of recycled products as part of their manufacturing process, in addition to the EPR mandated by SWM 2016 guidelines, would be advantageous. Recycling companies will benefit from tax breaks, which will help to establish standards and, as a result, responsibility in the recycling system [15]. According to my research, just five out of 300 plastic recyclers in Hyderabad are Pollution Control Board (PCB) certified, emphasizing the significance of bringing the industry up to national standards. The ambitious Circular Economy Package proposed by the European Commission is a positive start in the right direction (European Commission 2015). While the European Environment Agency strives for a recycling rate of at least 50% in each of the 31 nations, several have already achieved their goals. Sweden, for example, has a 99 percent recycling rate and just 1% of daily trash goes to landfills, with the majority of organic waste being used to produce electricity through WTE plants [19].

Waste is a by-product of human activity that is either unused or inevitable. Because of the tremendous rise in population, waste management has become a major issue, particularly in developing countries. Because municipal authorities have not been doing their jobs correctly, the guidelines and structure of the policy for waste management services in India are quite bad [20]. Disposing of waste items has become a big issue for growing countries like India. In recent years 90% of garbage is disposed of in unused land using one of three methods: landfilling, incineration, or composting. Landfilling has been determined to be an undesirable strategy due to population growth, a lack of landfills, and financial obstacles. The burning of solid trash in open dumps will emit nearly 22,000 tonnes of air pollution each year, resulting in direct human exposure [21]. Because of leachate production, poorly maintained landfill sites contribute to contamination of groundwater [22]. The second option is incineration, which poses many risks to the environment and the general public. The third approach is composting, which is thought to be the best way to manage garbage, however large-scale

composting plants in developing nations have failed due to a lack of straightforward scientific methodologies. After careful consideration, none of these methods will provide a viable answer for solid waste management. Waste disposal until recycling is a process that can cost a lot of money and have an impact on our country's economy [23]. Waste management encompasses activities such as waste collection, transportation, processing, disposal, or recycling, as well as waste monitoring [24]. Trash disposal, particularly solid waste, is an integral aspect of an integrated system. Waste minimization and recycling should be given higher attention. The local government is in charge of rubbish collection until it is separated. Biodegradable garbage, non-biodegradable waste, compostable waste, and reusable waste can all be separated [25]. The current state of waste management must be determined, as it has become a global concern and political priority. Many problems must be overcome to ensure global waste management sustainability. SDGs (Sustainable Development Goals) must be created. To achieve the global goal of the SDGs, specific activities must be taken. Climate change and garbage management are intertwined [26]. In Indian cities, it has become a big environmental issue. Solid waste dumps in open areas will exacerbate environmental problems and pose a threat to residents. MSW is generated, stored, collected, transferred, processed, and disposed of regularly. Because of a lack of good planning, the six processes of storage, transfer, and processing are not being followed properly. As a result, the process becomes more complex, resulting in higher costs. Unscientific disposal has a variety of negative effects on human health and the environment [27].

The interplay of humans and their surroundings is a complicated phenomenon. The capacity of the Earth to support humans is dictated not only by fundamental dietary needs, but also by our resource use, waste output, and technologies used in various applications. We have, in reality, exceeded the planet's carrying capacity as a result of rising population and resource usage patterns. The Earth's natural resources are no longer sufficient to meet our needs and support our economic activity [28]. The danger of exceeding the Earth's ability to absorb our waste products has been highlighted by global warming. Furthermore, the repercussions of surpassing the sustainable supply of critical resources, as well as how far we have progressed along this chain, are not well understood and are frequently treated from an economic and industrial perspective. The ability of the planet to absorb our garbage is a fundamental element determining waste treatment technology adaptation. Landfilling is undoubtedly the most well-known method of waste management. But this kept increasing till date. The table below shows the rapid growth of solid waste produced in a given period [29].

