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Challenges of Solid Waste Management in India

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Abstract: *The Indian Prime Minister got the prestigious Global Goalkeeper Award for the Swachh Bharat Abhiyan from the Bill & Melinda Gates Foundation. There is no denying that India has improved its sanitation coverage, but the country's biggest shortcoming is its poor waste management infrastructure. Available literature shows that India's informal recycling sector which consists of waste pickers plays a crucial role in segregating and recycling waste, but in most cases, they are not formally trained and at times they burn waste at landfills to keep themselves warm at night and end up setting landfill fires that cause air pollution, and because of inadequate gear, they are also exposed to diseases and injuries. As India continues to rebuild, its citizens should ensure that they avoid reaching the dangerous levels of the average westerner in plastic consumption and waste production because waste reduction is better than any kind of waste management. And India's traditional wisdom of "Aparigraha" which is very relevant even today can play a key role in achieving that.*

Keywords: Waste Management; Waste Management Crises; Pollution; Solid Waste

I. INTRODUCTION

Where solid waste is properly managed, after the waste is generated, it is segregated at the source, then properly stored, collected, transported, and treated (Kumar *et al*., 2017). In an effective solid waste management model, there should be a goal to reduce, reuse, recover and recycle waste by using the appropriate technologies and the waste that is disposed of in landfills should be minimized, most importantly, landfills should be properly managed so that they don't become a source of greenhouse gases and toxins. But in many cities of India, the waste that is generated is just recklessly dumped in most cases, some are dumped on the streets and some is dumped in landfills that are not properly managed and this ends up polluting the air, soil, and underground water (Tripathi *et al*., 2020).

Urban India generates 62 million tonnes of municipal solid waste (MSW) annually, and it has been predicted that this will reach 165 million tonnes in 2030. 43 million tonnes of municipal solid waste is collected annually, out of which 31 million are dumped in landfill sites and just 11.9 million are treated (Kothari *et al*., 2021). There are not enough public bins, and the available bins are not even covered, in many cases, waste overflows out of those bins and ends up going all over the streets. Waste transporting vehicles is not even covered in many cases which also causes littering of the streets (Hantoko *et al*., 2021). Many citizens in India recklessly litter the streets too. Probably, they only littered the streets with banana leaves or bowls made of dried leaves a few years earlier, those kinds of litter were not that harmful as they were biodegradable and could even be eaten by stray animals. But in India today, what is mostly littered is plastic and in any society, it's not easy to bring a quick cultural change (Yukalang *et al*., 2020).

India's informal recycling sector consists of waste pickers who play a crucial role in segregating and recycling waste, but in most cases, they are not formally trained and at times they burn waste at landfills to keep themselves warm at night and end up setting up landfill fires that cause air pollution, and because of inadequate gear, they are also exposed to diseases and injuries (Puri *et al*., 2008). The sizes of landfills in India are constantly increasing and that is fast becoming a major concern. Contrary to the composition of waste in western countries, the majority of India's waste is organic which means that there is a tremendous opportunity to compost a lot of it, but to make it possible (Sharholy *et al*., 2008), Indians need to adopt the practice of segregating waste at its source, that is why Indian needs to follow the guidelines that are set by the Indian Government in its official solid waste management rules.

The Solid Waste Management Rules focus on the segregation of waste at its source. All commercial institutions and resident welfare associations are required to partner with the Urban local body and segregate waste into different categories-biodegradable, non- biodegradable, construction-demolition, domestic-hazardous, horticulture, sanitary, etc.

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In addition, they also need to process biodegradable waste through on-site composting and the recyclable waste has to be given to authorized recyclers or waste pickers (Kumar *et al*., 2022). If the Solid Waste Management Rule is properly implemented and is also adopted by the people, it can simply transform the waste management system in India (Agnihotri & Jha, 2021). This is a perfect opportunity for all the stakeholders, urban local bodies, Non-governmental organizations, Resident Welfare Associations, Public and Private institutions, and Waste Management Start-Ups to come on board, get interlinked and benefit from a combination of centralized and decentralized waste management system.

The amount of high-calorific waste is increasing in India and the country is gradually trying to adopt waste segregation at the source, these two factors are crucial in running waste-to-energy projects, apart from that, there exist waste-to-energy technologies that can process unsegregated and high moisture-low calorie waste too and that can be very useful for a country like India as in many cases bringing a quick change in people's behavior is not easy and something needs to be done urgently (Hazra *et al*., 2007; Kumar & Gautam, 2022).

The objective of study and method of literature review:

The objective of this study is to evaluate the machoism and challenges of Solid Waste Management in India by reviewing available literature in the field.In this research, results have been obtained from the literature collected traditionally. Research papers have been collected from various databases in which Dada Base NCBI, PubMed, SpringerLink, Google Scholar, & Publon is available online.

II. WASTE GENERATION IN INDIA

India is experiencing rapid urbanization while remaining a country with physical, climatic, geographical, ecological, social, cultural, and linguistic diversity. The population of India was 1252 million in 2013, compared with 1028 million in 2001. Population growth is a major contributor to increasing MSW in India.

