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How to make it work for solid waste management

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We are thankful to Swati Singh Sambyal for her contribution to this survey.

Maps used in this document are not to scale.

Citation: Sonia Devi Henam and Dinesh Raj Bandela 2020, *Segregate, Segregate, Segregate: How to make it work for solid waste management*, Centre for Science and Environment , New Delhi

Published by
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How to make it work for solid waste management

Contents

1. Segregation is the key

Over the past few years, governments across India have ramped up efforts to sweep cities clean. Union government's Swachh Bharat Mission (SBM), launched on 2 October 2014, is a nationwide campaign that has provided impetus to the country's cleanliness drive.

The country cannot be clean until it learns to manage its waste. Governments struggling against massive and ever-growing quantities of solid waste have learnt a crucial lesson: there simply isn't any space for landfills in India today. Not only is land scarce, but people living near proposed landfill sites often protest against such projects, making them unviable or litigious. This Not-In-My-Backyard (NIMBY) attitude is good news if it leads to processing of waste, for reuse as compost or in recycling.

But any effort to process waste requires segregation—waste must be sorted into different usage streams. Not segregating waste creates myriad of problems. For instance, organic wastes from households and municipalities have unacceptably high methane production potential that can have an adverse impact on the environment if dumped carelessly. Not segregating waste also increases the risk of contamination of recyclables and reduces their marketing possibility and value. Even if waste is to be incinerated to generate energy, segregation is the key.

Ideally, segregation must be performed before waste leaves the establishment that produces it, be it a home or an institution. The situation in residential areas, from where most of our waste comes, differs from area to area and solid waste management (SWM) must be tailored to these needs. Segregation of waste at source greatly helps in providing localized solutions, improving collection efficiency and maximizing resource recovery from waste.

Hence, segregation at source is critical for SWM to succeed. It is, therefore, the most important element of city strategies across the world. How well do they do this? What can we learn from the experience?

Unfortunately, we have learnt that this is where many cities and regions falter, multiplying headaches for governments and city administrations. Others segregate better. What do they do differently? How do they make segregation paradigms work? Does it improve their ability to manage solid waste? How does the collected waste get processed and reused? This paper seeks to explore these questions in detail.

Is segregation of waste mandatory in India?

Segregation of waste was introduced as a legal mandate and policy plank in the Municipal Solid Wastes (Management and Handling) Rules, 2000, but lack of awareness meant that not much progress was made regarding implementation.

The Solid Waste Management (SWM) Rules of 2016, notified by the Ministry of Environment, Forest and Climate Change (MoEF&CC), created a new mandate for segregation of waste.[1] These rules state that source-segregation of waste is necessary so that it can be turned into wealth, through recovery, reuse and recycling. All generators of solid waste, including households, have to segregate waste into three streams: biodegradables, dry (plastic, paper, metal, wood, etc.) and domestic hazardous (cleaning agents, diapers, napkins, mosquito repellants, etc.) before handing it over to waste collectors. The rules also define establishments that generate over 100 kg of waste daily as bulk waste generators (BWGs). This includes markets, events (with more than 100 persons in attendance), hotels, restaurants, malls and railways.

All BWGs are required to ensure that they segregate waste at source and hand over the segregated waste to collectors or any other agency specified by the local authority. Food waste from hotels and restaurants must be utilized in composting or biomethanation. Resident welfare and market associations, and gated communities sprawling over an area of more than 5,000 m^2 are mandated to segregate waste at source as well, and hand over recyclable materials like glass, paper, plastic and tin to authorized waste pickers and recyclers. Local bodies have to provide easy access to waste pickers and recyclers for collection of segregated waste.

As per the 2016 SWM rules, MoEF&CC is responsible for the overall monitoring of implementation of SWM rules in the country. Central Pollution Control Board (CPCB) collects data from State Pollution Control Boards (SPCBs) and Pollution Control Committees (PCCs) and submits an annual report on the state of solid waste management in the country to MoEF&CC.

The Ministry of Housing and Urban Affairs (MoHUA) is responsible for coordination with state governments and Union territory (UT) administrations to take periodic review of the measures taken by states and local bodies for improving solid waste management practices and execution of solid waste management projects funded by the ministry. Urban Development Departments of states or Union territories prepare solid waste management policies and strategies consistent with SWM rules. At the municipal level, local authorities (ULBs) are responsible for framing bye-laws and prescribe criteria for levying of spot fine for persons who litter or fail to comply with the provisions of SWM rules, which might include non-segregation of waste. For example, municipal council of Panchgani (Maharashtra) has provisions for penalties for non-segregation of waste by households and commercial areas in its municipal bye-laws for solid waste management.

On 2 October 2014, the Central government launched an ambitious flagship programme to make India open defecation-free and achieve 100 per cent scientific management of municipal solid waste in the country. Thus was born the Swachh Bharat Mission (SBM), under the aegis of MoHUA.

The ministry came out with guidelines on SBM for states and ULBs regarding various components of the mission, including release and utilization of funds, and monitoring the objectives of the mission.

On 5 June 2017, on the occasion of World Environment Day, and in order to enthuse cities and citizens on waste segregation initiatives, and create the necessary excitement to make it a mass movement, the erstwhile Ministry of Urban Development (now MoHUA) proposed that 4,041 ULBs should start source-segregation and also ensure that the waste thus segregated does not get mixed again during transportation.[2] To achieve this ambitious target, MoHUA then proposed a campaign to create awareness on the importance of waste segregation, focusing on the adoption of the principles of Reduce, Reuse, Recover, Recycle, Repair, Refuse and Rethink. It also sought to promote the idea that after making serious efforts to minimize waste, all components of MSW must be utilized in a manner ensuring the full potential of the waste is tapped.

As per MoHUA's standard operating procedure, states and ULBs have been assigned roles in bringing about behavioural changes in the society regarding the utter importance of waste segregation and segregation at source via extensive multimedia campaigns, planning meetings with all stakeholders, involvement of religious leaders, and targeting school and college students. However, the standard operating procedure does not mandate source-segregation but only promotes it.

Pertinently, CPCB's 2018–19 *Annual Report on Implementation of SWM Rules, 2016* makes the following key observations:

i. Waste processing and disposal facilities are in shambles in a majority of the states.
ii. Most dumpsites are unscientific and operate without paying heed to SWM rules. All streams of waste or unsegregated waste are disposed of at dumpsites. As per the SWM rules, landfill sites should preferably be used only for depositing inert waste and rejects.
iii. Mixed MSW in dumpsites causes environmental and health hazards, and often lead to open fires.
iv. Four years have passed since SWM rules, 2016 were notified. But most states and UTs are yet to formulate policies and implementation strategies aligned with them.[3]

Waste generation and management in India

How much waste does India generate? Of the total waste generated, how much is segregated and processed? There are two official sources for data on this question: MoHUA (through Swachh Survekshan conducted under SBM) and MoEF&CC (through CPCB).

Swachh Survekshan (SS) is a cleanliness survey launched in 2016 as part of SBM to assess and rank cities on various sanitation and cleanliness parameters.

Table 1: Overview of solid waste management in India

	Generated	Collected	Treated	Sent to landfills	No information
In tonnes per day	152076.7	149748.6	55759.6	50161.33	46155.77
Per cent		98	36	33	30

Source: Annual Report on Implementation of Solid Waste Rules (SWM), CPCB, 2018–19

The primary goal of SS is to encourage large-scale citizens' participation and create awareness among all sections of the society about the importance of working together towards improving the liveability of towns and cities.

Additionally, these surveys intend to foster a spirit of healthy competition among towns and cities to improve their service delivery to citizens, and thus steadily move towards creating cleaner cities.The criteria for ranking cities have been progressively improved by the SS to better capture not just waste collection but its processing as well (see *Box: Changing indicators for waste management in Swachh Survekshan*).

MoHUA estimates put the amount of municipal solid waste (MSW) generated in India in 2018–19 at 147,613 tonnes per day (TPD),while MoEF&CC estimates put it at 152,076 TPD.[4] This would mean between 54 and 56 million tonnes of waste produced annually.

Both ministries state that a bulk of the waste generated is collected. According to SBM, roughly 94 per cent is collected. CPCB puts this number at 98 per cent.

But the two estimates differ on the amount of waste that is processed or treated. According to SBM, which collates data only from wards with 100 per cent door-to-door collection, roughly 60 per cent of the waste is 'processed'. It is not clear what this processing of waste entails.

CPCB estimates present a clearer picture of the waste generated, collected, treated and sent to landfills. According to it, of the total waste collected, some 36 per cent is 'treated' and another 33 per cent is sent to landfills. No data is available for the remaining one-third of the waste that is collected (and, of course, the 2 per cent waste that is not collected at all).

However, CPCB data does not clarify how much waste is segregated in the country. SBM, on the other hand, does provide data on how much source-segregation is being practiced in 63,204 wards.

CHANGING INDICATORS FOR WASTE MANAGEMENT IN SWACHH SURVEKSHAN

In 2016, capital cities of states and Union territories and 73 other cities with a population of more than one million each were covered under the Swachh Survekshan (SS). By 2017, SS was expanded to 434 cities, each with a population of more than 0.1 million.[1] In the third round in 2018, the survey covered 4,203 cities, and by 2019 as many as 4,237 cities were included.[2] In 2020, SS has been made continuous—to improve monitoring, progress is tracked quarterly (instead of annually). This helps recognize and reward performance better.

In 2017, SS incentivized, through weightages assigned to different tasks, a centralized approach towards waste management. The top cities—Indore, Bhopal and Vishakhapatnam—had focused more on collection of unsegregated waste and transporting it to landfills, with only a minimal quantum of waste being processed.

The 2018 survey changed the weightages to encourage innovative practices and sustainable solid waste management. The current survey (2019–20) has reworked the priorities for waste management substantially in order to bring sustainable management of solid waste to the forefront. The objective is to minimize, reuse and recycle waste.

Indicators of waste management 2019–20

Indicator	Assessment reason and explanation	Marks
Collection and transportation		
Percentage of wards covered with operational door-to-door collection of waste	This parameter examines whether the urban local body (ULB) has a system in place for door-to-door collection of waste. Every unit, whether a household, commercial establishment or a shop, needs to have the facility of door-to-door collection of waste for a ward to fulfill this criterion.	100
Percentage of wards practicing source-segregation of waste	This parameter examines whether a ULB has a system in place for collection of waste in a segregated manner (wet and dry waste). Domestic hazardous waste needs to be collected separately (in a separate bag or container). Segregated waste must be maintained in separate streams till it reaches the processing plant (material handling unit) or is disposed of at a site.	125
Information and communication technology (ICT)-based monitoring mechanism	This parameter examines whether ICT-enabled mechanisms are in place for ward-wise collection and transportation from gates, monitoring of Garbage Vulnerable Points (GVPs) and attendance of sanitation staff.	40
Percentage of informal waste pickers formally integrated into sustainable livelihoods	Formally integrating informal waste pickers helps improve the living standards of the urban poor by engaging them in collection and transportation, and processing (e.g., material recovery facilities)	35
Plastic Waste Management Rules, 2016: Whether the ULB has banned single-use plastics, including < 50 micron plastics, during all festivals, social gatherings and events	Single-use plastics, or disposable plastics, are used only once before they are thrown away or recycled. These items include plastic bags, straws, coffee stirrers, soda and water bottles, and packaging of most edible items.	30

Indicator	Assessment reason and explanation	Marks
Whether measures have been taken to reduce generation of dry or wet waste	This indicator helps in assessing a ULB's efforts to reduce waste generated by household, commercial and industrial establishments in the city. The focus should be on reducing the amount of waste to be finally transported to the processing or disposal site or processed through on-site composting.	50
Processing and disposal		
Whether the capacity of wet waste processing facilities in the city matches the total wet waste generated by the city	The indicator would assess whether the city has adequate facilities and infrastructure to process the wet waste it generates.	50
Percentage of wet waste actually processed by centralized and decentralized facilities	This indicator assesses the extent of centralized and decentralized management of wet waste generated in the city. The amount of wet waste being sent landfills should be minimized.	150
Percentage of dry waste (excluding plastic and domestic hazardous waste) collected that is actually processed, reused and recycled by centralized and decentralized facilities	This indicator assesses the extent of centralized and decentralized management of dry waste generated in the city. Is the dry waste a city produces being recycled or reused sufficiently?	60
Percentage of total plastic waste collected that is treated, reused and recycled, either by centralized or decentralized processing	This indicator assesses the extent of centralized and decentralized management of plastic waste generated in the city. Is the plastic waste the city produces being recycled or reused?	40
Percentage of total domestic hazardous waste collected that is treated, either by centralized or decentralized processing	This indicator assesses the extent of centralized and decentralized management of domestic hazardous waste generated in the city.	30
Status of remediation of existing dumpsites undertaken or achievement of no legacy waste (dumpsites)	This parameter assesses whether remediation is being practiced or if a city continues to dump waste in an unplanned manner, in contravention of the SWM Rules of 2016.	60
Does the city have sanitary landfills? Or are landfills not required (the city is a zero landfill city)?	This parameter assesses whether landfill sites of the ULB are scientifically planned and in accordance with SWM Rules of 2016.	50
Percentage of Bulk Waste Generators (BWGs), including those generating more than 100 kg (or less, if notified by the state government or city authorities) of waste per day, practicing on-site processing of wet waste or outsourcing the task to private agencies	This parameter assesses whether BWGs in the city (including RWAs) are practicing on-site composting. Processing is not be outsourced to the ULB, unless the city has more than 0.1 million population, in which case it can do so on a commercial rate. Outsourcing of waste processing to the ULB will not be considered for marking.	50

Indicator	Assessment reason and explanation	Marks
Whether the city has empanelled service provider(s) managing collection and processing of dry and wet waste to cater to BWGs or households not being covered under door-to-door collection.	This indicator assesses coverage of waste collection and processing of waste from establishments which otherwise could not be catered to by the ULB existing collection mechanism. Arrangements like 'on call' services for gate-to-gate collection and for any social or public event fall under this category. ULB should empanel private service providers as a back-up for already established collection and processing mechanism. In cities with less than one million population, ULBs can provide similar arrangement (including through non-governmental organizations and self-help groups).	30
Percentage of households processing their wet waste at home or community level	This indicator assesses the extent of home composting done in the city. Information, education and communication (IEC) campaigns, supported by proper handholding, will help citizens adopt home composting, thus taking ownership of their wet waste. Households under RWAs fall within the definition of BWGs and do not contribute to this indicator.	50
Percentage of Swachhata App or Local App complaints covering issues related to littering, garbage dumping and overflowing litter bins	The Swachhata app is a fourth generation complaint redress mobile and web platform. It is a quantum leap in how complaints and grievances are being redressed by municipal corporations in India.	40
Percentage of operational cost of sanitation and solid waste management covered by property tax (SWM or sanitation sub-head); user charges (for SWM or sanitation-related services; sale of city compost); and advertisement rights on community and public toilets, and litter bins	This indicator helps assess the extent of cost recovery by solid waste management services. Salaries disbursed to daily wagers, contractual or outsourced staff through service providers (against vacant posts) will be added to the cost.	40

Source: Swachh Survekshan, MoHUA, 2019

So how much waste is segregated?

The numbers vary, depending on whom you ask.

Segregation according to Swachh Bharat Mission data

From time to time, SBM makes public an overarching update on the progress towards its goals. State-wise implementation of SWM is one of the components of such updates. They also contain datasets on source-segregation in India. Even though the data is limited to municipal wards with 100 per cent source-segregation, it is useful in creating an overall picture for the entire country (see *Table 2: State-wise status of implementation of Swachh Bharat Mission*).

