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ORF OCCASIONAL PAPER

NOVEMBER 2020

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ORF OBSERVER RESEARCH FOUNDATION

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Solid Waste Management in Urban India: Imperatives for Improvement

ABSTRACT

Across India, existing systems for the collection, transportation and disposal of solid waste are mired in chaos. The problem is more acute in the urban areas, where rapidly growing populations generate increasingly larger quantities of solid waste that urban local bodies (ULBs) are unable to manage effectively. Improper management of solid waste poses risks to the environment and public health. This paper dissects the state of solid waste management in India and offers recommendations to solve the myriad challenges.

Attribution: Satpal Singh, "Solid Waste Management in Urban India: Imperatives for Improvement," *ORF Occasional Paper No. 283*, November 2020, Observer Research Foundation.

INTRODUCTION

Solid waste management (SWM) has emerged as one of the most massive development challenges in urban India. Numerous studies indicate that the unsafe disposal of waste generates dangerous gases and leachates, due to microbial decomposition, climate conditions, refuse characteristics and land-filling operations. According to the 12th Schedule of the 74th Constitution Amendment Act of 1992, urban local bodies (ULBs) are responsible for keeping cities and towns clean. However, most ULBs lack adequate infrastructure and face various strategic and institutional weaknesses, such as poor institutional capacity, financial constraints, and a lack of political will.[1] While many Indian ULBs do receive government assistance, almost all of them continue to be financially fragile. India has already exhausted all available landfill sites, and the concerned ULBs do not have resources to acquire new land. Moreover, finding new landfill sites is a difficult task as local officials are averse to setting aside land in their jurisdiction for waste that come from other areas.[a]

Various legislations have been passed for regulating the manner of waste disposal. The Ministry of Environment, Forest and Climate Change (MoEFCC) and the Ministry of Housing and Urban Affairs (MoHUA) have together rolled out policies and programmes to address these issues. However, most of these have failed to achieve their objectives due to a lack of clarity and awareness amongst the stakeholders, and poor enforcement by the regulators.[2]

a This is popularly known as the mindset, 'Not in My Backyard' (NIMBY). In waste, this translates to the idea that people would not want other people's waste in their surrounding areas. Needless to say, this mentality has made the task difficult for ULBs with respect to waste storage (Mani and Singh, 2015).

REVIEW OF LITERATURE

There is a large volume of literature on the different aspects of SWM in India. For example, in her paper, "Municipal Solid Waste Management in India: A Critical Review," Prof. Sudha Goel suggests that regular monitoring and data collection are essential for designing an efficient SWM system.[3] To improve SWM practices in the country, Goel recommends establishing a centralised database on ULB experiences in SWM, and using modern tools and technology such as remote sensing, GIS and mathematics optimisation.

Meanwhile, in their 2016 paper, Rajkumar Joshi and Sirajuddin Ahmed[4] argue that lack of awareness and technical knowledge, inadequate funding, and ineffective implementation of laws and policies are the reasons for the failure of Municipal Solid Waste Management (MSWM). Som Dutta Banerjee,[5] for his part, highlights the challenge of infrastructure. Banerjee argues that private participation in SWM must be encouraged to ease the burden on the public coffers.

Chavan and Zambare[6] have also observed that the essential inadequacies of SWM in India are in treatment methods and techniques. In his paper, "Sustainable Solid Waste Management in India," Annepu[7] explores ways to reduce the quantity of solid waste. In Mumbai alone, the open burning of solid wastes and landfill fires emit nearly 20,000 tonnes per year of air pollutants on land. Amongst other ways to repurpose waste, such as by creating fly-ash bricks, Annepu recommends the integration of informal recycling into the formal system by training and employing waste-pickers for the door-to-door collection of waste, and allowing them to sell the recyclables they collect.

Gopal Krishna,[8] in his paper, "Why Urban Waste Continues to Follow the Path of Least Resistance," argues that SWM cannot improve unless institutional and financial issues are addressed. Krishna criticises the 2016 SWM Rules, framed by the MoEFCC, Government of India, stating that they fail to make any provision against the NIMBY syndrome or provide a mechanism for the implementation of Extended Producer Responsibility (EPR).[b] The paper suggests that the rules should incentivise systems where producers minimise waste and take responsibility for the reuse and/or recycling of used products.

In their paper, "Sustainable Municipal Solid Waste Management in India: A Policy Agenda,"[9] Shyamala Mani and Satpal Singh suggest that the policy agenda for sustainable SWM needs to drive behavioural change amongst citizens, elected representatives and decision-makers to minimise waste and maximise reuse and recycling.

There is also the study of the SWM system in urban India by Karthykeyan et al.[10] It finds the failure of ULBs in providing proper SWM service and the general lack of awareness to be the main reasons for poor waste management in India. Thus, the rationale for encouraging private-sector participation (PSP) is to gain efficiency, expertise and technology, not finance. If the private sector provides higher standards of waste management service at the same cost, or equivalent service at a lower cost, compared to ULBs, then PSP

b Extended Producer Responsibility (EPR) is a policy approach wherein a producer is held responsible for the post-consumer stage of a product, typically for defined tasks, recycling and storage and treatment. EPR programmes are commonly made mandatory through legislation, but can also be adopted voluntarily (MoHUA, 2016).

should be leveraged for private-sector efficiency and to ameliorate the methods of waste management by ULBs.

In "Transforming Urban Waste Management in India," Mazumdar[11] outlines the various tools to overcome the problems of urban waste management. The study recommends that urban waste management be streamlined using technology, and that the system of SWM be made techno-economically viable and sustainable.

The author of this paper, in a previous one, "Decentralised Solid Waste Management in India: A Perspective on Technological Options,"[12] proposed a decentralised approach to SWM, along with appropriate technologies to solve the problems of processing and treating waste.