Table 1: Population growth in India between 1911 and 2011. Source: Provisional Population Totals-India, 2011

Census year	Population × 106	Decadal growth ×106	Average annual exponential growth rate (%)	The progressive growth rate compared with 1911 (%)
1911	252.0	13.7	0.56	5.75
1921	251.3	−0.8	−0.03	5.42
1931	278.9	27.6	1.04	17.02
1941	318.6	39.7	1.33	33.67
1951	361.1	42.4	1.25	51.47
1961	439.2	78.1	1.96	84.25
1971	548.1	108.9	2.20	129.94
1981	683.3	135.1	2.22	186.64
1991	846.4	163.1	2.16	255.05
2001	1028.7	182.3	1.97	331.52
2011	1210.2	181.4	1.64	407.64

Estimating the quantity and characteristics of MSW in India and forecasting future waste generation is fundamental to successful waste management planning. The quantity of MSW generated depends on living standards, the extent, and type of commercial activity, eating habits, and season. India generates approximately 133 760 tonnes of MSW per day, of which approximately 91 152 tonnes are collected and approximately 25 884 tonnes are treated. MSW generation per capita in India ranges from approximately 0.17 kg per person per day in small towns to approximately 0.62 kg per person per day in cities (Doaemo *et al*., 2021).

Table 2: Waste generation per capita in Indian cities. Source: Kumar *et al*.

Population	Waste generation rate (kg per capita per day)
cities with a population <0.1 million (eight cities)	0.17–0.54
cities with a population of 0.1–0.5 million (11 cities)	0.22–0.59
Cities with a population of 1–2 million (16 cities)	0.19–0.53
Cities with a population >2 million (13 cities)	0.22–0.62

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III. CURRENT WASTE MANAGEMENT IN INDIA

3.1 Key Waste Management Legislations in India

The MoEF issued MSW (Management and Handling) Rules 2000 to ensure proper waste management in India and newly updated draft rules have recently been published. Municipal authorities are responsible for implementing these rules and developing infrastructure for the collection, storage, segregation, transportation, processing, and disposal of MSW. Chandigarh is the first city to develop SWM in a planned way and has improved waste management compared with other Indian cities.

3.2 Role of the Informal Sector in Waste Materials Reuse and Recycling

The informal sector has a very important role in India and this must be integrated into formal SWM systems. The informal sector is characterized by small-scale, labor-intensive, largely unregulated, and unregistered low-technology manufacturing or provision of materials and services (Yukalang *et al*., 2018). Waste pickers collect household or commercial/ industrial waste and many hundreds of thousands of waste pickers in India depend on waste for an income, despite the associated health and social issues. Pickers extract potential value from waste bins, trucks, streets, waterways, and dumpsites. Some work in recycling plants owned by cooperatives or waste picker associations (Agnihotri and Tiwari, 2020). Waste picking is often the only source of income for families, providing a livelihood for significant numbers of urban poor and usable materials to other enterprises. Waste pickers in Pune collect organic waste for composting and biogas generation. Waste pickers also make a significant contribution by keeping cities clean.

A recent study of six Indian cities found that waste pickers recovered approximately 20% of waste, with 80 000 people involved in recycling approximately three million tonnes. It is estimated that every tonne of recyclable material collected saved the ULB approximately INR 24,500 per annum and avoided the emission of 721 kg CO2 per annum (Sharma *et al*., 2021).

3.3 Waste Collection and Transport

Waste collection, storage, and transport are essential elements of any SWM system and can be major challenges in cities. Waste collection is the responsibility of the municipal corporations in India, and bins are normally provided for biodegradable and inert waste. Mixed biodegradable and inert waste is often dumped, with open burning a common practice (Agnihotri, 2021). Improvements to waste collection and transport infrastructure in India will create jobs, improve public health and increase tourism. Local bodies spend around Rs. 500-1000 per tonne on SWM with 70% of this amount spent on collection and 20% spent on transport.

3.4 Waste Disposal

SWM disposal is at a critical stage of development in India. There is a need to develop facilities to treat and dispose of increasing amounts of MSW. More than 90% of waste in India is believed to be dumped in an unsatisfactory manner (Singh *et al*., 2022). It is estimated that approximately 1400 km^2 was occupied by waste dumps in 1997 and this is expected to increase.

3.5 Environmental and Health Impacts of Waste Dumping

Waste dumps have adverse impacts on the environment and public health. Open dumps release methane from the decomposition of biodegradable waste under anaerobic conditions. Methane causes fires and explosions and is a major contributor to global warming (Kumar & Gautam, 2022) There are also problems associated with odor and migration of leachates to receiving waters. Odour is a serious problem, particularly during the summer when average temperatures in India can exceed 45°C. Discarded tires at dumps collect water, allowing mosquitoes to breed, increasing the risk of diseases such as malaria, dengue, and West Nile fever (Agnihotri, 2018). Uncontrolled burning of waste at dump sites releases fine particles which are a major cause of respiratory disease and cause smog. Open burning of MSW and tires emits 22,000 tonnes of pollutants into the atmosphere around Mumbai every year (Agnihotri, 2019). The impacts of poor waste management on public health are well documented, with increased incidences of nose and throat infections, breathing difficulties, inflammation, bacterial infections, anemia, reduced immunity, allergies, asthma, and other infections