Table 2: State-wise status of implementation of Swachh Bharat Mission*

State	Total number of wards	Wards with 100 per cent door-to-door collection	Wards with 100 per cent source segregation	Total waste generation (metric tonnes per day or MTD)	Total waste processed (MTD)	Total waste processed (per cent)
Andhra Pradesh	3,409	3,409	3,300	6,141	3,850	63
Andaman and Nicobar	24	24	23	100	86	95
Arunachal Pradesh	75	75	11	181	0	0
Assam	943	698	368	1,432	759	53
Bihar	3,377	3,276	1,107	2,272	1,159	51
Chandigarh	26	26	24	479	455	95
Chhattisgarh	3,217	3,217	3,217	1,650	1,485	90
Daman and Diu	28	28	28	32	24	75
Dadra and Nagar Haveli	15	15	15	55	55	100
Delhi	294	294	59	10,500	5,775	55
Goa	217	217	173	250	175	70
Gujarat	1,427	1,427	1,187	10,721	8,938	87
Haryana	1,496	1,401	935	4,783	2,296	48
Himachal Pradesh	497	490	490	377	294	78
Jammu and Kashmir	1,081	809	137	1,431	238	16
Jharkhand	932	897	752	2,135	1,281	60
Karnataka	6,464	6,464	3,694	10,000	5,400	54
Kerala	3,536	3,022	3,536	2,696	1,914	71
Madhya Pradesh	7,115	7,115	7,005	6,424	5,589	87
Maharashtra	7,322	6,590	6,346	23,450	12,806	58
Manipur	306	270	196	174	101	58
Meghalaya	114	27	27	268	10	4
Mizoram	264	264	230	236	83	35
Nagaland	234	148	30	461	277	60
Odisha	2,024	2,009	1,402	2,721	1,306	48
Puducherry	122	122	116	415	55	13
Punjab	3,123	3,064	2,664	4,100	2,501	61
Rajasthan	5,389	5,389	4,419	6,500	4,680	72
Sikkim	53	53	50	89	62	70
Tamil Nadu	12,814	12,429	10,891	15,437	10,497	68
Telangana	2,112	2,020	1,008	8,634	6,735	78
Tripura	310	277	243	450	239	53
Uttar Pradesh	12,007	11,872	8,294	15,500	8,990	58
Uttarakhand	1,170	1,170	669	1,541	731	46
West Bengal	2,938	2,527	558	7,700	700	9
Total/ Average	**84,475**	**81,135**	**63,204**	**149,334**	**89,545**	**60**

*Upto January 2020

Source: SBM, 2020

Under SBM, cities have to ensure 100 per cent source-segregation of waste. As per SBM's 2019 data, 74.8 per cent wards in the country segregate all their waste at source (see *Table 3: Source-segregation as per Swachh Bharat Mission data*).[5]

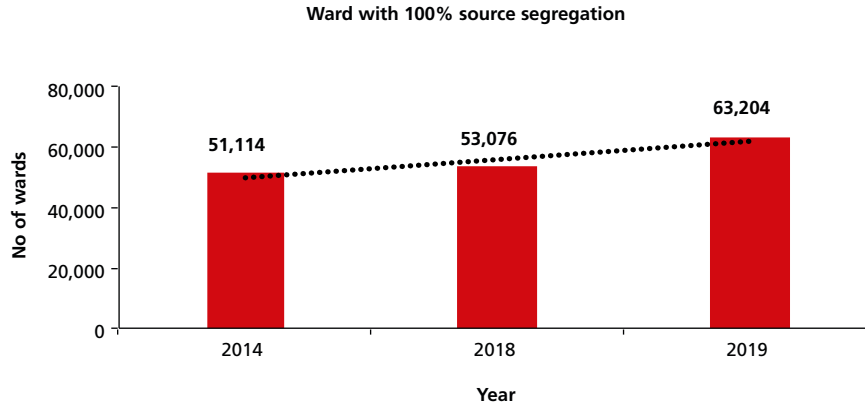
Table 3: Source-segregation as per Swacch Bharat Mission data

Total wards	Number of wards with 100 per cent source-segregation	Percentage of wards with 100 per cent source-segregation
84,475	63,204	74.8

Source: Swacch Bharat Mission, 2019

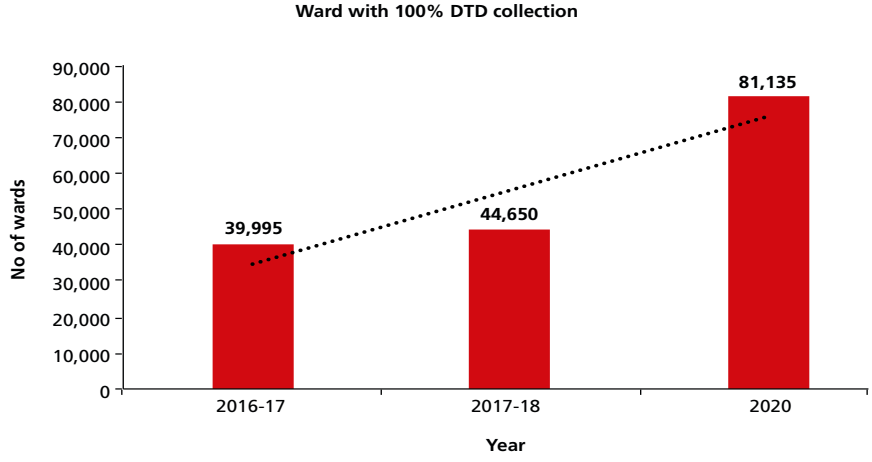
As per SBM data, the number of wards segregating waste at source has increased from 60 per cent in 2014 to 75 per cent in 2019 (see *Graph 1: Comparative annual source segregation*). Door-to-door collection of waste, emphasized by the ministry as it ensures segregated waste is collected at source and households do not dump waste, has gone up from 50 per cent in 2014 to close to 100 per cent in 2019 (see *Graph 2: Comparative annual door-to-door collection*). Waste processing has also gone up from 18 per cent to 60 per cent in the corresponding period (see *Graph 3: Comparative annual waste processing*).

Graph 1: Comparative annual source segregation



Source: Compiled from SBM data, 2020

Graph 2: Comparative annual door-to-door collection



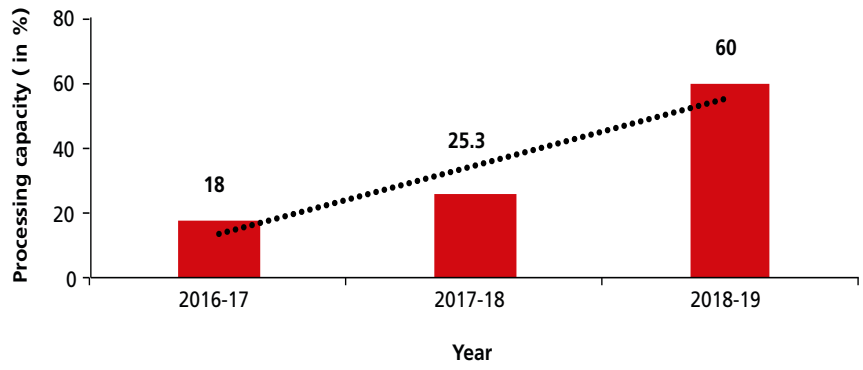
Source: Compiled from SBM data, 2020

STAR-RATED CITIES

Star rating for garbage-free cities	
Cities with 1-star ratings	70
Cities with 3-star ratings	65
Cities with 5-star ratings	6

In 2018, to motivate cities to achieve garbage-free status, MoHUA launched the Star Rating Protocol for Garbage-free Cities. It is a single metric rating system, based on 12 parameters regarding SWM covering, among other things, source-segregation, door-to-door collection, compliance by bulk waste generators, daily sweeping, scientific processing of waste, scientific land filling, plastic waste management, construction and demolition waste management, dumpsite remediation, and citizen grievance redress system. All of these factors contribute to a city's overall cleanliness and garbage-free status. At present, Ambikapur, Indore, Mysuru, Navi Mumbai, Rajkot and Surat are the only cities with certified 5-star ratings.

Graph 3: Comparative annual waste processing



Source: Compiled from SBM data, 2020

In 2018, SBM developed a star rating system to push cities towards better performance on all parameters of waste management. In 2019–20, only six cities—Ambikapur, Indore, Mysuru, Navi Mumbai, Rajkot and Surat—got 5-star ratings (see *Box: Star-rated cities*).

Segregation according to CPCB data

CPCB data on source-segregation is a little more haphazard. To illustrate, in its *Annual Report on Implementation of Solid Waste Rules (SWM)* for the year 2018–19, it lists segregation details in the percentage form for states like Andhra Pradesh (where 74 per cent solid waste is segregated) while for some other states (like Chhattisgarh and Himachal Pradesh) it just provides the number of wards that are segregating waste (see *Table 3: Compliance of states with SWM rules of 2016*).

Table 3: Compliance of states with SWM Rules of 2016

State	Door-to-door collection	Segregation	Other good practices
Andaman and Nicobar Islands	In all the 24 wards of Port Blair	70 per cent	Streets are swept on a daily basis. Spot fine imposed for littering. Plastic collection centres have been established
Andhra Pradesh	By all ULBs. 98 per cent households	74 per cent	Ongole Municipal Corporation and Chirala Municipality have developed sanitary landfill facilities. Greater Visakhapatnam Municipal Corporation and Tirupati Municipal Corporation are in the process of setting up sanitary landfills
Arunachal Pradesh	In 27 towns	In 10 towns	
Assam	In 403 wards in 101 ULBs	Not practiced	
Bihar	In 3,159 out of 3,337 wards	In 783 out of 833 wards	Three major cities (Biharsharif, Munger, and Muzaffarpur) and three major towns (Bodhgaya, Rajgir and Supaul) have been identified as model cities and towns for their waste management systems
Chandigarh	100 per cent	80 per cent	Bye-laws have been notified by Municipal Corporation of Chandigarh
Chhattisgarh	By all municipal authorities using tricycles and mini-tippers	168 ULBs	166 municipal bodies have composting and recycling facilities in the form of compost sheds and 'garbage clinics' respectively
Daman and Diu	Daman Municipal Corporation: 100 per cent. Daman District Panchayat: 90 per cent. Diu Municipal Council: 100 per cent door-to-door collection. Diu District Panchayat: 100 per cent	Daman Municipal Corporation: 100 per cent. Daman District Panchayat: Segregation carried out at the time of door-to-door collection	In Daman, 100 per cent manual sweeping is carried out by both local bodies. In Daman, 70 per cent households practice storage of waste at source in domestic bins
Delhi			
Goa	In 14 towns	In 14 towns	In eight towns, storage and processing facilities, and covered transportation, are available for waste
Gujarat	100 per cent	68 per cent	
Haryana	In a majority of the towns	20 per cent	Cluster-based integrated approach to SWM adopted by the state
Himachal Pradesh	In 61 ULBs	In 32 ULBs	
Jharkhand	In 42 towns	In 42 towns (70.8 per cent)	
Jammu and Kashmir	Jammu: Carried out only in a few local bodies or wards. Kashmir: 80 per cent of households in Srinagar city through Srinagar Municipal Corporation	Jammu: Source-segregation has been implemented by municipal councils of Reasi, and Katra, and the cantonment board only. Kashmir: No source-segregation of waste is being carried out	

State	Door-to-door collection	Segregation	Other good practices
Karnataka	By 274 ULBs	No source-segregation. Some segregation by ULBs with processing facilities, in other places, mixed waste is dumped in landfills	
Kerala			
Nagaland	50 per cent in Kohima	40 per cent source-segregation in Kohima.	Kohima Municipal Council has decentralized waste management in all 19 wards or colonies and has formed 19 'ward sanitation committees' for primary waste management and collection. The wards have been declared community bin-free. A waste processing facility is being set up at Dimapur. A pilot project by Kiphire Town Council under which 11 ULBs propose to go for segregated collection and vermi-composting of biodegradable waste at the ward level
Lakshadweep	4,991 workers employed (for collection of non-biodegradable waste)	375 informal waste-workers segregate waste	
Madhya Pradesh	In 364 towns and cities	In 249 towns and cities	
Maharashtra	By 384 ULBs	By 369 ULBs	
Manipur	By 12 ULBs	Two-bin system has been introduced in some ULBs on a trial basis. Daily to occasional clearing of storage depots carried out by ULBs as per requirement	Fencing of the sanitary landfill site at Lamdeng. Daily covering of disposed waste at the dumpsite with soil by one ULB
Mizoram	Yes	Started in nine local councils in Aizawl and one town	
Meghalaya	By six ULBs	By one ULB (Shillong Municipal Board)	
Odisha	By all 114 ULBs	By 52 ULBs	
Punjab	In 117 cities and towns	In 31 cities and towns	
Puducherry	By the Puducherry Municipality	In 10 wards	Biodegradable waste is being composted, vermi-composted or biomethanated to produce gas by the Karaiakal Municipality
Rajasthan	From 3,181,174 households	By 59 ULBs	
Sikkim	Yes	Segregation of dry and wet waste has been started in various wards of the Gangtok Municipal Corporation	Collection of waste by sounding of bells in most towns to increase efficiency

State	Door-to-door collection	Segregation	Other good practices
Tamil Nadu	97 towns: 100 per cent. 27 towns: 80–100 per cent. 11 towns: less than 80 per cent	17 towns: 100 per cent. 57 towns: 80–100 per cent. 40 towns: 50–80 per cent. 21 towns: less than 50 per cent	
Telangana	By all ULBs. 95.9 per cent of households covered	About 43 per cent source-segregation (Greater Hyderabad Municipal Corporation: 62 per cent; other ULBs: 24 per cent)	
Tripura	In 115 wards	By eight ULBs	
Uttarakhand	In 1,106 out of the 1,170 wards	Source-segregation in 366 wards	
Uttar Pradesh	About 97 per cent	Partially	
West Bengal	82.4 per cent	18.4 per cent	

Note: A blank box means no description was provided

Source: Compiled from Central Pollution Control Board (CPCB) Annual Report 2018–19

According to CPCB's 2018–19 report, while door-to-door collection of waste has taken root, 'segregation-at-source is not being practiced in most states'.

Nevertheless, data collated by CPCB shows that many cities and states are making comprehensive and robust efforts to segregate waste at source. Andaman and Nicobar, Andhra Pradesh and Chandigarh have achieved over 70 per cent source-segregation, while other states and Union territories report that progress has been made in this direction, with most states having initiated source-segregation in ULBs or wards, and segregation facilities cropping up around the country.

Where do we stand?

Much more still needs to be done.

While it is true that segregation is mandated by the SWM rules of 2016 and is also one of the policy objectives of SBM, the fact of the matter remains that municipal bye-laws that were supposed to ensure implementation of the mandate of segregation at the grassroots-level have been slow to come up. This is particularly worrisome in the light of the clear-cut timeframes provided for implementation of various mandates under SWM rules of 2016. For example, the timeframe for identification of suitable sites for setting up solid waste processing facilities was one year; and for enforcing the practice of segregation of biodegradable, recyclable, combustible, sanitary, domestic hazardous and inert solid waste at source was two years. Local body were required to frame bye-laws incorporating the provisions of the rules within one year from the

date of notification. They were also supposed to notify user and tipping fees, spot fines and penalties for non-segregation of waste. Progress has been slow (at best) on these fronts.

Datasets crafted by CPCB and SBM underline a few other critical problems. The data is fuzzy, to say the least. Metrics vary from ULB to ULB and state to state and there are no uniform and standardized parameters to assess a waste management system or adjudge changes and improvements. Government bodies are still not making a clear distinction between mere segregation and segregation at source; a difference central to an efficient and physically and financially viable waste management system.

It is clear that while segregation of waste is the stated objective of the policy for waste management, it is yet to be achieved substantially and in full measure.

How do we work towards achieving these goals?

In order to help promote segregation of waste in urban India, Centre for Science and Environment (CSE) launched 'Forum of Cities That Segregate' in December 2017 as a platform for sharing and exchanging knowledge on SWM, with a focus on segregation of waste. CSE also came out with a *Forum of Cities That Segregate Assessment Report 2017–18*, that delves deeper into segregation at the city level, albeit for only a few cities.[6] The focus-oriented and result-driven forum is expected to help state and Central authorities in moving towards the goal of 100 per cent source-segregation sooner than later.

2. The CSE survey on cities

Cities across India have taken countless steps towards adopting strategies and implementing practices for sustainable waste management. While some are simply struggling to ensure adherence to basics like segregation and processing, others have improved the processes of recycling, reduction and reuse.

In 2016, CSE carried out a survey of fourteen India cities to understand their waste management systems and highlight best practices. These cities are Alleppey (Kerala), Bobilli (Andhra Pradesh), Panaji (Goa), Mysuru (Karnataka), Aizawl (Mizoram), Pune (Maharashtra), Surat (Gujarat), Suryapet (Telengana), Agartala (Tripura), Bengaluru (Karnataka), Chandigarh (Punjab), Delhi, Gangtok (Sikkim) and Shimla (Himachal Pradesh). The results were published in the form of a book titled *Not in My Backyard: Solid Waste Management in Indian Cities*, which has now become a seminal work in the field.