SOLID WASTE MANAGEMENT IN INDIAN CITIES

Solid Waste Generation and Composition

In 2016, the world's cities collectively generated 2.01 billion tonnes of MSW, with a per capita volume of 0.74 kilograms per day.[13]. "With rapid population growth and urbanisation, annual waste generation is expected to increase by 70 percent from 2016 levels to 3.40 billion tonnes in 2050."[14]

Table 1: Regional Waste Generation (annual)

Region	Waste Generation (Million Tonnes)
East Asia & The Pacific	468
Europe & Central Asia	392
South Asia	334
North America	289
Latin America & The Caribbean	231
Sub-Saharan Africa	174
Middle East & North Africa	129

This variation in the solid waste generation is based on various factors, including population growth, improved incomes, and changing consumption patterns.[15] The growth of urban population, in particular, directly results in increased waste generation.

In India, the volume of waste generation has been increasing rapidly over the last few years. According to the "Swachhata Sandesh Newsletter" by the MoHUA, as of January 2020, 147,613 metric tonnes (MT) of solid waste is generated per day, from 84,475 wards (See Table 2). The 2014 report by the "Task Force on Waste to Energy," under the Planning Commission,[16] estimates that urban India will generate 2,76,342 tonnes per day (TPD) of waste by 2021; 4,50,132 TPD by 2031; and 11,95,000 TPD by 2050. The per capita waste generation is 450 grams per day, and has increased at a rate of 1.3 percent per annum.[17] The amount of waste generation in 84,456 wards varies from 32 MT to 22,080 MT per day, as of January 2020. Maharashtra generates the highest, at 22,080 MT per day (from 7,322 wards), while Sikkim generates the lowest, at 89 MT per day (from 53 wards). Amongst the Union Territories (UTs), Delhi generates the highest amount of waste, at 10,500 MT per day. Overall, Daman & Diu is the lowest waste generator in India.

Table 2: Waste Generation by Wards under SBM, as of January 2020

States/UTs	Total Wards	Total Waste Generation (MT/D)
Andhra Pradesh	3,409	6,141
Andaman and Nicobar	24	90
Arunachal Pradesh	75	181
Assam	943	1,432
Bihar	3,377	2,272
Chandigarh	26	479
Chhattisgarh	3,217	1650

States/UTs	Total Wards	Total Waste Generation (MT/D)
Daman & Diu	28	32
Dadra & Nagar Haveli	15	55
Delhi	294	10,500
Goa	217	250
Gujarat	1,427	10,274
Haryana	1,496	4,783
Himachal Pradesh	497	377
Jammu & Kashmir	1,081	1,489
Jharkhand	932	2,135
Karnataka	6,464	10,000
Kerala	3,536	2,696
Madhya Pradesh	7,115	6,424
Maharashtra	7,322	22,080
Manipur	306	174
Meghalaya	114	268
Mizoram	264	236
Nagaland	234	461
Odisha	2,024	2,721
Puducherry	122	415
Punjab	3,123	4,100
Rajasthan	5,389	6,500
Sikkim	53	89
Tamil Nadu	12,814	15,437
Telangana	2,112	8,634
Tripura	310	450
Uttar Pradesh	12,007	15,500
Uttarakhand	1,170	1,589
West Bengal	2,938	7,700
Total/Average	84,475	14,7613

Source: MoHUA, 2020.[18]

Solid waste can be separated into three categories: (i) biodegradable waste or organic waste (food and kitchen waste, green waste vegetables, flower, leaves, fruits and paper, etc.), (ii) inert and non-biodegradable waste (construction and demolition waste, dirt, debris, etc.) and (iii) recyclable waste (plastic, paper, bottles, glasses, etc.). The report by the Task Force of the Planning Commission places biodegradable waste at 52 percent, followed by inert and non-biodegradable components at 32 percent. The share of recyclable waste is placed at 17 percent and has seen a constant rise over the years. Based on the data available on a few cities, biodegradable waste varies between 55 to 60 percent on an annual basis.[19]

The increasing quantity of plastic waste has become a significant challenge and is a major contributor to environmental degradation. India generates 26,000 TPD of plastic waste, i.e. 9.4 million tonnes per annum. To address this issue, the National Green Tribune (NGT) has directed the Central Pollution Control Board (CPCB) to implement a strict ban on the import of plastic waste in India, since it is toxic to the environment. Moreover, massive plastic collection drives have been conducted, and as of 21 October 2019, a whopping 4,024 MT of plastic waste has been collected with the help of over 6.41 crore citizens.[20] Much of this non-recyclable plastic is used in the construction of roads and furnace oil. According to the NGT bench, "Local bodies to encourage the use of plastic waste for road construction or waste to energy etc. ... every producer or brand owner is required to make an application for registration or for renewal of registration and such registration is done as per checklist issued by the CPCB." [21] The Ministry, too, is actively engaging with the National Highway Authority of India (NHAI) to ensure the reuse of the non-recyclable plastic waste collected, with the Ministry of Road Transport and Highways encouraging the use

of plastic waste in the construction of national highways, especially in areas that have a population of five lakh or more.