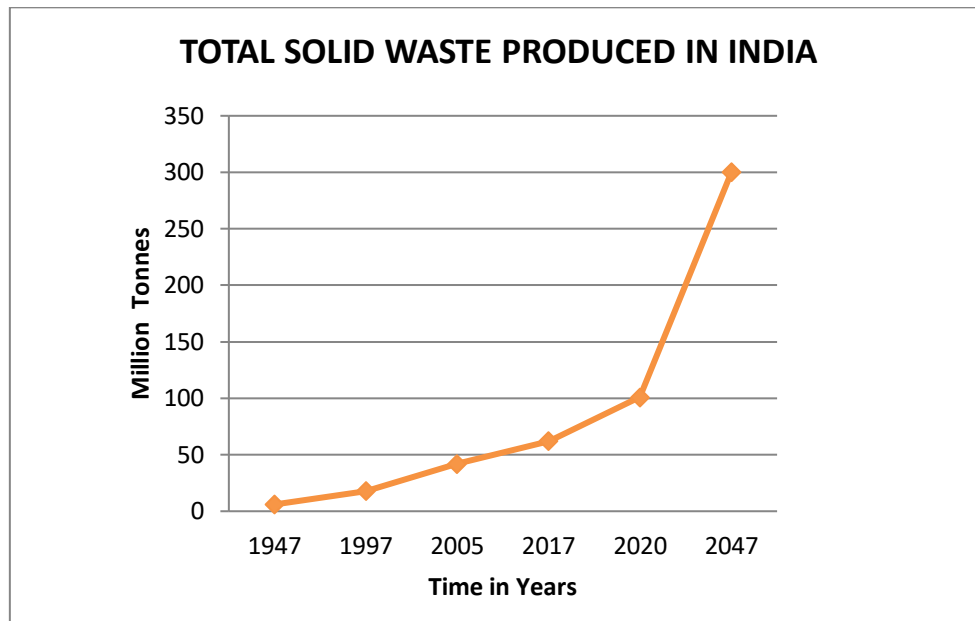


Fig. 3 – Graph exhibiting the growth of Solid Waste generated in India

Until the 1970s, landfilling was done unceremoniously, with rubbish dumped in any convenient site without regard for health, safety, environmental protection, or financial effectiveness [28]. Only approximately 30% of the MSW produced two decades ago was recycled. Only in the last decade has the necessity of trash reduction and recycling been recognized, and in 2012, a recovery rate of 48 percent was attained thanks to an extensive education program on source separation of domestic waste [30]. In addition to recycling, growing waste-to-energy programs, technological advancements, and pollution control systems have all helped to reduce the amount of waste that ends up in landfills, primarily in Europe, and could serve as a model for other countries in the future. The design, operation, and management of landfills are constantly being explored, and new procedures are being implemented to reduce pollution of the air and water. For example, landfill gas collection can help reduce greenhouse gas emissions (GHG). However, the economics of landfill collection and energy recovery must be persuasively shown. The typical methane percentage of landfill gas is roughly 50% due to partial oxidation in the landfill, and even with an excellent gas collection system, some of the gas produced in landfills is lost to the atmosphere [31]. Because of the low level of methane in landfill gas, major upgrading work is required, putting the benefits of the waste gas in jeopardy.

The purpose of the study was to determine the current state of household solid waste management practices and associated factors in Dire Dawa. According to the results of the poll, only 31% of them properly dispose of solid garbage. There was a link between poor solid waste management and educational status, marital status, family size, average monthly income, year of stay in current households, the position of household from a major road, MSSE access, awareness of SWM, attitude toward SWM, and law enforcement. MSSE's poor performance was due to a lack of manpower, budget, and infrastructure, such as insufficient vehicles. The proportion of households with

incorrect solid waste management in this study was 31%, which was practically identical to a survey conducted in Ethiopia's Ambo town [32], where only 31.56 percent of households adequately manage solid waste. However, according to research conducted in Bangladesh [33], 39 percent of households dispose of waste improperly. Furthermore, research conducted in Accra [34] indicated that 61.0 percent of HHs used community dumpsters or had rubbish cleaned up from their households by private contractors. The remaining 39.0 percent dumped their trash in gutters, streets, holes, and shrubs nearby. This disparity could be due to the criteria established by the principal investigator to classify proper and improper waste management, as well as the respondents' living styles in the study area and socioeconomic differences, which all contribute to an increase in the percentage of improper households. When opposed to literate individuals, those who are illiterate were twice as likely to be improper in this study. This finding is consistent with a study conducted in another part of Ethiopia [33], which indicated a favorable relationship between the educational level of HH heads and the properness of waste management at the household level.