The survey offered renewed confirmation, if at all it was needed, that segregation was the key to a good waste management system. Unsegregated waste was an evil which needed to be nipped in the bud, and so segregation at source was the golden rule.

In December 2017, CSE launched its 'Forum of Cities that Segregate' initiative to promote and implement the source-segregation model of waste management. Twenty urban local bodies (ULBs) from 13 cities—Panchgani (Maharashtra), Balaghat (Madhya Pradesh), Patna (Bihar), Bobilli (Andhra Pradesh), Indore (Madhya Pradesh), Amdavad (Gujarat), Bhopal (Madhya Pradesh), Greater Hyderabad (Telangana), East Delhi Municipal Corporation (New Delhi), Thiruvananthapuram (Kerala), Mysuru (Karnataka), Alappuzha (Kerala), Bengaluru (Karnataka), Gangtok (Sikkim), Gurugram (Haryana), South Delhi Municipal Corporation (New Delhi), Vajiapur (Maharashtra), Gaya (Bihar), Imphal (Manipur) and Muzaffarpur (Bihar)—were part of this forum.

Subsequently, in 2018, CSE released its rating of select cities from the forum that manage and segregate their municipal waste most efficiently. However, this assessment was only based on data provided by ULBs; information was crosschecked with local residents and other stakeholders, but no visits were made to the cities themselves.

A need was felt to carry out another survey like the one we had done in 2016, to assess the changes, if any, during these years and gauge the general direction in which waste management is moving in the country.

For this survey, we zeroed in on a few new cities in the country—Ambikapur, Bhopal, Hyderabad, Indore, Kumbakonum, Muzaffarpur, Panchgani, Tirupati, Vijayawada and Warangal—to assess their waste management systems. Most of these cities were ranked amongst the cleanliest under Swachh Survekshan 2019: Indore was ranked first; Ambikapur, second; Tirupati, eighth; Vijayawada, 12th; Bhopal, 19th; Greater Hyderabad, 35th; and Warangal,

DINESH RAJ / CSE

CSE's intervention in Muzaffapur's solid waste management has borne fruit

81th in the more than 0.1 million population category; while Panchgani was ranked thirteenth in the less than 0.1 million population category. Researchers from CSE visited these ten cities, collected data and information from ULBs, interacted with various stakeholders, and crosschecked the information provided by the ULBs to ascertain whether ground realities matched the data provided. The situation in each city yielded many valuable lessons. It was also clear that there were gaps in and concerns about the existing waste management scenario.

This report documents waste management practices followed by the selected cities, starting from segregation, collection and transportation (C&T) and processing right upto disposal. There is a special focus on segregation and we have tried to understand the reasons for gaps and shortcomings.

RITESH SAINI

AMBIKAPUR

Women's self-help groups segregate waste to keep the city clean

Area:
40 sq km

Population
0.145 million

Waste generated
40–50 TPD

Snapshot of solid waste management in the city:
34 self-help groups (SHG) formed in 18 area-level federations

Organic waste processed for city compost:
30–35 TPD

User charges collected:
Rs 16 lakh per month

Money made through sale of inorganic waste:
Rs 4–6 lakh per month

Livelihood earned by each of the 471 SHG members:
Rs 6,000 per month

Ambikapur is a zero-landfill city in the Surguja district of Chhattisgarh. It has become a role model of effective waste management and the whole state is following in its footsteps in an endeavour to become India's first zero-landfill state.

The city of 0.145 million inhabitants is spread over an area of 40 square kilometers. Ambikapur Municipal Corporation (AMC), which manages the city's solid waste, is divided into 43 wards. According to AMC, the city generates about 45–50 tonnes of waste per day, of which around 55 per cent is biodegradable. In 2015–16, about 50 per cent waste was segregated at source in all wards of the city. This has improved to 100 per cent now, thanks to the city's new waste management programme, run entirely by women self-help groups (SHGs).

How it started

Before 2015, Ambikapur was like any other city in India, trying to find a solution to the ever-growing problem of waste. Even

the particularities of the problem in the city could easily be a replica of many other cities in India. Just outside the city limits, at a place where a signpost welcomed visitors to the city, an ironic dumping ground buzzed with flies and stank prohibitively.

In 2015, the city initiated the 'Swachh Ambikapur Mission City Level Federation' (SAMCLF), a unique project aimed to clean up the city. From the very beginning, people's active participation was recognized to be the cornerstone of effective waste management. To this end, the administration sought active participation of elected representatives, religious leaders, community-based organizations and institutions, volunteers and the general public to arrive at a consensus regarding the appropriate manner to deal with the dumping ground. Of particular interest to municipal administrators were the self-help groups (SHGs) that had been organized in the city to promote women's livelihood but which functioned almost entirely in name only. SAMCLF sought to leverage these SHGs for solid waste management.

A training programme was organized for interested women volunteers. Around 800 women volunteers from 34 SHGs (the total number of SHGs in the city was 64) were trained on segregation of waste and composting techniques, out of which 500 agreed to participate in door-to-door collection of waste. The SHGs were organized into 18 area-level federations (ALFs) that, in turn, were federated in the form of a city-level federation (CLF)—Swachh Ambikapur Sahakari Samity.

The Ambikapur model

CLF's activities can be broadly categorized into three segments:

1. Door-to-door collection of waste and segregation in waste segregation centers, where the sale of organic and inorganic items also takes place
2. Work in tertiary segregation centers
3. Ensuring community participation for source-segregation

Segregation has been institutionalized into a three-tier system: primary source-segregation for the household level, secondary source-segregation at 'garbage clinics' and tertiary segregation at the Tertiary Segregation Centre.

Door-to-door collection and processing from 27,352 households and 4,648 commercial and other establishments is the responsibility of 471 SHG members. Each secondary segregation centre consists of three–four members.

Members of all SHGs have been provided with a unified dress code—sarees. Members report to their respective centres by 7:30 a.m. and, after donning shoes, cap and masks commence their daily collection drives. Each centre has been provided with manual or battery-operated tricycles, depending on the size of the ward. Each tricycle is accompanied by three workers and one supervisor who is responsible for motivating households and commercial establishments for providing segregated waste (segregating at source) and also for collection of user charges. Each centre makes rounds in batches of two–three teams twice a day in case of residential areas and thrice a day in case of commercial establishments.

DIDI BARTAN BANK, AMBIKAPUR

'Didi Bartan Bank', a unique livelihood initiative for two ALFs formed under Deendayal Antyodaya Yojana–National Urban Livelihoods Mission (DAY–NULM), City Mission Management Unit, Ambikapur, involving 21 SHGs with 210 women members, purchased steel utensils for Rs 34,000 from the revolving fund support of Rs 50,000 provided to each ALF through DAY-NULM. The underlying idea behind the initiative is to curb the use of non-recyclable items like disposable utensils—plastic glasses, spoons, thermocol plates—that contribute to environment pollution. Instead, the initiative seeks to promote the use of steel utensils in social functions. As of now, each ALF has procured one set of steel utensils, containing 100 plates, four bowls, one spoon, one glass, serving bowls, buckets and jugs. These utensils will be rented out to social functions, initially within the city, at a subsidized rate of Rs 15 per set, against the market rate of Rs 20 per set. Impressed by the potential positive environmental impact the initiative can have, a local transport association, Paras, has also sponsored one set of steel utensils for the city-level federation formed under DAY-NULM.

RITESH SAINI

Didi Bartan Bank showcasing their utensils in an exhibition in Chhattisgarh

The collected waste is then segregated at secondary segregation centres into organic and 17 inorganic categories. Inorganic items are sold off at the centres themselves to enlisted vendors at a good price. Organic waste is converted into manure in compost pits. The centres grow vegetables using manure made from the organic waste. Manure is also sold to agriculture and horticulture departments and in the open market to farmers. Each ALF earns around Rs 4–5 lakh per month from the sale of inorganic waste, vegetables and manure.

A tertiary segregation centre further segregates inorganic items. This center, segregating inorganic items into 156 categories, generally handles excess waste from the secondary segregation centres.

Simultaneously, an awareness campaign under the aegis of the municipal corporation seeking to educate the masses about the benefits of source-segregation has been put into action.

Impact of the model

The cost of solid waste management in Ambikapur has been reduced by 52.51 per cent. With less waste needing transportation over shorter distances, transport-related costs alone account for 41.43 per cent of these savings. When refuse gets 'consumed' before it putrefies, the need for disinfectants automatically abates. About 8.28 per cent savings relate to the decreased consumption of chemical disinfectants.

Also, a very crucial point of savings not reflected in any analysis and difficult to quantify relates to the trenching ground. The dumpsite was remediated by women workers and the municipality without utilizing large sums of money or hiring external consultants.

When a systems financial model is changed from wage-labour to community-ownership, worker efficiency goes up significantly. In real terms, the number of workers required for the job goes down by more than 50 per cent.

As significant as financial benefits are the environmental benefits. Elimination of the trenching ground and drop in the use of chemical disinfectants has substantially positive implications for the environment.

Socially, the city has woken up to the issue of solid waste management. Citizens have been sensitized to the different dimensions of the issue. The perspective on 'waste' has changed to 'resource'. This is reflected in reports filed by the women workers that some families have started recovering inorganic items at home for sale in due course and have stopped passing it out as waste.

SONIA HENAM / CSE

BHOPAL

Innovations in Information and Communication Technology (ICT) and plastic waste recycling catapult Bhopal towards cleanliness

Area:
413 sq km

Population
2.3 million

Waste generated
877.57 TPD

Organic waste processed for city compost:
430.01 TPD

User charges collected:
Rs 68.9 lakh per month

Money made through sale of compost:
Rs 52,250 per month

Number of *Sarthak Karmis* handling plastic waste:
3,500

Livelihood earned by each *Sarthak Karmi*:
Rs 6,000–24,000 per month

Known for its lakes, Bhopal has invested heavily in setting up solid waste management infrastructure facilities over the past few years. Bhopal Municipal Corporation (BMC) is responsible for managing the waste generated in the city of 2.3 million people. BMC has 85 wards of administration. Bhopal has 100 per cent door-to-door collection and 80 per cent segregation efficiency in all wards.[1] The city generates and collects 877.57 tonnes of waste per day, of which around 55 per cent is biodegradable. After processing, around 15–20 per cent of inert waste is sent to landfills.

How it started

In 2010–11, Bhopal generated about 350 tonnes of waste per day, out of which plastics alone constituted 23.08 tonnes.[2] At that time, door-to-door collection of waste was done by informal waste collectors using bicycle-rickshaws between 7 a.m. and 11 a.m. Each rickshaw could only make five–six rounds

per day, which was far less than what was required if all households were to be covered. In 2014, BMC identified and integrated the informal waste collectors into their system. Each household had to pay the waste collectors Rs 50–60 a month for the service.[3]

But the city had no segregation system in place and no post-treatment operation for municipal solid waste. The waste that was collected was simply transported to the dumpsite.[4]

Things started to change with the launch of Swachh Bharat Mission in 2014. BMC began to focus on ways and means to improve waste management in the city. By 2016, things in the city had improved enough for the first *Swachh Survekshan* survey to rank Bhopal 21st on various parameters in the areas of cleanliness, hygiene and sanitation.[5]

Waste management in Bhopal

Bhopal has emphasized on capacity building of municipal staff through recruitments and use of innovative information technology tools. It has also made plastic waste a focus area. The city follows both centralized and decentralized models of waste management and activities include door-to-door collection of segregated waste, transportation to garbage transfers stations for secondary manual segregation, and recycling of dry waste. An Integrated Waste Management Facility (IWMF), spread over 65 acres, has been constructed at Adampur Chavni, for tertiary segregation and treatment of wet waste. About 430.01 tonnes of biodegradable waste is converted into manure daily at the biomethanation plant at Bittan Market and through windrow composting at the IWMF.

Innovations in Information and Communication Technology

One of the highlights of Bhopal's waste management system is that all new motorized vehicles (Tata Magic vans) provided for door-to-door collection from the 377,171 households and shops in the 85 wards have global positioning system or radio frequency identification (GPS/RFID). This allows tracking of the movement of garbage collectors, ensuring accountability. It has helped the city achieve 100 per cent efficiency in door-to-door collection. Segregation at source in Bhopal was started in August 2016. In 2017, segregation efficiency was about 50–75 per cent.[6] Within a span of two years, the segregation rate has improved to 80 per cent.[7] Internet-of-things (IoT)-based fill-sensor devices installed in garbage bins help to keep littering due to overflow of the bins in check.

Segregated waste is brought directly to garbage transfer stations where it undergoes manual segregation. Here, waste is earnestly weighed and the daily data recorded. Dry waste is segregated into 14 streams: LDPE, glass, PET bottles, rubber, shoes, etc., by *Sarthak Karmis* (ragpickers). Non-recyclable plastic waste is sent to the processing site at Bhanpur, where it is converted into pellets or lumps to be used by the cement industry. Unsegregated waste, if any, goes to the IWMF.

YAADGAR-E-SHAHJEHANI GARBAGE TRANSFER STATION

Improving livelihoods of *Sarthak Karmis* via plastic waste management

In 2018, a garbage transfer station was set up by BMC at Yaadgar-e-Shahjehani. Eight *Sarthak Karmis* have been integrated with the centre, and they earn around Rs 400–500 per day. They have been provided with ID cards by BMC.

The staff record data meticulously. Each *Sarthak Karmi* collects about 1-2 tonnes of bottles, cardboard, chappals, double-coated plastic, jute bags, paper, tetra packs, etc. daily, which are then segregated. *Sarthak Karmis* drop off the collected waste at garbage transfer centres, where it is weighed and inventorized. *Sarthak Karmis* are paid on a weekly basis. Additionally, 30–40 tippers make two–three trips every day to bring in around 2.5 tonnes of waste. This quantity increases to around 5 tonnes during festivals.

Plastic material thus collected is scanned, segregated and bailing is undertaken. Each bale (with dimensions of 2.5 x 3 x 3 feet) weighs around 100 kg. It is transported to the processing site at Bhanpur where it is converted into pellets or lumps, to be used as fuel in cement kilns, or fillers to build roads. Bailing has made the programme financially viable by cutting down transportation costs significantly. Each truck can now carry around 12–14 tonnes of bailed material, whereas it could only carry around 5 tonnes of loose plastic waste earlier. Moreover, *Sarthak Karmis* are also engaged in employment opportunities from other allied activities, like vermi-composting, paper making and recycling of plastic and other dry wastes.

SONIA HENAM / CSE

Garbage transfer station at Yaadgar-e-Shahjehani

The Bhopal Model of plastic waste management

Managing plastic waste was a challenge in Bhopal. Of the total waste generated in the city, about 14–15 per cent was plastic waste dumped into landfills. Ragpickers and other informal waste workers were mainly responsible for handling this waste.[8] They are mostly illiterate women from the socially and economically marginalized sections of the society, rendering them vulnerable to exploitation and diseases. Sarthak, a local NGO, had been working for the uplift of these communities since 2008. In 2010, an initial UNDP grant under the Small Grants Programme (SGP) of the Global Environmental Finance (GEF) enabled Sarthak to conduct focused interventions in five wards of BMC and it began to organize ragpickers into self-help groups (SHGs) for proper collection and recycling of plastic waste. In 2014, Sarthak was awarded another grant by UNDP to mobilize more than 2,000 unorganized ragpickers and increase their socio-economic capacities through improved municipal solid waste management practices in 70 wards of BMC. The project was implemented in close collaboration with BMC, and had the support of the state Department of Housing and Environment to set up a sustainable business model for plastic recycling known as 'Bhopal Model'.[9]

Under this model, waste workers and ragpickers have been institutionalized in the form of *Sarthak Karmis* through SHGs, restoring their dignity and respect in the society and relieving them of the blemish of waste scavengers. *Sarthak Karmis* are trained to enhance their skills and practices to handle waste reprocessing units.

By the end of 2016, 646 ragpickers had been organized into 42 SHGs. More than 60 per cent of them were women, who began to earn Rs 200–800 daily from selling plastic waste. Members from 40 SHGs were also taught to make bags out of used polythene, which is sold in exhibitions across India. Approximately

CARRY YOUR OWN BAG CAMPAIGN

As soon as one enters Bhopal, one can see many signs of Carry Your Own Bag (or #CYOB) campaign. BMC started the campaign to raise public awareness about polythene bags. BMC is making an all-out effort to ban single-use plastics (polythene) and spot fines are slapped on violators of the ban. #CYOB campaign seeks greater participation of people in this campaign.