On the occasion of World Environment Day on 5 June 2017, the Government of India announced a "National Strategy" to phase out all forms of single-use plastic by 2022, to eliminate not only plastic bags and bottle but also other items such as plastic cutlery, straws, Styrofoam containers and coffee stirrers. A FICCI study estimates that 43 percent of India's plastic goes towards making disposable, single-use packaging, like those used by e-commerce facilities such as Amazon and Flipkart.[22] A total of 18 states and UTs have imposed bans on plastic manufacture, stock, sale, or use of plastic carry bags, including Andhra Pradesh, Arunachal Pradesh, Assam, Chandigarh, Chhattisgarh, Delhi, Goa, Gujarat, Himachal Pradesh, Jammu & Kashmir, Karnataka, Maharashtra, Odisha, Sikkim, Tamil Nadu, Uttar Pradesh, Uttarakhand and West Bengal.[23] However, the bans have not been successfully enforced due to poor state capacity.[24]

Waste Collection and Transport

Waste collection and transport are essential elements of SWM. The MoEFCC estimates that only 75–80 percent of the total municipal waste gets collected and only 22–28 percent of this is processed and treated.[25] A large portion of the collected waste is often dumped indiscriminately, clogging the drains and sewerage systems. These also become breeding grounds for rodents and insects, which are vectors of deadly diseases. According to a study released by ICRIER in January 2020, Delhi has the lowest collection of garbage (39 percent) while Ahmedabad has the highest (95 percent).[26]

The country's informal sector plays a huge role in waste management. However, informal-sector workers are not officially recognised and lack legal status and protection. They collect more than 10,000 tonnes of reusable waste every day, without protective equipment such as gloves and masks, and often even the essentials of uniforms and shoes.

Current SWM rules do not provide any incentives for waste-pickers, nor do they recognise the economic value of informal waste recycling work.[27] Under the new rules, municipalities are directed to include the informal waste-pickers in their waste-management process. Under the Swachh Bharat Mission-Urban (SBM-U), the Government of India has published a guide, "An Inclusive Swachh Bharat through the Integration of the Informal Sector: A Step by Step Guide," to help ULBs and states integrate informal waste-pickers and promote the reuse and recycling of solid waste.

One key aspect of efficient SWM is "waste segregation." It is now mandatory for waste generators to deposit their waste in colour-coded bins—blue for dry waste and green for wet waste—to ensure proper recovery, reuse and recycling. This reduces the burden of SWM on ULBs significantly. Wet waste is used for composting or biomethanation in a decentralised manner.[28] Tamil Nadu has achieved 100 percent segregation in 20 of its 50 smaller municipalities, and 80–90 percent in the rest. However, in most states, the mixing of segregated and unsegregated waste remains a serious problem. To motivate people to segregate their waste, the MoHUA launched a "Source Segregation Campaign" on World Environment Day 2017, under the Swachh Bharat Mission. Under this Campaign, all cities and towns were to adopt "source segregation" as a mass movement. According to the 2020

"Swachhata Sandesh Newsletter" by the MoHUA, 63,204 wards (74.82 percent) have achieved 100 percent waste segregation at the household level as of January 2020 (See Table 3). In Chhattisgarh and Kerala, all households in all wards have successfully adopted the practice of waste segregation. Amongst the UTs, Daman & Diu and Dadra & Nagar Haveli have achieved 100 percent source segregation.

Table 3: 100-percent Source Segregation by Wards under SBM, as of January 2020

States/UTs	Total Wards	Ward with 100% Source Segregation
Andhra Pradesh	3,409	3,300
Andaman and Nicobar	24	23
Arunachal Pradesh	75	11
Assam	943	368
Bihar	3,377	1,107
Chandigarh	26	24
Chhattisgarh	3,217	3,217
Daman & Diu	28	28
Dadra & Nagar Haveli	15	15
Delhi	294	59
Goa	217	173
Gujarat	1,427	1,187
Haryana	1,496	935
Himachal Pradesh	497	490
Jammu & Kashmir	1,081	137
Jharkhand	932	752
Karnataka	6,464	3,694
Kerala	3,536	3,536
Madhya Pradesh	7,115	7,005
Maharashtra	7,322	6,346
Manipur	306	196
Meghalaya	114	27
Mizoram	264	230
Nagaland	234	30

States/UTs	Total Wards	Ward with 100% Source Segregation
Odisha	2,024	1,402
Puducherry	122	116
Punjab	3,123	2,664
Rajasthan	5,389	4,419
Sikkim	53	50
Tamil Nadu	12,814	10,891
Telangana	2,112	1,008
Tripura	310	243
Uttar Pradesh	12,007	8,294
Uttarakhand	1,170	669
West Bengal	2,938	558
Total/Average	84,475	63,204

Source: MoHUA, 2020.[29]

The new SWM rules of 2016 have mandated the door–to-door collection of segregated waste with waste generators obligated to pay a "user fee" to the waste-collectors. However, the rules do not provide details on how the fee is decided—whether it is charged based on the quantity or type of waste generated.[30] According to the "Swachhata Sandesh Newsletter," 81,135 wards (96.05 percent) out of 84,475 wards across India have achieved 100 percent door-to-door waste collection as of January 2020, including all wards in Andhra Pradesh, Arunachal Pradesh, Chhattisgarh, Goa, Gujarat, Karnataka, Madhya Pradesh, Mizoram, Rajasthan, Sikkim and Uttarakhand. All UTs, too, now have 100 percent provision of door-to-door collection (See Table 4). At the city-level, Mysuru has made significant progress in this area, as well as in source segregation. Mumbai and Chennai have achieved 80 percent door-to-door collection.[31] In 2012, Warangal won the Clean Cities Championship; however, Tirunelveli, Vengurla and Uttarpara-Kotrung are yet to achieve complete door-to-door collection of waste.