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IV. BARRIERS TO IMPROVED WASTE MANAGEMENT IN INDIA

The current status of SWM in India is poor because the best and most appropriate methods from waste collection to disposal are not being used. There is a lack of training in SWM and the availability of qualified waste management professionals is limited. There is also a lack of accountability in current SWM systems throughout India (Kumar *et al*., 2019). Municipal authorities are responsible for managing MSW in India but have budgets that are insufficient to cover the costs associated with developing the proper waste collection, storage, treatment, and disposal. The lack of strategic MSW plans, waste collection/segregation, and a government finance regulatory framework are major barriers to achieving effective SWM in India.

Limited environmental awareness combined with low motivation has inhibited innovation and the adoption of new technologies that could transform waste management in India (Fadhullah *et al*., 2022). Public attitudes to waste are also a major barrier to improving SWM in India.

V. CHANGES REQUIRED TO IMPROVE WASTE MANAGEMENT IN INDIA

Core to the vision for waste management in India is the use of wastes as resources with increased value extraction, recycling, recovery, and reuse. ULBs need to be responsible for waste management, with the ULB Commissioner and Chairman directly responsible for the performance of waste management systems. Waste management needs to be regarded throughout Indian society as an essential service requiring sustainable financing. The case presented to a ULB for a properly funded system must demonstrate the advantages of sound investment in waste management.

A strong and independent authority is needed to regulate waste management if SWM is to improve in India. Without clear regulation and enforcement, improvements will not happen. Strong waste regulations can drive innovation (Monika & Kishore, 2010). The waste management sector needs to include attractive and profitable businesses with clear performance requirements imposed by the ULB, with financial penalties applied when waste management services are not working effectively (Agnihotri *et al*., 2021). Finance for waste management companies and funding for infrastructure must be raised from waste producers through a waste tax. An average charge of 1 rupee per person per day would generate close to 50,000 crores annually, and this level of funding would probably be sufficient to provide effective waste management throughout India (Goswami *et al*., 2021).

Information on future quantities and characterization of wastes is essential as this determines the appropriateness of different waste management and treatment options. State-level procurement of equipment and vehicles is necessary for primary and secondary collection with effective systems for monitoring collection, transport, and disposal (Yousefi *et al*., 2021).

Littering and waste in the streets is a major problem in India that has serious impacts on public health. Nagpur has introduced a system for sweeping roads in which every employee sweeps a fixed road length (Kulkarni &Anantharama, 2020).Waste management must involve waste segregation at the source to allow much more efficient value extraction and recycling. Separating dry (inorganic) and wet (biodegradable) waste would have significant benefits and should be the responsibility of the waste producer (Sarkodie *et al*., 2020).

Long-term waste management planning requires visionary project development by ULBs, the private sector, and NGOs. The roles and responsibilities to deliver sustainable systems need to be defined, with monitoring and evaluation to monitor progress. Experiences should be shared between different regions of India and different social groups. There are several research institutes, organizations, NGOs, and private sector companies working on a holistic approach to SWM, and future waste management in India must involve extensive involvement of the informal sector throughout the system (Ram *et al*., 2021).

There is a need to develop training and capacity building at every level. All Indian school children should understand the importance of waste management, the effects of poor waste management on the environment and public health, and the role and responsibilities of each individual in the waste management system (Ferronato & Torretta, 2019). This will develop responsible citizens who regard waste as a resource opportunity.

VI. CONCLUSION

India needs to spend a lot of money to create an effective waste management infrastructure but a clean India will be able to earn more by attracting more tourists. A clean India will also save more on its public health care and also it will

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save money by avoiding those city floods which happen during monsoon due to the drains that are chocked by plastic. Moreover, new jobs will be created and people will start looking at waste as an opportunity to create wealth. In relatively small patches, many streets and districts in India are well maintained and clean too, but these success stories are not enough. India needs a lot more of them and it needs them urgently. Furthermore, India shouldn't follow the unethical Western trend of waste dumping in poorer countries. There is a need to cultivate community awareness and change the attitude of people towards waste, as this is fundamental to developing proper and sustainable waste management systems. Sustainable and economically viable waste management must ensure maximum resource extraction from waste, combined with safe disposal of residual waste through the development of engineered landfill and waste-to-energy facilities. India faces challenges related to waste policy, waste technology selection, and the availability of appropriately trained people in the waste management sector. Until these fundamental requirements are met, India will continue to suffer from poor waste management and the associated impacts on public health and the environment.

VII. ACKNOWLEDGMENT

The data displayed in this study has been taken from the websites of various journals and institutions, which have also been cited as per the requirement. We thank all the institutes and researchers who have published research papers in their respective fields. Electronic data hubs (NCBI, PubMed, SpringerLink, ResearchGate *et al*.) provide us with valuable research items for free for which they should be thanked.

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