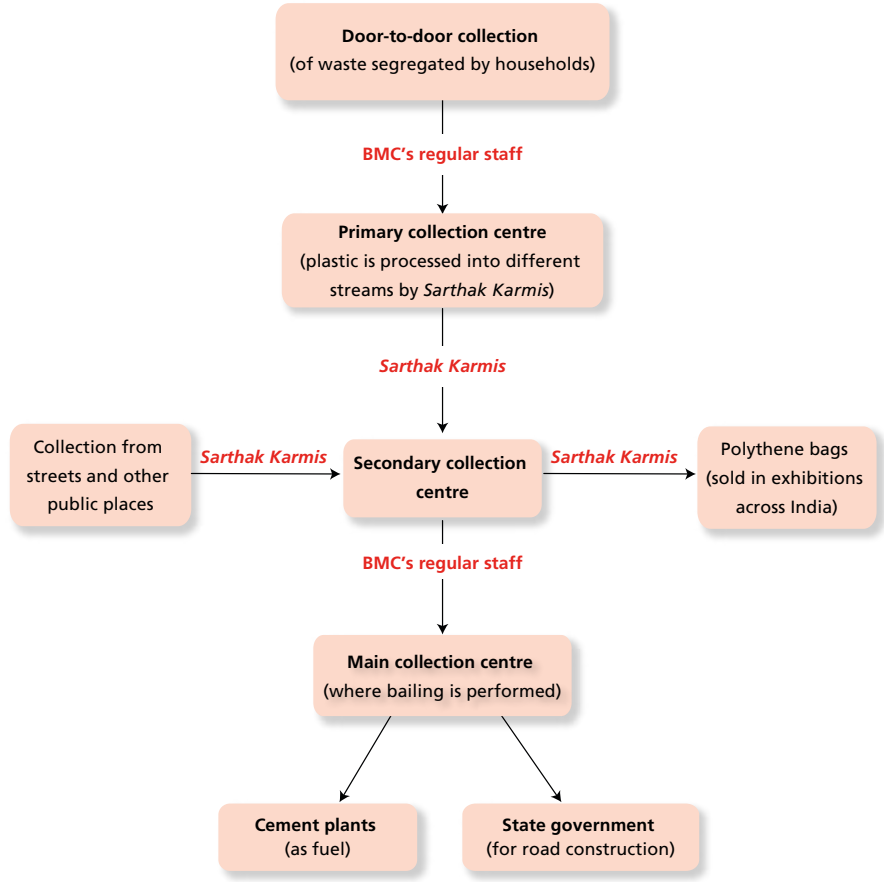
Many voluntary organizations are collaborating with BMC in this campaign in public places, vegetable markets and other important places. One such organization is Mahashakti Seva Kendra (MSK), an NGO that makes bags from scraps and rags.

BMC helps to connect MSK with Resident Welfare Associations (RWAs) across Bhopal. RWAs collect old clothes in their apartment complexes, and hands them over to MSK, where they are converted into beautiful bags and returned to the RWAs. MSK has made around 10,000 such bags already from old T-shirts, trousers, shirts and table covers. MSK also uses these rags to make up-cycled tablemats, table runners, coasters, bowls, you name it. By using rags, MSK ensures that they don't end up in landfills.

The fascinating part of the campaign is that it creates a circular economy, aimed at eliminating waste and the continual use of resources. It also creates green jobs, especially for women, ensuring that they get fair wages. It is a win-win combination for the economy, the planet and the women workers.

10 tonnes of plastic waste are collected from five recovery centres in Bhopal every day. Around 45 tonne of plastic waste is sold to cement factories in and around Bhopal to be used as fuel in furnaces. Another 60 tonnes of plastic waste is sold to Madhya Pradesh Rural Road Development Authority every month to be used in road construction. As a result, around 3,500 ragpickers have been organized into SHGs in Bhopal.[10] The success of this project has inspired the establishment of a pilot plastic recovery centre in Indore.

Schematic diagram of collection and processing of plastic waste in Bhopal



Source: Adopted from UNDP, 2014

Impact of the model

BMC has been able to save funds, generate income and integrate informal workers into its waste management system. By installing GPS/RFID in vehicles, BMC saved Rs 6–7 crore in 2017 through efficient route mapping and reduced use of fuel.[11] In 2019, BMC collected about Rs 8.2 crore as user fees and made Rs 6.2 lakh from the sale of compost.[12] Overall, the total expenditure on SWM was about Rs 31.8 crore and the total revenue generated from user fees, sale of compost and property taxes was about Rs 35.2 crore. Therefore, BMC saved about Rs 33.3 lakh.

Recycling and reprocessing of waste has also been beneficial for the larger economy of the city. For instance, one cement factory alone saved Rs 14 crore in two years on account of fuel cost through the use of plastic as fuel. In 2009, compressed plastic waste used to be sold to cement plants at Rs 1.70 per kg. Now it is sold at about Rs 5.50 per kg, of which about 4.30 per kg is paid to *Sarthak Karmis*. In 2019, *Sarthak Karmis* collected about 2,498 tonnes of plastics that were sent for co-processing in cement kilns, and for construction of roads by Madhya Pradesh Rural Road Development Corporation.[13]

BMC was able to develop an end-to-end system of waste management, creating local and affordable innovations on plastic waste recycling. For its excellent work on SWM, Bhopal has been applauded by MoHUA and CPCB in the media, and was even awarded the second Cleanest City in the Country in 2017's and 2018's Swachh Survekshans (SS), The 2019 SS declared it the cleanest capital city. Representatives from many states, notably Andhra Pradesh, Bihar, Chhattisgarh, Jharkhand, Karnataka, Tamil Nadu, Rajasthan and Uttar Pradesh, have visited Bhopal to learn about and from the model. Success of the Bhopal Model has also led to the release of a policy document on plastics by the state government, specifying that waste workers and ragpickers be integrated with collection centres in urban areas across the state.

DINESH RAJ / CSE

HYDERABAD

Integrating the informal sector by providing them 'swachh auto tippers' has worked waste wonders

Area:
625 sq km

Population
6.73 million

Waste generated
5,300 TPD

User charges collected:
Rs 60 per household per month

Organic waste processed for city compost:
30–300 TPD

Number of informal waste collectors integrated into the municipal primary collection:
2,500

Livelihood earned by each of the 2,500 waste collectors:
Rs 26,000 per month

Greater Hyderabad Municipal Corporation (GHMC) stretches over an area of 625 sq km and covers a population of 6.8 million (as per Census 2011). The city is divided into 150 wards, 30 circles and six municipal zones. Tremendous growth in the IT and IT-enabled services industries has resulted in rapid increase in the city's population.

The city generates 5,300 tonnes of waste daily, 54 per cent of which is biodegradable. GHMC practices centralized as well as decentralized processing of waste. About 16 per cent of waste is sent to landfills.

Mismanagement: the older way

Before 2009, Hyderabad used to collect waste from households and dump it on the outskirts of the city. In the process, five major dumpsites had been created—Auto Nagar, Fathullaguda, Gandhamguda, Jawahar Nagar and Shamshiguda. Jawahar Nagar was the biggest dumpsite,

spread over 135 acres and with an estimated height of 60 metres. In 2018, GHMC decided to close the Jawahar Nagar dumpsite by biocapping it. It soon realized that creating dumpsites might seem expedient but the task of closing them is nothing short of Herculean. The project dried Rs 141 crore of corporation funds.Realizing that procurement of additional land for dumpsites was no longer possible, GHMC slowly let go of the older way of managing waste.

Hyderabad's new model of waste management

The city has made significant gains in decentralized waste management based on source-segregation. Door-to-door collection of segregated waste happens in two ways; one, directly by sanitation workers employed by GHMC and, two, by 'swachh auto tippers'. Segregated waste is transported to the transfer station in each circle—18 out of 30 circles have decentralized composting units to handle wet waste, with an average capacity of 5 TPD.

Dry waste is channelized to 31 dry waste collection centres (DWCCs). These DWCCs are operated on corporate social responsibility (CSR) funds. A waste collector and a representative from the funding agency handles the operations at each DWCC.

Integrating the informal sector

In 2014, a baseline study identified 2,500 informal waste collectors in the city. The corporation came up with an idea to integrate them into mainstream waste management. Each of them was provided with a 'swachh auto tipper' by GHMC. These autos, with partitions for collecting dry and wet waste separately, were purchased by the corporation through a bank loan. Each informal collector only had to make a one-time payment of Rs 40,000 as the margin amount, the EMIs are paid by GHMC.

Each auto is designated to collect segregated waste from 600 households every day. A fixed user fee of Rs 60 per month is to be paid to the collector. Thus, each collector makes about Rs 36,000 a month. After deducting diesel expenses of Rs 10,000, this leaves each collector with a monthly income of Rs 26,000.

Overview of waste management in Hyderabad

Number of dry waste collection and management centres	31
Number of decentralized waste management centres	64
Decentralized composting units run by bulk generators	770
Segregation percentage in 120 wards	60
Number of centralized integrated waste management facilities	1
Name of the operator of the integrated waste management facility	Hyderabad Integrated Municipal Solid Waste Limited (sister company of Ramky Group)
Years of concession	25
Year of commissioning	2009
Capacity of the facility	6,000 TPD

Source: GHMC, 2019

Segregated waste collected by swachh auto tippers and by GHMC's own sanitation workers reaches a dedicated transfer station where recyclables are sold to DWCC operators. The rest of the waste is taken to a centralized facility in Jawahar Nagar village in Medchal Mandal, which is around 27 kilometers from the city outskirts.

Plastic waste management

GHMC has equipped all DWCCs with fatka machines (a blower machine to clean plastics and reduce contamination). In 2018–19, around 774 tonnes of plastic were channelized for recycling through the DWCCs.

In 2016, GHMC issued a circular for compliance with the Plastic Waste Management (PWM) Rules, 2016 and laid out guidelines to strictly enforce the circular. As per the circular, an enforcement officer is responsible for administering the implementation of PWM rules through:

1. Prohibition on stocking, distribution, selling and use of any carry bag (with or without a handle) less than 50 microns in thickness.
2. Ensuring that sachets or pouches using plastic material (including VMCH resin) are not used in storing, packing or selling gutkha, tobacco and pan masala (excluding those made from compostable material as per IS/ ISO:17088: 2012).

GHMC has also created a regime of fines for entities using, stocking or selling carry bags, sachets and pouches containing plastic material as follows:

1. First offence: Rs 10,000
2. Second offence: Rs 25,000
3. Third offence: Closure of the unit and confiscation of the material

Centralized treatment facility

GHMC formulated its integrated solid waste management project in 2008. In 2019, the project was entrusted to the private operator Hyderabad Integrated Municipal Solid Waste Limited under a public–private partnership (PPP) in the 'built, operate and transfer' mode for 25 years.

The facility recovers about 35 per cent of dry waste as refuse-derived fuel (RDF), a portion of which is sold to cement manufacturing units and the rest is stockpiled to be used in the 24 MW waste-to-energy plant, which is under an internal test run and is expected to be fully operational by June 2020. It also recovers about 1 per cent of recyclable plastic (mainly because most recyclable plastic has been recovered by waste pickers in the city itself). The facility generates about 300 tonnes of compost daily, which is sold through fertilizer marketing companies. About 15 per cent of inerts are disposed of into a scientific landfill.

Characterization of MSW received at Jawahar Nagar centralized facility (per day)	
Average MSW received	5,339 MT
Dry waste	2,406 MT
Wet waste	2,933 MT

Source: GHMC, 2019

A SWACHH AUTO TIPPER OPERATOR

Prabhudas is an operator of a swachh auto tipper (SAT). In 2010, after moving to Hyderabad from his village in the Mahabubnagar district, Prabhudas worked as a construction labourer for six months. It did not pay enough to feed his family, so he switched to collecting waste from households along with his wife, who also moonlighted as a domestic help. They used to sell recyclables to an aggregator but the bad quality of the collected plastic meant that the flat rate at which they sold it was barely enough for them to scrape through.

In 2016, he was provided with the tipper by GHMC against a margin amount of Rs 40,000. He was happy to pay the margin amount through hand loans from his friends and family. Now he collects only segregated waste from 600 household allocated to him, at the monthly rate of Rs 60 per household. He recalls the initial days when people used to create a lot of problem in giving segregated waste and paying the user fees. GHMC sent a sanitary field assistant to assist him in creating awareness about waste management. Now he starts his collection drive at 5:30 a.m. and continues till 11:30 a.m. He can sell the segregated plastic at the transfer station or to any aggregator if it pays better.

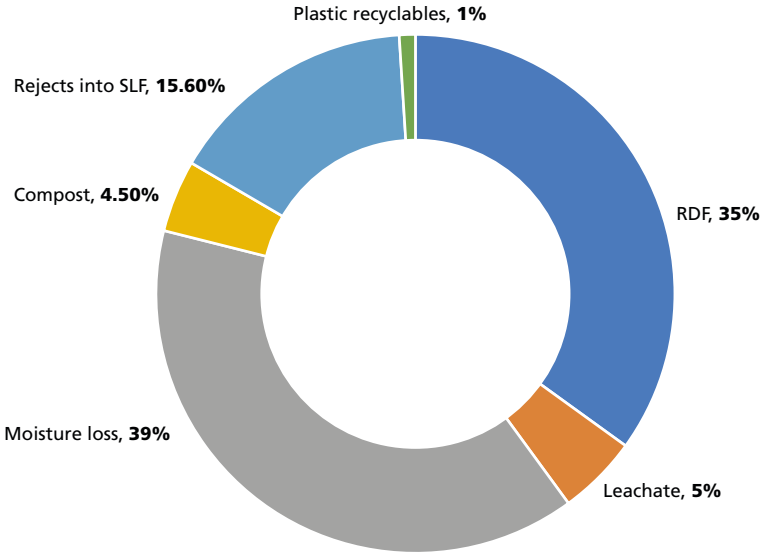
He explains that he successfully collects user fees from about 550 households, as the rest or either not occupied or are locked. He spends around Rs 9,000–10,000 every month on diesel for his tipper. He has already managed to pay back the loans he took and is mulling the installation of solar panels on his auto. This goes to show how keen he is on reducing the expenses on collection further, even if it demands an initial investment. Prabhudas is a proud father of two kids, one of whom attends a government school.

DINESH RAJ / CSE

A proud operator of a swachh auto tipper

The project does not include the tipping fee, as the cost of transporting waste to the centralized facility is borne by GHMC. However, a fee of Rs 958 per tonne is paid to the concessionaire for processing and disposal of the waste.

Waste composition after processing



Source: CSE, 2019

Impact of the model

Hyderabad is the first city in Telangana to identify informal waste collectors and integrate them into primary waste collection. This has helped the city to generate sustainable livelihood for 2,500 waste collectors while also ensuring that source-segregation is implemented. The wages load of the corporation has also been reduced. GHMC reckons that creating a self-reliant primary collection system along with assets for ten years through the swachh auto tipper model is better than paying minimum wages to 2,500 sanitation workers (average Rs 10,000 per waste collector per month).

In 2016, the city council passed a resolution banning plastic carry bags. This ban is strictly enforced. GHMC collected a sum of Rs 5.19 crore between 2016–17 and 2018–19 as fines for violations of the ban. In addition, 108 plastic manufacturing units have also been shut down.

Though the city claims 100 per cent door-to-door collection, the on-ground situation does not substantiate these claims. Despite the operation of swachh auto tippers, robust collection and a streamlined multitier segregation system, the percentage of dry waste reaching the centralized facility was found to be only about 45.

SONIA HENAM / CSE

INDORE

An integrated approach to waste management makes Indore the cleanest city in the country

Area:
275 sq km

Population
2.7 million

Waste generated
1,165 TPD

Madhya Pradesh government has declared Indore as a 'model city' for cities in the state having populations of more than 0.5 million. The city of 2.7 million inhabitants is spread over an area of 275 sq km. Indore Municipal Corporation (IMC), which manages the city's solid waste, has 85 administrative wards under 19 zones. According to IMC, the city generates about 1,165 tonnes of waste per day, 45 per cent biodegradable, 50 per cent of non-biodegradable and about 5-6 per cent of inert. Indore produces about 65 tonnes of construction and demolition (C&D) waste a day.