Table 4: 100-percent Door-to-Door Collection by Wards under SBM, as of January 2020

States/UTs	Total Wards	Wards with 100% Door-to-Door Collection
Andhra Pradesh	3,409	3,409
Andaman and Nicobar	24	24
Arunachal Pradesh	75	75
Assam	943	698
Bihar	3,377	3,276
Chandigarh	26	26
Chhattisgarh	3,217	3,217
Daman & Diu	28	28
Dadra & Nagar Haveli	15	15
Delhi	294	294
Goa	217	217
Gujarat	1,427	1,427
Haryana	1,496	1,401
Himachal Pradesh	497	490
Jammu & Kashmir	1,081	809
Jharkhand	932	897
Karnataka	6,464	6,464
Kerala	3,536	3,022
Madhya Pradesh	7,115	7,115
Maharashtra	7,322	6,590
Manipur	306	270
Meghalaya	114	27
Mizoram	264	264
Nagaland	234	148
Odisha	2,024	2,009
Puducherry	122	122
Punjab	3,123	3,064
Rajasthan	5,389	5,389
Sikkim	53	53
Tamil Nadu	12,814	12,429
Telangana	2,112	2,020
Tripura	310	277
Uttar Pradesh	12,007	11,872

States/UTs	Total Wards	Wards with 100% Door-to-Door Collection
Uttarakhand	1,170	1,170
West Bengal	2,938	2,527
Total/Average	84,475	81,135

Source: MoHUA, 2020.[32]

The transportation of solid waste is yet another challenge, since many cities lack proper transport facilities. The vehicles typically used for primary collection are handcarts or tricycle with containers or bins, tricycle with hydraulic tipping containers, light commercial vehicles (mini truck) with hydraulic tipping containers, four-wheeled mini trucks with international standard garbage collection bins. The selection of vehicles usually depends on various factors such as the quantity of waste, distance, road width and condition, and process technologies. To save travel time, minimise human errors, and improve the monitoring system, many ULBs have installed Global Positioning System (GPS), Geographic Information System (GIS) and Global System for Mobile Communication in their trucks to collect waste from secondary sources for waste disposal.

Processing, Treatment and Disposal of Solid Waste

The processing technologies currently adopted in India include composting, biomethanation, recycling, refuse-derived fuel, incineration, pyrolysis, waste-to-wealth and waste-to-energy. Which technology is used depends on a variety of factors: the kind and quantity of waste available and its calorific value, fund and resource availability, capital investment, cost recovery, in-house capacity of ULBs, land availability, and environmental sensitivity to locations.

Chhattisgarh processes the highest proportion of waste (90 percent) amongst all states, while Meghalaya processes the lowest (four percent). Amongst the UTs, Dadra & Nagar Haveli processes 100 percent waste, whereas Chandigarh processes 95 percent. Delhi processes only 55 percent, which is below the average of 60 percent across 84,475 wards (See Table 5).

Table 5: Total Waste Processing under SBM, as of January 2020

States/UTs	Total Wards	Total Waste Processing (%)
Andhra Pradesh	3,409	63
Andaman and Nicobar	24	95
Arunachal Pradesh	75	0
Assam	943	53
Bihar	3,377	51
Chandigarh	26	95
Chhattisgarh	3,217	90
Daman & Diu	28	75
Dadra & Nagar Haveli	15	100
Delhi	294	55
Goa	217	70
Gujarat	1,427	87
Haryana	1,496	48
Himachal Pradesh	497	78
Jammu & Kashmir	1,081	16
Jharkhand	932	60
Karnataka	6,464	54
Kerala	3,536	71
Madhya Pradesh	7,115	87
Maharashtra	7,322	58
Manipur	306	58
Meghalaya	114	4
Mizoram	264	35
Nagaland	234	60
Odisha	2,024	48

States/UTs	Total Wards	Total Waste Processing (%)
Puducherry	122	13
Punjab	3,123	61
Rajasthan	5,389	72
Sikkim	53	70
Tamil Nadu	12,814	68
Telangana	2,112	78
Tripura	310	53
Uttar Pradesh	12,007	58
Uttarakhand	1,170	46
West Bengal	2,938	9
Total/Average	84,475	60

Source: MoHUA, 2020.[33]

Large quantities of waste are usually processed through either biomethanation or composting technology for generating biogas, electricity and compost. Biogas has 55–60 percent methane and can be used as fuel for power generation. For the treatment of biodegradable waste, the commonly adopted methods are aerobic composting and vermicomposting. This compost is used for growing vegetables and plants in homesteads.

A key component of composting is the efficient segregation of waste, which becomes a constraint in India, where mixed waste is often dumped in open areas. (This is also a major contributor to global warming.) Segregation can help reduce the burden of transportation of waste as well as lower leachate and greenhouse gas (GHG) emissions. If the waste is segregated at source, various components can be utilised in different types of production processes, generating marketable use value.[34]

Source segregation of waste helps in recovering and utilising a higher percentage of recyclable waste. Dry waste contains several

non-recyclable components, such as plastic bags, laminated metallised plastics or mylar, shredded paper and textiles. While glass, plastics and metals are recyclable, paper is both recyclable and biodegradable. Currently, "seven million tons of paper is being consumed in India for packaging, of which only 33 percent is being collected and recycled." Used newspapers, textbooks, magazines etc. are either used for making paper bags or recycled to produce newsprint and writing or printing papers. The reuse and recycling of plastic require little energy during production.[35] Shopping bags can be converted to eco-friendly recycled products. The Coorg municipality in Karnataka has been recycling plastic carry bags using polylooms, which is a plastic weaving handloom.

The 2016 SWM Rules define recycling as "the process of transforming segregated solid waste into a new product or a raw material for producing new product." Reusable and recycled waste constitute 18–20 percent of the total waste and the process of separating them from mixed waste is both energy- and time-intensive. Recyclable material is generally collected by ragpickers, waste-pickers, itinerant waste buyers (*kabariwala*), dealers and recycling units, which reduces the volume of waste and saves the cost of collection, transportation and disposal; lowers the burden on landfill sites; and reduces pollution and other environmental impacts. Moreover, recycling has significant economic benefits, such as reducing the need for import of raw materials and fertiliser and providing livelihood opportunities for recyclers.

From an economic perspective, recycling pays only when the additional cost of collection materials, sorting them for recycling, and recycling and marketing them is recovered from the recycled product.[36] According to a study conducted by ICRIER, few cities

have biomethanation plants that produce manure, whereas composting facilities are present in many cities, although heavily underutilised because of a lack of demand for compost.