MSWM is a difficult problem in developing countries like Bangladesh, where urbanization is rapidly increasing. Municipalities in Bangladesh provide solid waste management services. Although it is a vital service, it does not receive the attention it deserves, and the quality of service is low. This has resulted in a slew of issues in the urban environment as well as public health in most Bangladeshi cities and towns. The per capita generation of solid wastes in urban residential areas in developing countries is much lower than in developed countries; however, in developing countries capacity to collect, process, dispose of, or cost-effectively reuse solid wastes is significantly limited when compared to developed countries [35]. Bangladesh is a developing country with the world's ninth and twelfth most populous and densely populated countries. Between 2010 and 2015, the predicted urban

population growth rate was 3%. Bangladesh generates roughly 30 million tonnes of garbage every year, or 150 kilograms per capita [36]. In 2025, the Waste Generation Rate (kg/cap/day) is predicted to reach 0.6 [37]. In Bangladesh's biggest cities, the total waste collection rate is around 35%. Cities face difficulty in managing garbage in a socially and environmentally responsible manner as a result of these trends. Solid waste management accounts for around 10-15% of municipal budgets [36]. However, it is insufficient since, like in most developing nations, solid waste management has been largely disregarded and understudied as an environmental concern. The provisions of the Municipal Solid Waste Rules 2000 must be implemented as soon as possible. Waste management practices that are ineffective must be replaced with a scientific approach. Waste collection and waste segregation are two aspects of SWM that demand prior attention and have the potential to expand the waste management industry's market. Public knowledge, on the other hand, is crucial for source reduction.

After treatment, any trash that remains should be disposed of in closed landfills. Effective Solid Waste Management should be implemented not just in urban regions, but also in rural areas. Although the government has taken several steps to improve waste management services, there is still a long way to go. The 'Swachh Bharat Abhiyan,' also known as the 'Clean India Mission,' is the most recent effort. One of the goals of this campaign is to raise public awareness of the need for efficient trash management. It attempts to engage residents in the Clean India initiative and to clean up urban and rural areas with public assistance. The government has also amended its regulations to open up the waste management industry to private enterprises. The public-private partnership (PPP) model has been used for a variety of services including the collection, transportation, treatment, landfill site development, and unit operation and maintenance. The PPP model can assist in generating and increasing revenues, as well as increasing competency levels, both of which are necessary for effective solid waste management. Finance, institutional deficiencies, and a lack of public support, on the other hand, are major roadblocks to effective solid waste management. Only 80-90 percent of the entire budget is spent on collection and transportation; additional money should be allocated to solid waste disposal and treatment. The sector's existing business model's viability is nevertheless a source of worry. To successfully decentralize their obligations and foster a business environment in the private sector, local organizations should be supported financially and given access to decision-making opportunities [38].

III. CONCLUSION

Correct trash segregation at the source and the garbage's passage through multiple recycling and resource recovery streams are essential for efficient waste management. The residual waste is subsequently dumped safely in sanitary landfills. Sanitary landfills are the last resting place for inorganic waste that cannot be recovered or

repurposed, including unusable municipal solid waste from waste processing facilities. The high cost of transporting MSW to remote disposal sites is a significant disadvantage of this approach. The better the environment, the more materials can be transported to a recycling center. These ten items should be recycled at all times, in both your home and at your place of employment. If you're unsure, contact your local government to find out how and where these goods should be recycled.

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