How it started

Prior to 2016, door-to-door collection in Indore was below par. Primary collection was done by waste collectors, secondary collection and transportation was carried out by a private contractor—A2Z Infrastructure Limited. Collected waste was transported to an open dumping ground in Devgurudia.

Organic waste processed for city compost:
~ 495 TPD

Revenue generated:
Rs 5 crore per month

User fees collected:
Rs 2 crore per month

Infrastructure for collection of waste:
- 600 small tippers with compartments
- 500 wheelbarrows and pushcarts
- 44 big tippers
- 40 compacters

However, the quality of the services was poor. Waste was collected in central dustbins and garbage containers lining the main streets and open government land. Often, these bins and containers would be overflowing with garbage, leading to health hazards for the citizens. A combination of poor collection and transportation of waste, and indiscipline among the sweeping staff gave the city a filthy look. Even a PIL was filed against the authorities by an activist, which eventually led to the termination of A2Z's contract in August 2015.[1]

City authorities realized that its solid waste management needed a complete overhaul. Improving door-to-door collection was recognized as the first and most important step in that endeavour. In December 2015, a pilot project was started in two wards. An identification study was carried out to ascertain the population of the two wards and the exact quantity of waste they produced. Based on this, a comprehensive route plan was prepared, which included a detailed vehicle and staff deployment plan.[2] Eighty *safai mitras* or waste collectors, 40 cycle rickshaw and one motorized garbage tipper were designated for the pilot. One small tipper could cover 1,000 households in a single trip. By 2016, IMC had extended the project to 10 wards, with four–six garbage tippers deployed in every yard. Waste collection cost was reduced to Rs 1,662 per tonne from Rs 2,886 per tonne.[3] The city corporation also started a 'bin-free initiative'. By December 2016, Indore had become a bin-free city.

Waste management in Indore

Indore has adopted an integrated approach to solid waste management, under which comprehensive waste prevention, recycling, composting and disposal is undertaken. This approach includes 100 per cent door-to-door collection, source-segregation, ICT-based interventions, plastic waste management, and treatment and processing of waste.

Citizen participation and strict monitoring by city administration

To ensure that better waste management practices take root, the city administration applied the stick-and-carrot method.

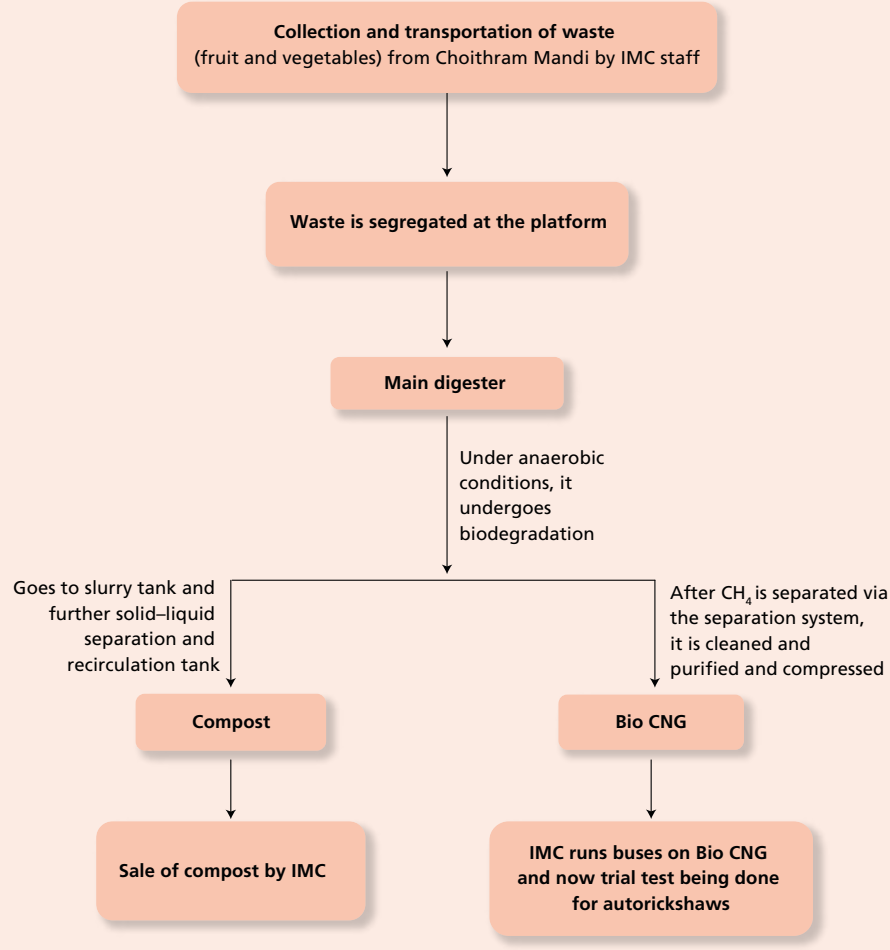
The stick is fines on any violation or non-compliance with solid waste management bye-laws. There are fines on littering, non-segregation and open burning, starting at Rs 500 and going up as high as Rs 1 lakh. A group of NGOs has been roped in to help with monitoring. In the initial months, till a new normal was established, the commissioner of IMC and his 400-strong team (mostly composed of volunteers from the NGOs) used to scour the city street-by-street to check for violations. Even the rallies of senior politicians are not spared and have to comply with the rules against littering at the pain of negative publicity in the media.

The carrot is a huge awareness campaign. Well-known radio jockeys have been made brand ambassadors of the campaign. There are ads on TV and in newspapers. Talk shows are hosted and jingles composed to promote good waste management practices. Children and youth know the catchy jingles by heart. Slogans have been painted on 0.15 million square meters of wall space across the city, discouraging from and warning against spitting, public urination and littering.

BIOMETHANATION PLANT AT DEVI AHILYABAI HOLKAR FRUITS AND VEGETABLE MARKET

As part of its decentralized waste management approach, IMC awarded the tender to construct a biomethanation plant at Devi Ahilyabai Holkar fruits and vegetable market to Mahindra and Mahindra Ltd, Mumbai. The project cost was Rs 7.3 crore and the concession period is 15 years. At present, all the fruit and vegetable waste generated at Choithram Mandi (about 20 tonnes a day) is being collected and processed at the plant. The plant produces about 800 kg of purified and compressed bioCNG with 95 per cent methane content every day. Twenty-two city buses operate on the gas, and test runs are also being performed on auto-rickshaws. This means about Rs 5,000 will be saved every day on fuel. The digested slurry is passed through a solid–liquid separation unit. Filtered liquid is reused in slurry making while the solid is dried and converted into organic compost. The initiative helps reduce the carbon footprint of the administration and converts waste into wealth.

Flowchart of the process followed at biomethanation plant



Source: Adopted from NIUA 2019; IMC, 2019–20

The result is that households have begun to segregate waste into three fractions: biodegradable, non-biodegradable, and sanitary or domestic hazardous. All commercial establishments and bulk generators have also started practising source-segregation into two streams: biodegradable and non-biodegradable.

INDORE MUNICIPAL CORPORATION

Aerial view of windrow composting in Devguradia

Setting up good infrastructure

IMC gave out 100,000 dustbins for source-segregation to residents at a discounted cost (as the corporation does not believe in providing freebies). Segregated waste is collected by small compartmentalized vehicles (all of which have GPS and RFID) and brought to one of the ten ultra-modern garbage transfer stations (GTSs). The capacity of each GTS is about 150–200 tonnes per day. They are equipped with state-of-the-art machinery to quantify and process waste. GTSs have been nicknamed green transfer stations because each station saves about Rs 20 lakh on fuel consumption every year. Wet waste is subject to windrow composting at the central processing unit. Since waste is in segregation form, the compost produced is of good quality and fetches Rs 3–4 per kg. Each GTS also has its own biomethanation plant using 1.8 tonnes a day of waste to generate electricity for the station.[4] Wet waste from bulk generators (producing 50 kg and above per day) is processed at on-site and not sent to GTSs. As for dry waste, it is segregated manually into different components like metal, rubber and plastic by 343 employees of the material recovery facility (MRF) at Devgurudia. An automated MRF has also been proposed.

IMC has also set up a plastic collection centre (PCC) to recycle and reuse the city's plastic waste. Waste pickers separate recyclable plastic for reuse. Non-recyclable plastic is cleaned and shredded in the 'phatka machine'. Around 10 tonnes of shredded and purified plastic is sent to a cement plant in Neemuch daily, and about 10.5 tonnes is sent to Madhya Pradesh Rural Road Development Authority every day for construction of roads.

For managing C&D waste, IMC has set up a PPP processing facility. Under the PPP model, the corporation has provided 4 acres of land on a lease of 15 years for setting up the plant. C&D waste is subjected to a number of operations during processing. The products obtained are paver blocks with finished surface, rough paver blocks, rectangular paver bricks and masonry bricks. The private contractor is expected to recover the cost of construction of the C&D waste processing facility in eight years.

Two scientifically engineered landfills of 6.25 acre each have been constructed. Only inert waste is transferred to these sites.

Reclamation of legacy waste

The city has transformed its garbage landfill site into a beautiful garden within a tight timeframe. The reclamation project started in 2016–17. IMC outsourced the work to a contractor. About 0.2 million tonnes of waste were cleared out, but in 2018, about 1.2 million tonnes of new waste were dumped on the ground. IMC decided to take charge of the project as it realized that time was of essence if the task was not to become Sisyphean. Moreover, the contractor was charging about Rs 500 m^3; the entire project would cost IMC Rs 65 crore, which was beyond their financial capacity. They rented 10 trommels, 15 hortizontal screens, and more than 50 excavators and backhoe loaders. About 200 workers of IMC, under strict supervision, completed the work in just six months.[5] It only cost IMC Rs 10 crore.

Recyclables from biomining of the site were reused—recyclable polythene was sent to cement plants and for road-making. Recovered C&D waste was sent to the processing facility. Recovered soil was used to refill the ground where a granary is being developed. Leftover waste was sent to a secured landfill. The total reclaimed land is worth Rs 300 crore. A portion of it has been developed into a garden where a fairy artwork named *Swachhtakipari*, made from reclaimed waste, stands testament to the success of the initiative. The work complies with the requirements of Star Ranking of Garbage Free Cities protocol issued by Ministry of Housing and Urban Affairs (MoHUA).

Impact of the model

Indore has been ranked the top cleanest city in the country for three straight years. The city is working not only on aesthetic cleanliness but on management of waste by instigating behavioural changes among residents.[6] IMC has also been able to clear 1.3 million tonnes of waste through remediation of 100 acres of land worth Rs 300 crore.[7] Employees of the city's MRF used to earn Rs 150 a day collecting scraps from the streets. Now they earn Rs 300–350 a day.

Indore spent Rs 150 crore on waste management in 2018–19. It had a budgetary allocation of Rs 160 crore. It also earned Rs 60 crore from user fees, sale of compost, and fines and penalties. However, the financial sustainability of its waste management system remains a challenge.

DINESH RAJ / CSE

KUMBAKONAM

Temple town shedding dumpsite mentality in favour of composting and biomethanation, but segregation remains a concern

Area:
12.5 sq km

Population
0.14 million

Waste generated
80 TPD

City compost generated:
~ 2–3 TPD

Earning of municipality through sale of city compost:
Rs 5 lakh per month

Area reclaimed through bioremediation:
13.15 hectares

Money spent on improving waste management:
Rs 8.5 crore

Kumbakonam is a prominent temple town in the Tanjavur district, some 313 km south of Chennai, in Tamil Nadu. It is famous for its farm-based activities as well, that have earned it the moniker 'granary of South India'. The town has a population of 0.14 million (Census 2011) and stretches over 12.5 sq km.

Kumbakonam municipality has administration over 35,509 houses and is divided into 45 wards. Population growth has slowed down during the last couple of decades, mainly because there are no major industrial units in the area. Kumbakonam generates 80 TPD of solid waste, of which 65 per cent is biodegradable.

How it started

For 30 years, Kumbakonam municipality used to collect mixed waste and transport it to the dumping site in Thepperumanallur village, some 8 km from the town. The

dumpsite, spread over 3.5 acres, contained an estimated 0.35 million tonnes of waste. It was an eyesore for the villagers, with a pervasive acrid smell and seasonal fires.

When the villagers rose up against the use of their backyard as a dumping ground, Kumbakonam municipality was forced to look for alternatives. The town adopted a two-pronged strategy. Better collection and management of MSW and bioremediation of the dumpsite.

Remediation of the dumpsite

In 2015, the municipality decided to manage the 30 year-old legacy waste, making it the first bioremediation site in the country. The contract was awarded to Zigma, a fledgling environmental services company. The initial plan was to go for biocapping and maintenance of the landfill, but the technical support team of the municipality wanted to try the new biomining technology.

An area of 13.15 hectare has been reclaimed through biomining. An 80 TPD processing unit that manages the waste generated by the city has been established on the reclaimed land. In addition, a biogas unit has also been commissioned on the same land. Resources mined from the dumpsite were sent to Dalmia Cements in Dalmiapuram, some 70 km from the town, to be used as refused-derived fuel.

Revival of waste management

The municipality claims to collect 75 tonnes of waste every day, out of the 80 tonnes the town generates. The largest portion of this waste comes from households. Door-to-door collection is carried out in 23 wards by a private vendor and in the other 22 wards by the municipality itself. Secondary collection points (in the form of 200-litre community bins) are put in public places identified through spatial data like topographical maps, ward maps and Google images, analyzed using ArcGIS (GIS software). These community storage bins are supposed to receive segregated waste from households and

DINESH RAJ / CSE

Secondary segregation of waste collected door-to-door for recovery of recyclables

commercial establishments on push carts and tricycle rickshaws, but often, the waste in them is mixed. This is the case even in the 11 wards that practise source-segregation.

From the secondary collection points, waste is supposed to be transported to the integrated composting facility in six tippers and three mini-trucks. Again, this practice is not always followed and waste is burned in the secondary collection bins at many places to make space for more waste.

In 2017, the city spent Rs 8.5 crore on purchase of vehicles to transport waste and set up composting infrastructure. The average annual cost of handling solid waste is around Rs 47 lakh. No user fee is collected from households for collection of waste by the municipality.

Composting

The municipality operates a centralized composting facility at Thepperumanallur. The facility is supposed to receive segregated waste, however as a plan B, mechanical segregation facilities have also been installed at the site. The facility has a capacity to treat 70 tonnes of waste per day. The municipality generates about 80 to 100 tonnes of compost every month, which is sold at Rs 5 per kg to farmers. Recyclables recovered through mechanized segregation are sold to a local aggregator. Non-recyclable and non-biodegradable plastic and rags are stored as of now, since the corporation has not been able to finalize a cost agreement with nearby cement units for co-processing.

Biomethanation

In 2016, Pune-based Mailhem Engineers Pvt Ltd was commissioned to build

Overview of waste management

Estimated waste generation	70 TPD
Segregation percentage	Only 11 out of 45 wards practise source-segregation
Number of integrated waste management facilities (centralized)	1
Name of the operator of the integrated waste management facility (centralized)	Kumbakonam Municipality
Capacity of the facility	70 TPD
Number of decentralized composting units	0
Number of decentralized biomethanation units	1
Name of the operator	Kumbakonam Municipality
Capacity of the facility	5 TPD
Usage of gas output	Cooking fuel
Capacity of the output	20 kg methane per day

Source: CSE, 2019

a 5 TPD biogas system adjacent to the centralized composting facility in Thepperumanallur. The cost of the project was estimated to be Rs 1.9 crore. The plan was to transfer food waste from hotels and raw vegetable waste from markets to the biogas plant. However, the biogas plant is defunct and the contract ends in 2021.

Plastic waste management

Kumbakonam municipality is yet to draft bye-laws on solid waste or plastic waste management, but a ban on plastics has been imposed by the state government. The fine structure for stocking, selling, carrying and distributing banned plastic items is as follows:

First violation: Rs 25,000
Second violation: Rs 50,000
Third violation: Suspension of trade licence

Small traders and hawkers are fined Rs 500 for using banned plastic items. Between January and October 2019, the municipality collected fines of around Rs 9 lakh. Yet, plastic usage is prevalent and plastic waste is also burned at many places.