Disposal of Solid Waste

Waste dumping and open burning continue to be the principal methods of waste disposal in India. Most of the cities and towns dispose of their waste by depositing it in low-lying areas outside the city. The report of the Planning Commission of 2014 found that over 80 percent of the waste collected in India is disposed of indiscriminately in dump yards in an unhygienic manner, leading to health and environmental degradation. "The stench and ugly sight of garbage dumped on the road side, sometimes overflowing from drains or floating on the surface of the rivers is not at all uncommon in India. Also, with clogging of the drains with garbage, there is water logging and flooding of residential areas, roads and even railway tracks in the rainy season disrupting normal life. People also litter the streets and public places excessively."[37]

Landfilling technology is frequently used for the disposal of waste in India. However, the dumping grounds are often unsustainable as landfills, since they have no foundations, liners, levelling, cover soil, leachate management or treatment facility.[38] Research shows that most landfills in the country have now been exhausted. According to Dr. Gopal Krishna, seeking new sites for landfill and waste-processing facilities beyond municipal limits is likely to have grave political implications. The 2016 SWM Rules fail to provide the exact criteria for identifying such facilities, and the prevailing conditions lead to land-use conflict. The NIMBY syndrome, in particular, makes it difficult to find and acquire new

landfill sites. For instance, in Delhi, sites were identified in places such as Jaitpur in South East Delhi and Bawana in North West Delhi, but the proposals were opposed by the local inhabitants and villagers, who did not want garbage being dumped in their surroundings. A proposal to have landfills in Okhla Phase-I has also faced protest, since the land belongs to the Indian Railways, along with Sultanpur Dabas in North West Delhi and Tehkhand in South East Delhi.[39] The residents of Sukhdev Vihar, Ishwar Nagar, New Friends Colony, Jasola, Sarita Vihar and Haji Colony have protested against the waste-to-energy (WtE) plant in Okhla. According to residents, the lack of clean, breathable air and the 2,000-tonne per day waste incinerator at Okhla were the main election issue.[40] To address the issue, cities have started planning for decentralised disposal and treatment of waste within their geographical limits. Innovative measures such as 3Rs (Reduce, Reuse, Recycle) and the installation of "waste-to-compost" and biomethanation plants would help to reduce the load on landfill sites.

A widely used technology for recycling residual waste is WtE, which uses combustion to provide heat and power. Adopting recycling with this technology can significantly reduce dumping in India. RDF for resource recovery is not only an economically viable option for solid waste but also greatly reduces the requirement for landfill space. Increasing the use of this technology "would reduce disposal to land and generate clean, reliable energy from a renewable fuel source, reducing dependence on fossil fuels and reducing Greenhouse Gas (GHG) emission." However, "the majority of facilities have not worked effectively due to various operational and design problems."[41]

GOVERNMENT RULES AND POLICIES FOR SWM

Solid Waste Management Rules, 2016

The MoEFCC revised and notified the SWM Rules in April 2016, which replaces the Municipal Solid Waste (Management and Handling) Rules, 2000. The new rules have extended beyond the municipal jurisdiction. It provides for waste generators to segregate waste at source and allocate dry waste such as paper, plastic, glass and metal for recycling and reuse, as well as utilise wet waste from the kitchen for composting or biomethanation. The local authorities are responsible for setting up "the material recovery facilities or secondary storage facilities with sufficient space for sorting of recyclable materials to enable informal or authorised waste-pickers and waste-collectors to separate recyclables from the waste and provide easy access to waste-pickers and recyclers for collection of segregated recyclable waste such as paper, plastic, metal, glass, textile from the source of generation or from material recovery facilities." Moreover, the new rules prohibit waste generators from throwing, burning or burying solid waste in open public spaces, outside premises, or in drains and water bodies. Waste generators now have to pay a "user fee" to the waste-collector and a "spot fine" in case of littering and non-segregation. The rules enable ULBs to frame by-laws and prescribe the criteria for levying spot fines. The 2016 SWM Rules further recommend biodegradable waste to be processed, treated and disposed of within the premises, through composting or biomethanation.[42] Schedule 1 of the Rules provides the engineering specifications and criteria for setting up and operating landfill sites.[43]

Currently, the rules for waste segregation and recycling are poorly implemented, and many cities have failed to integrate door-

to-door collection into the informal sector. Further, the rules do not address the problems created by the NIMBY syndrome. According to the guidance note on MSWM, compliance with the SWM rules requires that appropriate systems and infrastructure facilities be put in place to undertake the scientific collection, management, processing and disposal of SWM. The 2016 Rules have recommended the constitution of a Central Monitoring Committee under the chairmanship of the Secretary of the MoEFCC. This committee will be responsible for monitoring the overall implementation of the 2016 SWM Rules.

Plastic Waste Management Rules, 2016

The MoEFCC notified the Plastic Waste Management Rules of 2016 in suppression of the earlier Plastic Waste (Management and Handling) Rules of 2011. The new rules expand the jurisdiction from the municipal area to rural areas, since plastic has now reached villages. The responsibility of waste generators is to segregate and store the plastic waste generated in accordance with the SWM Rules of 2016 before handing it over to an authorised waste collection agency. The rules mandate a user fee to be paid by waste generators, as may be specified in the by-laws of ULBs for plastic waste management.