The municipality has also been encouraging alternatives like areca leaf products (as the town is famous for areca nuts). Meat retailers' association of Kumbakonam has also chipped in by promising to give a discount of Rs 5 to customers who bring their own steel containers to carry meat.

Where does Kumbakonam go from here?

Kumbakonam municipality is on a path of revival after learning its lesson the hard way by having to spend Rs 1.5 crore on bioremediation of its old dumpsite. The lessons learned are that waste does not go simply by wishing it away, nor can you make it somebody else's problem in this day and age.

The town is taking baby steps towards an improved waste management regime. However, the percentage of segregation remains low, awareness among the residents regarding segregation is poor and the town is relying on a single centralized facility that operates on non-segregated waste. Composting waste that has not been segregated decreases the efficiency of the process and increases the risk of toxicity due to metal and other contamination. The city also needs to keep proliferation of plastics in check.

DINESH RAJ / CSE

MUZAFFARPUR

The first state-of-the-art decentralized waste processing centre in Bihar

Area:
26.68 sq km

Population
0.35 million

Waste generated
110 TPD

First city in Bihar state to achieve 80 per cent source-segregation of waste

Organic waste processed for city compost:
38 TPD

Dry waste diverted from reaching landfill:
20 TPD

Enhanced income of each waste collector by increased source-segregation:
Rs 3,000 per month

Muzaffarpur is the second biggest commercial centre in Bihar, after Patna. Administratively, the city is divided into 10 circles, which are further divided into 49 wards. Each ward consists of 1,500–3,000 houses. The city has a population of about 0.35 million as per the 2011 census.

The story of the Rautaniya dumpsite

The city had no waste management infrastructure to speak of prior to 2016. Waste collected from around the city was transported to the Rautaniya village, some 12 km from the city, leading to the creation of a garbage hill. Although the village was adversely affected by the dumpsite, business continued as usual for a long time as villagers were ignorant about their choices in the matter. By 2015, however, villagers started to express their unwillingness to allow the continuation of making the city' problem their own. The city administration knew they needed to make alternative arrangement to process their waste. Around this time,

Centre for Science and Environment (CSE) had brought out its seminal *Not in My Backyard: Solid Waste Management in Indian Cities*. It offered the administration models from all over the country which they could adopt and improve upon.

CSE's intervention

In 2016, CSE launched the 'Swachhata Swastya Samridhi' programme in Muzaffarpur. The objective of the programme was to enhance waste management system in the city over a period of three years. The programme, unlike any public–private partnership (PPP), was grounded in capacity building of the urban local bodies (ULB). Making the ULB the real owner of the initiative would ensure its complete participation, as CSE believes that responsibility comes with ownership.

CSE acted as the technical support provider for the project and the municipal corporation was the face, with CSR funding support. The project started with a basic estimate of waste generation in the city. According to the Model Building Bye Laws, 2004, per capita waste generation in India is about 300 grams per day. This gave a figure of around 170 tonnes of waste in Muzaffarpur.

CSE identified centralized non-segregation as the primary culprit of the city's waste management woes. Each of the 85,000 households in the city was provided with colour-coded twin-bins to promote source-segregation. Seventy volunteers were made responsible for door-to-door propagation to sensitize residents on the need of segregation and to check the progress made. These volunteers accompany waste collectors and check the levels of segregation each

Collection of segregated waste

DINESH RAJ / CSE

day. Their role is to ensure that over a period of time, segregation becomes a habit of the citizens. The citizens also receive training explaining the process of segregation. Within a month of the programme's initiation, most households in every ward started giving segregated waste to municipal workers.

City waste profile

Estimated total waste generation	110 TPD
Number of decentralized composting centres	7
Name of the operator	Muzaffarpur Municipal Corporation
Number of composting pits	246
Capacity of each composting pit	1.5 tonnes
Segregation percentage	80

Source: CSE 2019

Identifying the need for segregated transportation, Muzaffarpur's municipal administration modified its existing infrastructure to support collection and transportation of segregated waste. Nineteen tippers with partitions, four tractors with partitions, and 215 tricycles with bins were employed to collect and transport segregated waste. Non-segregated waste continued to be collected and transported in 46 tractors and 105 pushcarts. The number of vehicles collecting non-segregated waste decreased with time as the quantity of unsegregated waste diminished.

Processing of segregated wet waste started at one centre in the MRDA area with 40 composting pits each with a capacity of 1 tonne. By and by, more centres were developed in different parts of the city so that each area could have a centre in its vicinity and transportation of waste was minimized. Over a period of three years, seven processing centres with 246 compost pits have been commissioned. About 60 tonnes of segregated wet waste collected from all the 49 wards reaches these processing centres every day between 6 a.m. and 11 a.m.

Each composting facilities is equipped with a shredder. Organic compost is shredded before it is processed in the composting pit. Each facility is also equipped with a sieve, enabling sieving of processed particles less than 4 mm in diameter, to improve the quality of the compost.

Details of the processing centres

Processing centre	Number of composting pits
MRDA	40
Chandwara	106
Sikandarpur	80
LS college	20
Total	246

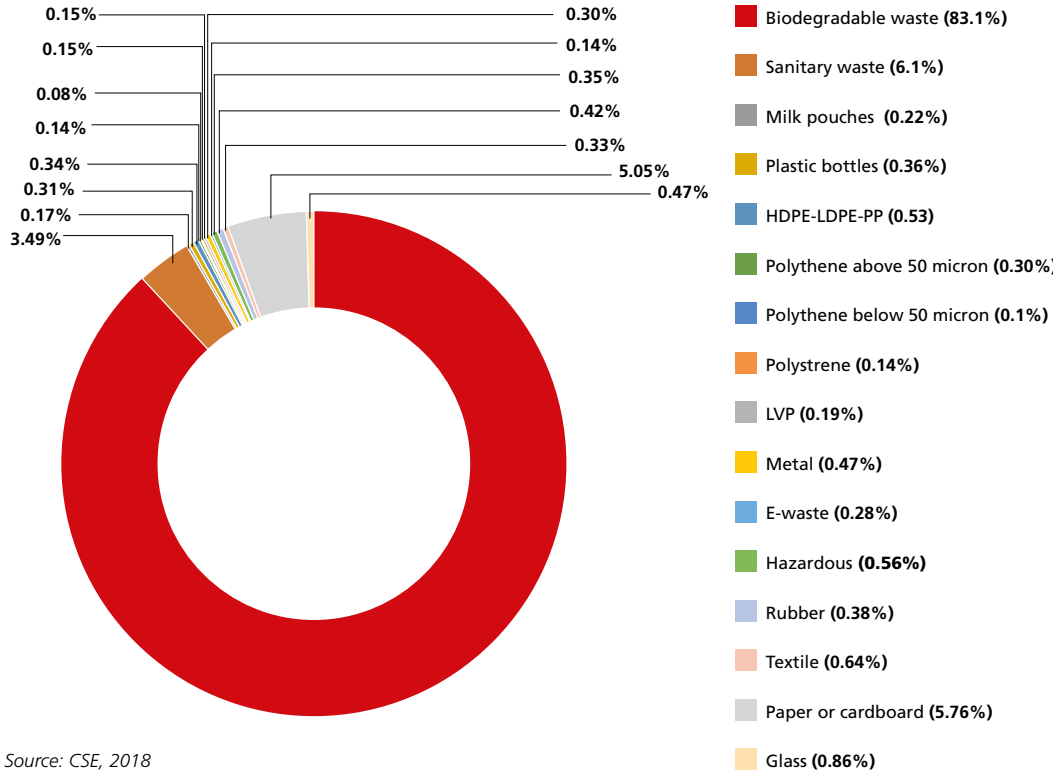
Source: Muzaffarpur Municipal Corporation

Recyclable dry waste is the property of sanitation workers and is taken from the blue bins during door-to-door collection. High value recyclables are sold by sanitation workers to earn extra income. The municipal corporation operates storage facilities at all processing centres for non-recyclable and low-calorific value dry waste. The corporation is awaiting the establishment of a centralized dry waste facility by the Urban Development Department, Bihar. Storing this waste also helps the corporation save the amount they would have to spend on transporting this waste for co-processing.

With an objective to identify the per capita and total waste generated by the city after two years of project implementation, an inventorization study was done by CSE in 2018. The study analysed samples of segregated waste at the doorstep of 175 households for two months. It revealed that the biodegradable portion of the waste generated by Muzaffarpur is around 85 per cent. This strengthened the argument for composting as a simple solution for complex waste management problems.

At present, Muzaffarpur generates around 2.5 tonnes of compost every month. To facilitate sale of the compost, the corporation tests its quality every six months. Parameters that are tested are moisture ratio, carbon–nitrogen ratio and salinity. The corporation has registered 'Muzaffarpur Jaivak Khad' as a trademark for selling compost. Compost is packed in sealed bags that have compost quality test report imprinted on them. It is sold at Rs 5 per kg. The corporation has earned around Rs 84,000 through the sale of compost till date.

Physical characteristics of waste in Muzaffarpur



Source: CSE, 2018

A term-end project evaluation in November 2019 determined that 80 per cent households in 49 wards segregate waste. Commercial establishments such as shops majorly generate dry waste and store it in cartons. Biomedical, sanitary or hazardous waste is handled separately from the wet and dry waste through a common biomedical waste treatment facility.

Muzaffarpur Municipal corporation has passed bye-laws enabling it to penalize burning of plastic waste and usage of banned plastic items. The bye-laws allow collection of fines of upto Rs 1 lakh and imprisonment of upto five years.

Impact of the intervention

By December 2019, Muzaffarpur had become the first city in Bihar with 100 per cent decentralized waste management with 80 per cent source-segregation. CSE continues to track segregation percentages.

The city composts around 38 tonnes of wet waste daily. Before decentralized composting was initiated in Muzaffarpur, its municipal authorities used to spend around Rs 1 lakh on fuel to transport wet waste. This has been reduced to Rs 20,000 (an 80 per cent reduction). Having said that, the collection and transport infrastructure is not adequate to cater to commercial and institutional areas of the city. This discourages segregation in these areas and may lead to littering.

The city's municipal corporation has pioneered the codification of solid and plastic waste bye-laws in the state. However, household and user fees collection is not enforced as per the bye-laws and the political will to impose user fee is also absent. This will put financial strain on the corporation in the long-run.

Muzaffarpur inaugurated an integrated waste processing centre (the first such centre in Bihar) in October 2018. The centre acts as a model site where local residents and officials from other ULBs in Bihar learn about waste processing. Adorned with beautiful Madhubani paintings done by local artists, it can also rightfully claim to be one of the most beautiful processing centres of the country. The initiative has been successful in diverting 20 tonnes of plastic waste daily from landfills, out of which around 18 tonnes are sent for recycling. But the cost of transportation of non-recyclable dry waste to a cement kiln is too high and needs to be reduced. The city also has plans to remediate its existing dumpsite.

Following the success of the Muzaffarpur model, the Urban Development Department of Bihar has suggested replication of the model in 105 other ULBs of the state. Around 21 other ULBs have started work in that direction. CSE is providing technical support to these ULBs for setting up decentralized waste processing systems.

SONIA HENAM / CSE

PANCHGANI

An active administration, strict monitoring and involvement of the private sector did the trick

Area:
40 sq km

Population
14,984

Waste generated
7.215 TPD

Once infamous for its *kachra* (garbage) points, Panchgani has today been restored as a pristine hill station, and is among the cleanest towns in the country. The town of 14,984 inhabitants generates about 7 tonnes of waste every day. It has achieved 100 per cent segregation efficiency within four years and processes every bit of its waste. The composting facility in the town treats about half of the waste it produces every day and helps generate revenue. Panchgani Hill Station Municipal Council (PHMC) manages the town's solid waste and is divided into 17 wards for administration.[1]

How it started

Being a hill station, the floating annual population in Panchgani is around 1–1.2 million. This put a severe strain on the town's municipal resources. Seven years ago, at any given time, the town only had about 510 staff members catering to the waste management needs of 1 million people. To paper

Organic waste processed for city compost:
3–3.5 TPD

User charges collected:
~ Rs 33,500 per month

Spot fines collected for littering and non-segregation:
~ Rs 15,500 per month

Money made through sale of compost:
~ Rs 80,000 per month

Money paid to the private contractor for collection and transport of waste:
Rs 11.36 lakh per month

over its manpower shortcomings, PHMC made use of big containers to collect garbage. But the main drawback of this system was non-segregation and mixing of waste, resulting in a Gordian knot of dumpsites.

To overcome this problem, PHMC decided to collect garbage only in the segregated form. As a first step, the 21 *kachra* points in the town, and all garbage containers and dustbins were removed. But this only served to reveal the lack of sufficient manpower in its painful details.

Waste management in Panchgani

To overcome these challenges, the PHMC adopted a multi-pronged strategy and implemented a slew of measures.

Leveraging private support

To begin with, the mayor, with the support of other elected representatives, roped in a private contractor, Aradhya Enterprise, for collection and transportation (C&T) of segregated waste. PHMC pays the contractor Rs 11.36 lakh per month for the services provided. C&T is performed by the 60 member-strong staff of the contractor, who make use of five tractors in the hilly terrain (once every day) and three other vehicles in the flat command areas (twice a day). The council provided insurance and protective gear like gloves, coats and gumboots to the staff.

After collection of waste in the segregated form, it is transported to the Swachha Bharat Point for processing. Wet waste is sent to the town's composting facility, where 3.5 tonnes of wet waste is bedded to compost every

SONIA HENAM / CSE

Swachh Bharat Point

day. Farmers happily buy the chemical-free organic manure at Rs 5 per kg. Bulk generators including boarding schools and large commercial enterprises compost on-site.

As for the dry waste, it is segregated into seven types: clothes, footwear, glass, metal, recyclable plastics and bottles, rubber, and shredded plastics. Milk pouches, PET bottles and other recyclables are sold to *kabadiwallas*. Plastics are crushed in a plastic crusher and sold at Rs 5 per kg. As Panchgani is an eco-sensitive zone, this waste is sent to the recycling company in Bhiwandi, in Maharashtra. About 150 bags of crushed bags are sent to the company every month. Shredded plastic is also sent to a contractor to be used in road construction.

Domestic hazardous wastes such as sanitary napkins and diapers are wrapped in paper and kept separately, to be collected along with the dry waste and sent for incineration to Satara, 50 km away from the town.

Being a small hill station, there is no secondary collection centre in Panchgani. PHMC is planning to set up a 6 TPD biomethanation plant to produce electricity, which will be constructed in a few months. Government of Maharashtra has sanctioned Rs 62.8 lakh for the project.

Sensitizing the masses

In the beginning, for almost a year, the staff of the private contractor segregated garbage taken from households. In the first phase of the plan, commercial properties, mainly hotels and schools, were targeted for compulsory segregation, which took about six months' time to achieve. Training programmes were held for waste workers on the importance of segregation. Sensitization programmes on segregation were also started for other citizens.

Residents were taught the process of segregating their wastes into three categories—wet, dry and hazardous. Waste collectors were instructed to refrain from picking up waste that was not properly segregated. To ensure that residents were constantly reminded of their responsibilities, *Swachhagrahis* (a name given to volunteers of SBM) were appointed to monitor day-to-day activities in all wards.

Once citizens realized the importance of segregation there was no looking back. Now, all 17 wards in the town are segregating 100 per cent at source. Even the tourist spots such as Parsi Point, Sydney Point and Tableland are visibly cleaner. Shopkeepers around these spots have their own separate bins for segregation. PHMC encourages people to use their own bins and cardboard boxes for segregation. Bins have only been provided in the slum areas under a CSR-funded programme.

A pinch of punitive action

PHMC passed municipal bye-laws on solid waste management, in adherence to the Solid Waste Management (SWM) rules of 2016. The bye-laws contain provisions penalizing littering, non-segregation of garbage and spitting with fines. Spot fines for non-segregation of waste at the household level and in

HOW PANCHGANI IS MINIMIZING SINGLE-USE PLASTIC

In Panchgani, plastics of less than 50 microns in thickness were banned in 2005, and thermocol was banned in the whole of Maharashtra in 2018. Monitoring of the ban on plastics is strong in Panchgani, and locals, including shopkeepers and vegetable vendors, take an active part in the initiative. For cereals, handle-less plastic bags of not than 50 microns are allowed by the state government. Local residents also carry their own bags when they go out for shopping. If any person or vendor is found using banned plastic bags, a fine of Rs 5,000 is levied on the spot. Regular raids to catch violators ensures compliance.

PHMC has taken a few other initiatives to eliminate polybags and end littering at tourist spots and in shops. Ten women's self-help groups (SHGs) were trained to make cloth bags and sell them to shops and vegetable vendors at Rs 15 per piece (with subsidy from the council, the market rate being Rs 20 per piece).

In Tableland, a popular tourist spot in Panchgani, the council has also appointed 11 SHGs to collect plastics, especially PET bottles. About six–seven gunny bag-worth of waste and bottles are collected every day. The council provides each member of the SHGs a salary of Rs 8,000 per month. Collected waste is taken to the Swachh Bharat point for segregation and processing. Now, the town is stepping up efforts to minimize use of other plastics as well to become a 'zero plastic town'.

commercial areas are Rs 500 and Rs 5,000 respectively. Spot fine on littering is also Rs 500. More importantly, there is a strict compliance and monitoring system in place. Ward councilors and staff of the municipal council regularly check for violations. Two officials are responsible for collecting fines, they collect around Rs 1.85 lakh per year for non-segregation and littering.

Impact of the model

Panchgani no longer has a disposal facility nor does it need one. Its existing disposal site, which once used to be a litter and stench hotspot, has been remediated into a public park and major tourist attraction-cum-learning centre, where stakeholders and locals come to learn about waste management. A vegetable garden using compost made from the received waste has also been set up at the processing site. With a minimum budget, constrained infrastructure and proactive administration, PHMC has been able to achieve 100 per cent source-segregation and making Panchgani a litter-free zone.

With an assigned budgetary allocation of Rs 5 crore for SWM in the financial year 2018–19, it is also generating revenue from user fees, sale of compost, and fines and penalties. PHMC charges 10 per cent of house tax for residential areas and 25 per cent for commercial areas and institutions as user charges for SWM. In 2018–19, it collected Rs 40 lakh as user fees, Rs 9.5 lakh from the sale of compost, and Rs 1.85 lakh as fines. Additionally, PHMC has given advertisement rights of Information Education and Communication (IEC) to Mala Jam factory, on payment of Rs 10 lakh per year to the council.[2]

For its commendable work on SWM, Panchgani has been applauded by MoHUA in the media, and was awarded 'Cleanest City in the West Zone' and 'Cleanest City in the Country (in the less than 0.1 million category)' in the 2018's Swachh Survekshan.[3]

DINESH RAJ / CSE

TIRUPATI

Eliminating single-use plastics sets an example for the rest of the state

Area:
27.5 sq km

Population
0.3 million

Waste generated
207 TPD

Tirupati, located in the Chittoor district of Andhra Pradesh, is famous for the Lord Venkateshwara temple in Tirumala. Tirupati has a residential population of 0.3 million people, as per 2011 Census, and receives a floating population of around 0.05 million per day, being a major pilgrim centre. Traditionally, Tirupati's economy has been predominantly pilgrimage-based, but in recent years the region has become the education and trade hub of the Rayalseema region of Andhra Pradesh. Municipal Corporation of Tirupati (MCT) is the body responsible for the city's waste management. The city stretches over 27.5 sq km and is divided into 50 municipal wards.

Waste management prior to 2016

In 2015, MCT carried out a solid waste generation estimation exercise. The estimate put the solid waste generated by the city at about 207 TPD. The biodegradable component was estimated to be 51 per cent and inert component about 12 per cent. Around 4 per cent of the total was estimated to be coconut waste.

Organic waste processed through vermi-compost:
14 TPD

Revenue generated by MCT from sale of vermi-compost:
Rs 12,000 per month

Additional income to each waste collector due to source-segregation:
Rs 3,000 per month

The city used to dump its mixed waste at Ramapuram, creating a large landfill of around 10.11 hectares. After the city had done the estimate in 2015, it realized that it could convert the huge biodegradable portion of its waste into compost.

Overview of waste management

Estimated waste generation	207 TPD
Number of integrated waste management facilities	1
Name of the operator of integrated waste management facility (centralized)	Municipal Corporation of Tirupati
Capacity of the facility	5 TPD
Number of decentralized composting units	3
Capacity of each composting facility	3 TPD
Number of decentralized biomethanation units	1
Capacity of the biomethanation facility	50 TPD
Estimated cost of the project	Rs 18 crore
Usage of gas output	Supply as cooking fuel

Source: CSE, 2019

Since then, the city has been moving towards sustainable waste management practices like source-segregation, decentralized composting and biomethanation. In 2016, it also decided to let go of single-use plastic and in the process became a role model for other cities.

Waste management in the city now

Segregation, collection and transportation

The city follows a partial system for segregation of solid waste into biodegradable and non-biodegradable components. At present, households in 29 wards (known as 'adarsh wards') have been provided with colour-coded bins to separate dry and wet waste free of cost under the Jawaharlal Nehru National Urban Renewal Mission (JNNURM). Segregated waste is collected by pushcart (each having four 60-litre bins). The city has a 100 per cent door-to-door collection efficiency of waste by sanitation workers. Waste from commercial areas is collected in tractor trolleys. As per MCT, 45 per cent of the waste is segregated.

However, the waste gets mixed again at secondary collection points. There are 168 secondary collection points in the city. From here, waste is transported to four transfer stations within the city. The oldest and largest transfer station stretches over an area of 0.8 hectare in ward no. 44. It is an open, uncovered area. Three new transfer stations have been built in the Leela Mahal area under the Smart Cities Project at a total cost of Rs 2 crore. These stations consist of covered bins and sheds, and have compacting facilities. These new collection centres are aimed at increasing the segregated collection and transportation percentage in the city.

Mixed waste is transported from the collection centres to the dumpsite in Ramapuram, some 12 km from the city, and segregated waste is sent for processing (vermi-composting and biomethanation) at Tukivakam, 15 km from the city.

Processing and disposal

Recyclable valuables are picked up from the waste manually by sanitation workers during their door-to-door rounds. They earn Rs 3,000 per person per month from selling them. MCT operates a 5 TPD vermi-composting unit at Tukivakam for processing biodegradable waste. Compost produced by the unit is sold at a rate of Rs 10 per kg. In addition, the city operates three decentralized composting units each with a capacity of 3 TPD at Balaji Colony, Bank Employees Colony and Old TPPM area; and nine horticulture waste processing units in parks, and three in vegetable markets. Moreover, ten resident welfare associations, with a combined processing capacity of 1.7 tonnes, process waste in-situ.

In 2019, at MCT's behest, a Rs 18 crore biogas unit was built at the Tukivakam village by Mahendra Pvt Ltd. The plant has a capacity to handle 50 TPD of waste and supplies biogas to hotels in its vicinity.

There are also plans to construct a 6 MW waste-to-energy (WtE) plant in Tirupati. The plant, which will process 600 TPD of waste, will be built under the Swachh Andhra Corporation and will also process waste from other cities

Informal waste pickers collecting recyclables from Ramapuram dumpsite

DINESH RAJ / CSE

DINESH RAJ / CSE

Small retailers selling reusable bags

and towns in the cluster, i.e., Chittoor, Nagari, Puttur, Srikalahasthi and Venkatagiri. However, local residents of Gajulamandyam Industrial Park of Renigunta Mandal, the site chosen for the WtE plant, are up in arms against it. As such, the future of the project remains unclear.

The dumpsite at Ramapuram is an open area occupying around 25 acres of land. Waste burning is a common phenomenon here. The way that leads to the dumpsite passes through abandoned stone quarries and naturally created ridges. To save fuel, tractor drivers dump the mixed waste on the way to the dumpsite in these quarries and ridges. MCT has not taken strict action against this trespass.

In 2019, MCT awarded a contract to Zigma to clear the 30-year old dumpsite. The processing company operates on a tipping fees arrangement with ULBs to mine legacy waste and extract valuable materials. The contract for one year is to clear 0.25 million tonnes of legacy waste. The prime aim is to reduce the size of the dumpsites by stabilizing the waste and separating valuable materials. The process involves extraction of soil, plastic waste, construction debris and metals. Zigma does not hold any right over the materials recovered under the contract. The municipal corporation uses the recovered soil to cover low-lying areas and as upper layer soil cover at the dumpsite. Plastic mined from the dumpsite is of low quality and cannot be recycled. It is sent for co-processing to industrial units. Recovered glass and metals are sent for recycling. The municipal corporation has identified authorized recyclers through a tendering process. Operations at the dumpsite started in August 2019 and the landfill is being cleared at a rate of 600 TPD.

Tirupati is a growing city with a lot of construction activity in every part of the city. In February 2019, MCT commissioned a C&D waste handling facility through a 20 year 'build, own, operate and transfer' (BOOT) agreement with Pro Enviro C&D Waste Management Private Limited. The facility is being developed under the Smart Cities Project. An area of 2 hectares has been granted to the concessionaire at the Tukivakam village, adjacent to the composting site. Operations have started with mobile equipment and the facility is expected to be fully functional by March 2020.

The concessionaire charges Rs 450 per tonne from bulk generators. The service is also available for one-time generators of C&D waste at the same rate.

Plastic ban

Being a major pilgrimage centre, Tirupati has a high floating tourist population. Usage of disposable cutlery and plastic water bottles was very high in the city, clogging its drains and adding to the city's pollution woes. MCT decided to act against the menace. Tirupati became the first city in the Andhra Pradesh to ban disposable bags. In fact, the city moved to ban plastic before the notification of the Central Plastic Waste Management (PWM) Rules in 2016. The city followed a three-prong implementation strategy. It increased the cost of disposable water bottles; it ran a month-long public campaign against plastic use; and, as a last step, it instituted fines.

The city has ensured strict implementation of the ban and the PWM rules. Disposable plastic-coated paper plates, thermocol plates, containers and dishes, water bottles with a holding capacity of less than 500 ml and packaging covers less than 50-micron in thickness are all banned in the city. Food is packed and served in banana leaf liners. Continued violation of the ban can attract fines upto Rs 25,000 and discontinuation of services like power and water supply. It can also lead to closure of an establishment using, storing or selling banned plastic materials.

The way forward

The city has successfully reduced waste destined for the dumpsite by increasing decentralized composting. Solid Waste Management Rules, 2016 and PWM are being implemented effectively. This resulted in the city being recognized as the best city in solid waste management (0.1–0.3 million population) during the 2018 Swachh Survekshan.

However, a lot still needs to be done. Roadside dumps in the city remain a problem. There is lack of awareness among residents about segregation. Even in wards where segregation is performed, the waste is mixed again at secondary collections points, making the whole process seem futile. Municipal workers do not use personal protection equipment. There is no engineered sanitary landfill for safe disposal of inert waste.

A big irony of the waste management system of the city is that on the one hand it has identified the problem posed by the dumpsite and has invested in clearing legacy waste through biomining, but on the other hand it continues to dump part of its waste next to the bioming site, creating a new garbage hill.

DINESH RAJ / CSE

VIJAYAWADA

Will segregation win over the city or will past WtE mistakes be repeated?

Area:
62 sq km

Population
1 million

Waste generated
550 TPD

Organic waste processed for city compost:
100 TPD

Organic waste processed as vermi compost:
28 TPD

Additional income to waste collectors due to source segregation:
Rs 4,500 per month

As part of the conurbation of the state capital Amaravati, Vijayawada is under the administration of the Andhra Pradesh Capital Region (APCRDA). The city is spread over an area of 62 sq km. As per the 2011 Census, it has a population of 1 million. The city is divided into 59 municipal wards and waste management is the responsibility of Vijayawada Municipal Corporation (VMC), the first corporation in the state to receive ISO 9001 certification for Quality Management Systems.

The city generates 550 tonnes of waste daily, 57 per cent of which is biodegradable. VMC practices centralized as well as decentralized processing of waste.

Burn it all: The old Vijayawada way

Vijayawada is considered a pioneer in experimenting with new technologies of waste management. In December 2003, VMC commissioned a waste-to-energy (WtE) plant to generate

electricity for Vijayawada and Guntur (a city adjacent to it) from the city's solid waste. This was the first WtE plant in the country, set up with financial assistance from the United Nations Development Programme (UNDP) and Ministry of New and Renewable Energy (MNRE). The prime stakeholders in the project, apart from VMC and Guntur Municipal Corporation (GMC), were Sriram Energy Systems Limited, who were appointed project promoters; Andhra Pradesh Technology Development and Promotion Centre (APTDC); and Technology Information Forecasting and Assessment Council (TIFAC), who provided technical expertise for creation of a process to optimize existing technology in tune with local waste characteristics and conditions. Andhra Bank had an equity stake in the project.

The 45 crore WtE plant, built over 4 hectares leased to Sriram Energy Systems Limited (SELS) by the state government, was intended to generate 6 MW of electricity a day for Transco (Andhra Pradesh's power distributor) at Rs 3.5 per unit. It would use 280 MT of waste from GMC and 225 MT from VMC per day. A dry run was carried out in December 2003. During the dry run, the processing of MSW was established only on a pilot scale at 2 MT per hour. The technology developed by TIFAC under the aegis of Central government's Department of Science and Technology for the pilot project was further studied and analyzed. It was improved upon to incorporate a critical and unique shredding operation for better heterogeneous waste input. This additional unit operation increased the capital expenditure (by Rs 6.4 crore) as well as requirements of higher power consumption. The plant was the first WtE in India to make use of a primary shredder.

DINESH RAJ / CSE

Defunct waste-to-energy plant

SESL faced difficulties in raising additional capital for the project. Internal rate of return of the project stood at 7.17 per cent, due to the increase in capital investment. Financial returns of the company were not able to match requirements for repaying the debts. In addition, project returns were reduced due to lesser power generation than expected, mainly due to technical problems in combustion equipment. Moreover, at the time, no technology was available in India to handle RDF generated from MSW. In 2007, after four years of irregular operation, the WtE plant was officially shut down due to the infeasibility of treating incoming mixed waste and economic non-viability.

Vijayawada's learning curve

Learning from the mistakes of the past, the municipal corporation decided to reengineer the whole waste management system based on source-segregation. The first step was to quantify and characterize waste generation to plan a proper waste management system. In 2015, VMC conducted a qualitative and quantitative assessment of solid waste as per the Central Public Health and Environmental Engineering Organization's (CPHEEO) manual, estimating that 500 TPD of MSW was generated by the city.

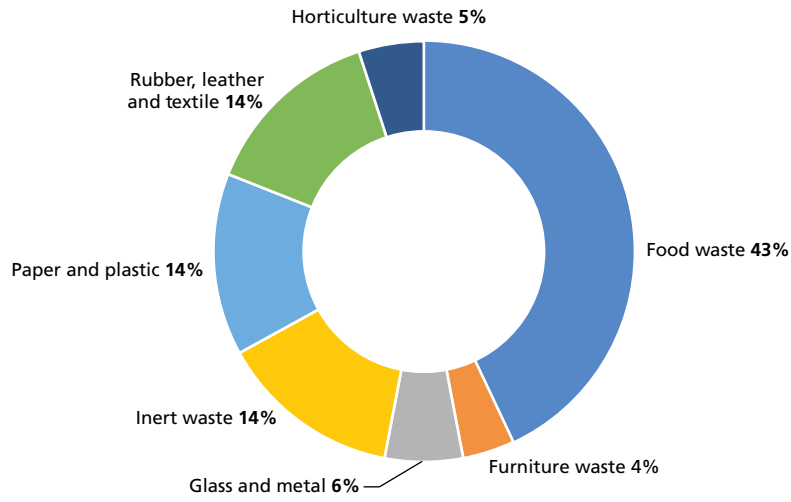
The bifurcation of Andhra Pradesh and establishment of the new capital Amaravati next door has resulted in exponential growth in Vijayawada's population, which will surely be reflected in the increase in its solid waste generation.

At present, about 43 per cent of the MSW generated in Vijayawada is biodegradable, 57 per cent is non-biodegradable and 16 per cent is inert. The moisture content of the waste is about 30 per cent and the ash content ranges between 18 per cent and 33 per cent. The average calorific vale is 1,400 kcal/kg. The highest calorific value is of waste from commercial areas, whereas the lowest calorific value is of waste from vegetable and meat markets. Calorific value of waste from the dumping sites was around 1,400 kcal/kg.