The MoEFCC further updated the Plastic Waste Management Rules of 2016, now called Plastic Waste (Amendment) Rules of 2018. The amendments lay out the challenges and opportunities in terms of collection, segregation and recycling of plastic waste, and propose policy and administrative interventions. Three major changes have been incorporated in the amendment. **First**, the term "non-recyclable multilayered plastic" has been replaced by "multi-

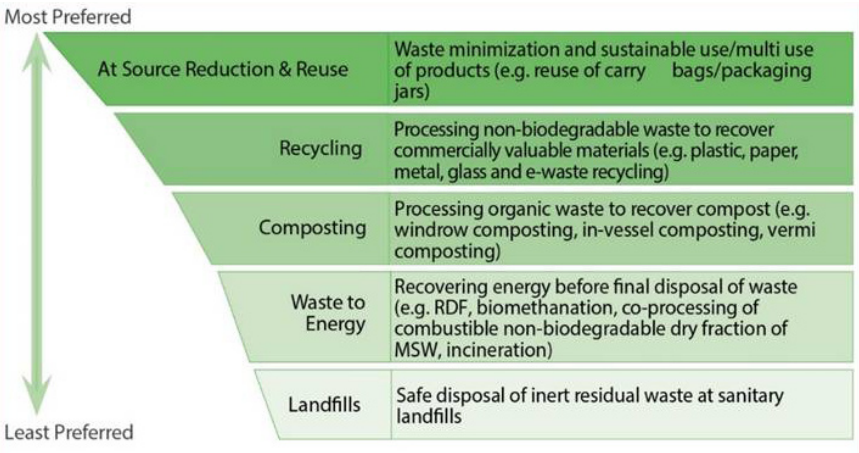
layered plastic which is non-recyclable or non-energy recoverable or with no alternate use" under Rule 9, in Sub-Rule 3. **Second**, Rule 15, dealing with the pricing of carry bags, has been omitted. "The rule earlier required vendors, who made plastic bags available, to register with the respective ULB ... the new rules attempt to establish a Centralised Registration System by mandating brand owners and producers operating in more than two states to register with the CPCB."[44] Third, the concept of Extended Producer Responsibility (EPR) has been introduced, according to which both producers and brand owners are responsible for collecting waste. Since plastic carry bags are the biggest component of littered waste, it has been proposed to increase the minimum thickness of carry bags from 40 microns to 50 microns, and a minimum thickness of 50 microns has been mandated for plastic sheets used in packaging and wrapping commodities. This will facilitate efficient collection and recycling of plastic waste.

Municipal Solid Waste Management Manual, 2016

The MoHUA, in collaboration with GIZ (Deutsche Gesellschaft fur Internationale Zusammenarbeit), developed the Manual for MSWM, in line with the SWM Rules of 2016. The Manual provides guidance to ULBs on planning, design, implementation and monitoring of MSWM systems. It advocates for the proper planning and management of MSW through a seven-step approach and advises on how to choose appropriate options for a city, based on the amount of waste generated, local waste characteristic, local geographical conditions, availability of land and other relevant criteria. This approach places special emphasis on community or stakeholder contribution and inter-departmental coordination at the local-authority level to ensure implementation success.

The planning process suggests the adaptation of the integrated solid waste management (ISWM) hierarchy (See Figure 1) for deciding the processing or technology solutions for MSW. Waste minimisation at source and reuse of products are the most preferred waste prevention strategies, followed by recycling to recover material resources to create new products. The least preferred option is the disposal of waste in open dumpsites. The ISWM is very closely linked to the 3R approach. It is a useful guiding document for all ULBs to ensure the environmentally sound management of solid waste and promote resource recovery from waste.

Figure 1: Integrated Solid Waste Management System Hierarchy



Source: MoUHA, 2016.[45]

Swachh Bharat Mission (Urban)

The Swachh Bharat Mission (SBM) was launched by the Indian government on 2 October 2014 for five years (2014–19), aimed at creating a "Clean India", with an emphasis on eliminating open defecation by October 2019. The SBM addresses the growing problems of open defecation, sanitation, and SWM. It seeks people's

participation in creating a trash-free environment, providing sanitation facilities and paving a way for Swachh Bharat.

The Mission Directorate has taken several steps to help cities accelerate their progress of implementation. Some of the important initiatives under this are discussed below:

Conducting Swachh Survekshan

Various rounds of Swachh Survekshan (SS) were conducted by the MoHUA to encourage citizen participation, ensure sustainability of initiatives taken towards garbage-free and open-defecation-free cities, institutionalise existing systems through online processes, and create awareness amongst all sections of society. The first round of the annual cleanliness survey was conducted in January 2016 across 73 cities; the second round was conducted in January–February 2017 across 434 cities. The third round was conducted in 2018 across 4,203 cities in 66 days, and became the largest-ever Pan-India Sanitation Survey in the world, impacting around 40 crore people. The fourth survey, SS-19, covered 4,237 cities in a record time of 28 days and was a fully digitised and paperless (See Table 6).

The fifth round of the annual Swachh Survekshan was conducted from 4 January 2020 to 31 January 2020 (28 days) in urban areas of the country, across 4,242 ULBs, 62 cantonment boards, and 92 Ganga towns under the aegis of SBU. The objective of the survey was to sustain the on-ground performance of cities along with continuous monitoring of the service level performance when it comes to cleanliness.[46] The results were declared on 20 August 2020, with Indore (Madhya Pradesh) retaining the first position. Surat (Gujarat) and Navi Mumbai (Maharashtra) grabbed the second and third positions, respectively. Varanasi (Uttar Pradesh) was the

Table 6: Swachh Survekshan, 2016 to 2020

	First Survey	Second Survey	Third Survey	Fourth Survey	Fifth Survey
Year	**2016**	**2017**	**2018**	**2019**	**2020**
Cities Covered	73-all million plus	434-Amrut Cities	4,203-ULBs+61 Cantonment Boards	4,237 ULBs + 62 Cantonment Board	4242 ULB+62 Cantonment Board + 92 Ganga Towns
Location	3,000+locations in 73 million plus cities	17,500 locations in 434 cities and towns	2.5 lakh survey locations	6.53 lakh survey locations	6,01,519 survey locations
Impact	NA	NA	40 crores lives	43 crores lives	
Top Five Cities	Mysuru Chandigarh Tiruchirappalli New Delhi Municipal Council Visakhapatnam	Indore Bhopal Visakhapatnam Surat Mysuru	Indore Bhopal Chandigarh Vijayawada Mysuru	Indore Ambikapur Mysuru Ujjain New Delhi Municipal Council	Indore Surat Navi Mumbai Vijayawada Ahmedabad

Source: MoHUA.

best Ganga town surveyed, while Patna and Gaya in Bihar were declared the dirtiest cities in the country. Amongst the 47 cities surveyed, South Delhi Municipal Corporation (SDMC), the North Delhi Municipal Corporation (NDMC) and the East Delhi Municipal Corporation (EDMC) were ranked 31, 43 and 46, respectively. However, the New Delhi Municipal Council (NDMC) emerged as the "Cleanest Capital City." Amongst the cantonment boards, Jalandhar ranked at the top, followed by the Delhi Cantonment Board.

The MoHUA launched the toolkit for the Swachh Survekshan 2021 on 3 July 2020. A new category of awards titled "Pretak Daaur Samman" was announced as part of SS-21. The award has five additional subcategories: Divya (Platinum), Anupam (Gold), Ujjwal (Silver), Udit (Bronze), Aarohi (Aspiring). The new award will categorise cities based on six indicator-wise performance criteria:

i. Segregation of waste into wet, dry and hazard categories

ii. Processing capacity against wet waste generated

iii. Processing and recycling of wet and dry waste

iv. Construction & Demolition (C&D) waste processing

v. Percentage of waste going to landfills

vi. Sanitation status of cities[47]

Star Rating of Garbage-Free Cities

To ensure continued scientific management of solid waste and motivate cities to achieve increased cleanliness, the MoHUA launched the Star-Rating Protocol of Garbage-Free Cities on 20 January 2018. The rating protocol is an outcome-based tool, not a process-based one. The single metric rating system, based on 12

parameters,[c] builds on the spirit of healthy competition amongst cities and the aspirations of cities to progress towards higher standards of "Swachhata" and sustainability.[48] The most significant feature of the rating protocol is that it provides stakeholders with a single metric to rate a city's overall cleanliness. Cities are required to carry out self-assessment and self-verification to achieve a certain star rating. To ensure that the star-rating aligns with the vision of making SBM a "Jan Andolan," citizen groups have to be involved through the system of self-declaration. The star rating is supported by a robust verification mechanism to ensure transparency and standardisation.

The MoHUA introduced a revised "Star-Rating Protocol for GFC 2019" on 28 June 2019 under the SBMU, as a single metric rating system for holistic evaluation of cleanliness and SWM through a graded approach. Based on the feedback received from states and cities, the following amendments have been recommended:

i. "Pre-qualifying criterion of **Domestic Hazardous Waste Processing** shall not be applicable for 1-Star and 3-Star certification. This criterion shall be evaluated only for 5-Star and 7-Star certification.

c The 12 parameters include door-to-door waste collection; segregation at source; sweeping of public spaces, commercial spaces and residential areas; waste storage bins, litter bins and material recovery facility; bulk waste generator's compliance; scientific waste processing, scientific landfills and C&D waste management; user fees; penalties, spot fines for littering, and enforcement of the ban on plastic; citizen grievance redressal and feedback system; eradication of crude dumping of garbage and dump remediation; cleaning of stormwater drains and the surface of water bodies; and visible beautification in the city.

ii. Desirable component with respect to Sustainability (D1) shall not be applicable for 1-Star and 3-Star and shall be evaluated only for 5-Star and 7-Star certification.

iii. Mandatory Component with respect to Grievance Redressal (M10) will be modified."[49]

Swachhata Hi Sewa Campaign

The "Swachhata Hi Sewa" Campaign was launched on 15 September 2017, with the aim of ensuring cleanliness through the various stakeholders in the "Jan Andolan" (National Movement). The highlights of the campaign that made it a success are listed below:

i. **Sewa Diwas**: A nationwide *shramdaan* (volunteering for cleanliness service) by stakeholders

ii. **Samagra Swachhata**: *Shramdaan* by citizens at large, municipal bodies, SBM ambassadors and corporates

iii. **Sarvatra Swachhata**: Massive cleanliness drives at iconic spots[50]

Compost Banao, Compost Apnao Campaign

The Urban Ministry launched a new multi-media campaign on waste-to-compost, titled "Compost *Banao*, Compost *Apnao*" under SBM-(U). The aim is to encourage people to convert their kitchen waste into compost for use as fertiliser and to reduce the amount of waste going to landfill sites. This campaign is an attempt to encourage citizens to contribute towards making their city clean.

THE IMPACT OF COVID-19

The COVID-19 pandemic is one of the gravest global crises in the modern era. In response to the pandemic, most countries imposed mandatory lockdowns, restricting the movement of the people. In India, the nationwide mandate came into effect on 25 March 2020 and was renewed four times, until 31 May 2020.[51]

Since the enforcement of the lockdowns, the Solid Waste Association of North America has noted many changes in the quantity and source of solid waste generated. While there has been no proven case of COVID-19 transmission through healthcare waste, "... excessive volume of COVID-19 waste (personnel protective equipment (PPE) kits, surgical mask, gloves) has become a significant challenge for its proper handling to the waste management authorities." To address the issue, guidelines have been articulated for citizens to effectively reduce and segregate waste. "[The] European Commission has formulated a guidelines document for waste management in the context of COVID-19 crisis ... The US occupational safety and health administration (OSHA) has pre-defined the safety guideline for personnel involved in MSW management ... The developing countries including India, Vietnam and Malaysia have published guidelines for the handling of medical waste and waste generated in infected households."[52] Additionally, many organisations have formulated guidelines for handling biomedical waste during the pandemic, including the Central Pollution Control Board, World Health Organisation, Centres for Disease Control and Prevention, International Solid Waste Association, and Occupational Safety and Health Administration.

The MoHUA is dedicated to promoting scientific SWM, especially in quarantined households. Sanitation workers who are

at the frontlines are amongst the most vulnerable due to the nature of their work. Keeping this in mind, the MoHUA has released multiple guidelines and advisories to be followed by states, local governments, and contractors employing sanitation and faecal waste management workers. The Central Advisory is divided into three board categories.

i. Standard Operating Procedure

ii. Specific measures for sanitation workers

iii. Availability of PPE kits/safety gears and disinfectants for sanitation workers

In addition to the broad categories, the MoHUA has issued advisories to help ULBs in the following areas:

i. Special cleaning of public places

ii. Safe disposal of waste from quarantined households

iii. Safe disposal of masks and other related waste from quarantined households, and transportation without mixing with other household wastes

iv. Welfare and protection of sanitary workers engaged in collection and transportation of COVID-19 waste

Several states and ULBs have also formulated their own digital solutions to control the spread of the virus and monitor the situation, such as smart-phone applications, online health tests, GIS and electronic passes. The District Administration of Jalandhar

has launched an app via Alluzo and a WhatsApp-based service to order essential services, available on government prices. Indore, the cleanest city in Madhya Pradesh, is using drones to sanitise crowded areas. The Indore Municipal Corporation has deployed two drones from private companies to sprinkle chemicals in such areas. Dungarpur (Rajasthan) has done exceptionally well in containing the spread COVID-19 despite limited resources. In Alappuzha, ULBs have come together to start a community kitchen for migrant labourers. "South Delhi Municipal Corporation has converted 91 of its Government Schools into shelters to accommodate hundreds of homeless and migrant workers."[53]

The nationwide lockdown has caused massive changes in the waste-management sector, such as an increase in the amount of infectious and biomedical waste, and a decrease in the percentage of MSW reaching landfills or dumpsites. While the amount of SWM has decreased due to the closure of restaurants, markets, malls etc., waste collection efficiency has been affected due to the decrease in municipal employees. "After the imposition of the lockdown, many waste-pickers could not pick up waste either because of restriction by police or apartment societies, affecting waste collection."[54] Moreover, the combined effect of the health crisis and economic slowdown has impacted the health and livelihoods of informal-sector workers.

EMERGING CHALLENGES IN SWM

India is the third-largest producer of solid waste, after only China and the United States. It faces significant challenges associated with waste collection, transportation, treatment and disposal. ULBs are ill-equipped to handle the increasing quantity of waste,

which is a direct result of India's ever-increasing urban population and average income, leading to drastic changes in the consumption pattern in cities. Some of the key challenges for the SWM system include a lack of waste segregation and doorstep collection, the use of inappropriate technologies for treatment, and the indiscriminate disposal of waste. A callous public attitude towards waste further exacerbates the situation. The key challenges in the context of SWM in India are briefly listed below:

1. Data on the quantum of waste generation in India is conflicting, since there is no system of periodic data collection on waste generation. Consequently, the estimations and projections of solid waste vary wildly from one agency to the other.

2. SWM Rules 2016 mandate the segregation of waste at the household level, i.e. waste generators must segregate the waste into the three categories: biodegradable, non-biodegradable and hazardous waste. Thereafter, the segregated waste must be handed over to the authorised waste-collectors. However, ULBs have failed to establish systems and technologies required for segregation, collection and processing of different categories of waste. Moreover, there is a public lack of awareness regarding the process of segregation.

3. Research has shown that waste collection efficiency is low in India, due to non-uniformity in the collection system. Waste collection efficiency is 100 percent only in those areas where private contractors and non-governmental organisations are actively involved.

4. Most cities and towns in India dispose of their waste by depositing it in low-lying areas outside the city, without taking

adequate precautions. Research shows that there is no land available for landfill. Since ULBs do not have the resources to acquire new land, finding new land becomes a major challenge.

5. No comprehensive studies have been conducted to cover all the cities and towns of the country, to characterise the waste generated and disposed of in landfills. Thus, it is difficult for the policymakers to provide suitable solutions for the waste produced for a particular region.

6. Local authorities lack adequate funding and infrastructure. Thus, they are unable to adopt innovative and appropriate technologies for waste treatment and disposal.

7. WtE is a widely used technology in India, but it faces several problems, including unsegregated waste and seasonal variation in waste composition. Various research documents show that most WtE plants cannot function effectively due to operational and design issues.

8. The COVID-19 pandemic has introduced a new set of challenges in the SWM system in India: maintaining social distances at the treatment plants and amongst the collection staff, and a shortage of PPE/safety gears for conservancy staff. These problems undermine the safety of SWM employees, waste treatment requirements, and other procedures.

9. There is a lack of proper planning and indigenisation of sophisticated waste process facilities, as well as the provision of regular training to waste-collectors.

CONCLUSION

The SWM system in India is in a critical state, as ULBs have largely failed to manage solid waste efficiently. Being heavily dependent on the state governments for funding, these local bodies lack the resources to acquire new land or obtain the technologies required for SWM. Moreover, waster pickers, who are key workers in the industry, lack legal status and protection, and are hardly effective or capable of enforcing systems in the collection and segregation of waste. For the situation to improve, institutional and financial issues must be addressed on priority. While the 2016 SWM Rules do address a significant number of issues, compliance remains weak. A policy paper or action plan must be prepared to promote the decentralisation of the waste management system.

To enhance the efficiency of SWM in India, citizen participation should be promoted, especially in source segregation and treatment processes. The policy agenda for sustainable SWM must drive behavioural change amongst citizens, elected representatives and decision-makers, to minimise wastage and littering, and increase reuse and recycling. Community awareness and a change in people's attitudes towards solid waste and their disposal can go a long way in improving India's SWM system.

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