Waste profiling helped VMC in charting out zones, and centralized and decentralized composting units in the city. The city started source-segregation of waste in 2017. Colour-coded bins were distributed by VMC in 27 lower-income wards. The remaining 32 wards were considered well-off and asked to use their own bins for segregation. About 70 per cent of waste in the city is segregated.

The city has been divided into 1,236 micro-pockets; each assigned a sanitation worker for primary collection of waste. On an average, each micro-pocket

Physical characteristics of waste in Vijayawada



Source: VMC 2019

has 250 to 300 households. VMC employs a retinal scan-based attendance system to track sanitation workers. Primary collection is done in pushcarts with green and blue bins. Recyclables (collected in the blue bins) are segregated by sanitation workers. Each sanitation worker earns around Rs 120–150 per day through sale of recyclables.

Collected waste is brought to an area designated in each micro-pocket. These are open areas with a solitary partitioned 3.3 cum capacity bin or a couple of 1.1 cum capacity bins to store dry and wet waste separately. These areas are monitored continuously to prevent overflow of waste; 32 micro-pockets have been installed with smart bins—underground bins with a facility for capping. The city presently operates a mix of composting and biomethanation units.

Composting

A portion of the collected wet waste is subject to decentralized composting. VMC has identified five locations within the city for decentralized composting. Wet waste from micro-pockets in the vicinity is composted at these centres. Each decentralized composting unit can handle upto 5 tonnes of organic compost a day.

Compost generated in each of the five stations

Name of the unit	Compost generated in 2019–20 (till January 2020) (in tonnes)
Rajiv Gandhi wholesale market	143
Kabela	837
U Subbarao Nagar	832
APIIC Colony	712
Excel plant area	832

Source: Communication with VMC in January 2020

VMC is also operating seven vermi-composting units. Compost from these units has the highest demand and is sold at Rs 10 per kg. Each unit has a capacity to handle 4 tonnes of biodegradable waste per day.

Biomethanation

The rest of the segregated waste is transported to the transfer station in Ajit Singh Nagar, some 9 km from the city, in tippers and trucks. However, it has been observed that sometimes dry and wet waste is put together in these vehicles, defeating the purpose of the whole exercise.

In 2003, a biomethanation plant was constructed near Ajit Singh Nagar by Mailhem Engineers Pvt Ltd. It had a capacity to process 20 tonnes of waste per day and produced about 1,000 cum of methane, which was cleaned and utilized to run a 250 KVA power engine. The plant was shut down in 2009 due to operation and maintenance issues.

A plan was made to revive the operations of the biomethanation plant and Arumugam Sundaram Fabricators, Chennai were awarded the tender for revival and operations of the plant for five years. The cost of the project is estimated at Rs 3.7 crore. The project is under test run and is expected to generate 140 KVA of power output. The output will be used to light up common areas of the JNNURM housing society adjacent to the biomethanation plant.

Management of old dumpsites

In 2018, VMC started bioremediation of the legacy dumpsite spread over 45 acres of land. The contract to clear 0.25 million tonnes of legacy waste was awarded to Zigma. The private company completed the job in nine months and applied for an extension of the tender to clear the remaining 55 thousand tonnes of legacy waste.

The estimated cost of clearing the legacy waste is around Rs 18 crore. Around 30 acres of land have been reclaimed through the process. C&D waste recovered from the bioremediation was used to fill low-lying areas; glass was recycled; and a part of the fuel was used to produce refused-derived fuel.

C&D waste management

Vijayawada generates about 150 tonnes of C&D waste per day. In November 2018, VMC awarded a contract to PRO Environs C&D Waste Management Pvt Ltd to recycle the city's C&D waste. The 200 TPD processing facility has been established on a 'build, operate and transfer' (BOT) model. The company was given land on a 20 year lease. The plant has been receiving and processing 80 to 100 tonnes of C&D waste per day and generating 25 tonnes of recycled sand and aggregates. Bulk generators have to either transport the C&D waste to the processing facility or pay transportation charges.

Overview of waste management in Vijayawada

Estimated total waste generation	550 TPD
Number of decentralized waste management centres (composting)	13
Number of composting centres in parks for horticulture waste	6
Decentralized composting units run by bulk generators (hotels and institutions)	4
Segregation percentage in 59 wards	70
Number of integrated waste management facilities	1
Name of the operator of integrated waste management facility (centralized)	Smart Waste Management Solutions, Madhya Pradesh
Capacity of the facility	80 TPD
Number of decentralized biogas units (methanization)	1
Capacity of the facility	20 TPD
Name of the operator	Arumugam Sundaram Fabricators, Chennai
Cost of the project	Rs 3.7 crore
Usage of gas output	For generation of electricity
Capacity of the generator set	250 KVA

Source: Communication with VMC in January 2020

Outcomes and critical issues

Despite the failure of the old WtE plant, VMC plans to be a part of a new 15 MW WtE plant to be commissioned in the cluster mode at Guntur. The city has the potential to treat segregated biodegradable waste, but due to lack of segregation, it continues to send about 40 per cent of the waste it generates to the Patapadu dumpsite, around 15 km from the city. Considering the constantly increasing segregation efficiency and the potential to process waste by increasing the number of decentralized composting centres, Vijayawada needs to rethink its participation in the expensive WtE plant.

DINESH RAJ / CSE

WARANGAL

Fastest growing city in Telangana learning to manage its dry waste through collection centres

Area:
407.7 sq km

Population
0.83 million

Waste generated
340 TPD

User charges collected:
Rs 60 per household per month

Organic waste processed for city compost:
30 TPD

Number of informal waste collectors integrated into the municipal primary collection:
410

Livelihood earned by each of the 410 waste collectors:
Rs 8,000 per month

Warangal has an area of 407.7 sq km and population of 0.83 million (as per the 2011 Census). It is a rapidly growing city, the second biggest in Telangana after Hyderabad and is fast turning into a hub for business. Greater Warangal Municipal Corporation (GWMC), which is responsible for the city's waste management, has divided it into 58 wards. The city generates about 340 tonnes of waste daily, of which 40 per cent is biodegradable.

Signs of change

Before 2016, when the winds of change began to blow, GWMC used to collect mixed waste from designated spots in the city and transport it to the dumping ground near Rampur village. Before that, it had made use of the same policy to dump waste in Madikonda village, where a mound of legacy waste, estimated to be 0.3 million tonnes in mass, covering an area of 13 hectares, and with a height of 10 metres, stood testament to the unsustainability of the practice.

In 2016, door-to-door collection in the city stood at 40 per cent and none of the wards practiced source-segregation. Tricycles with 4 bins of 40 litre capacity each would collect waste from households. Dry waste was transported in jumbo bags attached to the tricycle rickshaw. Larger community bins were placed in apartment complexes. Collected mixed waste was transferred to secondary collection points (50 dumper bins and 210 refuse collection bins), from where it was transported to the dumping site at Ramapuram. The frequency of bin clearance varied from daily to once in three days. A large number of informal waste workers also used to operate in the city.

The change: Swachh auto tippers

In 2016, inspired by the success of Greater Hyderabad Municipal Corporation's model of 'swachh auto tippers' (SAT), GWMC decided to follow suit. About 800 informal waste collectors were identified and introduced to the concept of SAT. Of them, 410 were found eligible for the programme and, as in Hyderabad, each had to make just a one-time payment of Rs 40,000 for their SAT, with the rest being paid by GWMC through EMIs. Each tipper has a capacity of 1.5 tonnes and costs the corporation around Rs 5.5 lakh.

Each of the 410 tippers is designated to collect segregated waste from 600 households. A fixed user fee of Rs 60 per household is charged for the service. As of now, user fee collection rate is only 40 per cent. On an average, each auto operator earns Rs 15,000 per month and the diesel expenses to operate the auto is Rs 7,000. In effect, each of the SAT waste collector ends up with a monthly income of Rs 8,000. Their income is augmented by the sale of recyclables recovered from the waste they collect. Primary collection of waste from all the 0.24 million households to the transfer station is done through SATs. The city has two transfer stations at Balasamudram and Potanuru.

Infrastructure for collection and transportation

1. Swachh autos: 410
2. Pushcarts: 500
3. Tricycles: 250
4. Tractors for mixed waste: 61
5. Compactors: 7

Source: GWMC, 2019

However, the segregation percentage in the city continues to be low (about 40 per cent). To promote waste segregation, municipal authorities have distributed 0.25 million colour-coded twin-bins to households in the city. SAT operators also push for it. But households have been slow to adapt this practice.

The operation of SATs is supported by 500 pushcarts and 250 tricycle rickshaws. In addition, 61 tractors, seven compactors and six dumper placers are utilized to collect mixed waste and waste from litter bins.

Processing and DWCCs

Waste that is segregated is sent to the nine decentralized waste processing centres. These centres are adjacent to the dry waste collection and management centres. The city operates eight composting units, each with a capacity of 3 TPD. Composting is done through box structures and the compost is used by GWMC. A 2 TPD vermi-composting unit is also operational in the city. The demand for compost from this site is high. Two waste-to-energy (biogas) plants, each with an intake capacity of 2 TPD have been commissioned in the pump house area. Each biogas plant has an installed capacity to generate 15 KVA and supports the lighting needs of parks adjacent to it. The system is

Overview of waste management in the city

Estimated total waste generation	340 TPD
Number of transfer stations in the city	2
Number of dry waste collection and management centres (DWCCs)	25
Master dry waste collection centre	1 (A facility to stock, bail and transfer all dry waste from 25 centres)
Number of decentralized waste management centres (composting)	9 (Eight with a capacity of 3 TPD and one vermi-composting unit of 2 TPD)
Number of decentralized waste management centres (biogas)	2 (Each with a capacity of 2 TPD)
Capacity of electricity generator set connected to the biogas plants	15 KVA
Usage of electricity	The electricity generated is used for lighting up two children's park
Number of composting centres in parks for horticulture waste	3
Decentralized composting units by bulk generators (hotels and institutions)	10 (On an average two TPD each)
Decentralized composting units by bulk generators (housing societies using 24 hour or other mechanized composting)	58 (On an average one TPD each)
Segregation percentage	40
Underground bins in the city	6 (Each with a capacity of 3.3 tonnes)

Source: CSE, 2019

based on the floating drum technology. However, during the survey visit, it was observed that the two biogas units were not functioning due to mixing of plastic waste in the digester. The digesters were being cleaned. The survey also found that about 30 tonnes of wet waste, out of the total of 136 tonnes, is processed in a decentralized manner.

The city also operates 25 dry waste collection centres (DWCCs) with the help of CSR funds. SAT operators can sell recyclables at these DWCCs. Women SHGs have been made responsible for running the DWCCs with operational support from a CSR team. Each of these 25 DWCCs are connected to a centralized collection point with a capacity of 800 sq ft. The facility is a proper civil structure with a monsoon shed and storage facility with designated areas for different type of recyclables.

The centralized facility (Master DWCC) has machine which follows a simple blowing technique to clean contamination in plastic. It also has a bailing machine which can compact 150 kg of plastic in one cycle. A good practice observed during the survey visit was that no plastic is rejected by the SAT operators. They collect high value plastics like PET and PP as well as low-value low-density black plastics. Multi-layer packaging is also bought by DWCC operators at the rate of Rs 5 per kg. The city is known for effectively managing its plastic waste. The principle of reducing is perfectly followed in the city by banning the usage of plastic carry bags, a ban which has been in effect for two years now.

The outcome

SATs have been plying the roads of Warangal for more than three years now and the difference is tangible. Segregated waste is collected and processed

SINGLE-USE PLASTIC

In the month of October 2019, a 4,500 resident-strong colony in the city declared itself 'single-use plastic free'. It handed over all its single-use plastic to GWMC and took a pledge not to use plastic in the future. Residents have been advised to purchase cloth bags and the entry and exit points of the colony are closely monitored. Violators are issued notices by the resident welfare association (RWA). In addition, every Sunday, documentaries are shown and discussions are conducted at the community hall. School kids are encouraged to participate in the drive through competitions in drawing and slogan writing. Kids are grouped based on the schools they go to and interschool competitions on plastic handling and effects of single-use plastics are held.

GWMC has a strict policy for implementation of plastic bag ban. The initiative started with creating awareness amongst commercial entities and markets. After the initial awareness programmes, the corporation started special drives to confiscate plastic bags from shops and other commercial entities. However, members of the general public found using plastic bags are not fined since plastic bye-laws are yet to be notified. Fines for stocking or selling carry bags by a commercial entity range from Rs 500 for the first offence to Rs 40,000 and suspension of trade licence for repeated offenders.

As of 2 October 2019, 14 metric tonnes of plastic bags were confiscated and a fine of Rs 12 lakh collected (since July 2019). Confiscated plastic is channelized for co-processing in the cement industry. GWMC has signed an MoU with Zuari Cements for safe disposal of the collected banned plastic items.

DINESH RAJ / CSE

Plastic-free vegetable market

in a decentralized manner and only mixed waste is sent to the dumpsite at Rampur. The city has improved its door-to-door collection to 100 per cent. However, source-segregation is picking up at a slower rate. About 38 per cent of wet waste is processed in a decentralized manner. The city has earned a well-deserved reputation for its strict and effective plastic carry bag ban.

The city does not have a sanitary landfill. It plans to increase the number of decentralized composting units to reduce the waste being transferred to the dumpsite. It has also finalized the detailed project report of green capping of the existing dumpsite. The city does not have bye-laws on plastic waste and is working towards a draft.

3. Learnings from the city survey

Our survey has revealed that much progress has been made in the selected cities. Data made available by ULBs—on the overall status of waste management, right from generation, segregation, door-to-door collection and transportation and, finally, treatment systems—as well as our own on-ground research and observations have made it clear that cities are taking waste management much more seriously than they were a decade ago. Bustling with innovative ideas and the energy to put those ideas into practice, urban India is making tangible progress towards managing its waste better.

But this in no way means that waste management systems and practices in Indian cities are ideal or even reliable. Far from it. Significant gaps endure and new challenges compound older ones. We need more policy and legislation at all levels, particularly at the municipal level, where bye-laws are the iron-grid of governance. Where ample codification exists, putting it into practice continues to be a challenge. We have also noticed cases where a particular policy or practice does not yield the expected results or fails spectacularly. In many such cases, the administration either persists with such failed enterprises or is too shell-shocked to try other innovations, bringing the progress made towards better waste management to a screeching halt.

Obviously, this is not an attitude that leads to success. We identify problems, learn from our mistakes and move on. Keeping that in mind, we are expounding the major learnings from our city survey as follows.

Local participations and strict implementation by administrators: No waste management system can succeed without strict implementation measures in place, and the strictest monitoring and punitive arrangements will fail in the absence of generous participation by citizens.

Take the case of a small town like **Panchgani**. The administration as well as the residents of the hill station were concerned about solid waste dumping in the city, made worse by the large floating population of tourists. Segregation (and segregation at source) were identified as key drivers of an improved waste management system. The new model was implemented earnestly by the administration and with enthusiastic participation of residents. Within no time, the city was able to achieve 100 per segregation efficiency. There is no reason this model can't work in every ward of a metro like New Delhi or Chennai.

Similarly, **Ambikapur**, a small city in Chhattisgarh, has shown that a well-managed local dry waste recycling (processing) facility can be established if there is a strong commitment from the municipality and active participation of key stakeholders. Like Panchgani, Ambikapur had very limited human and financial resources, but it managed to develop a model where women self-help

groups (SHGs) play a vital role in managing solid waste generated in the city. In this model, garbage clinics have been introduced, where further segregation of dry waste is done into 156 categories, which is the highest in any Indian city. Key factors of success include a clear vision and strong determination, which enabled the city to use a small initial investment from the municipality budget to mobilize a sizeable and dedicated workforce and bring the model into national limelight.

Taking another example. **Indore** in Madhya Pradesh has focused on three freedoms: **bin-free, dust-free and litter-free city**. Strict monitoring and implementation of municipal bye-laws act as a 'change-maker', catalyst and financier (through fines collected for violations) in order to drive waste management in the city towards a better future. Indore Municipal Corporation has a good segregation system in place and processes more than 95 per cent of the waste generated in the city, among the highest in the cities surveyed.

These three examples might appear to be different from one another, but they share a common thread. In each case, all stakeholders have walked hand-in-hand to identify the precise nature of the problems and to customize solutions.

Integrating the informal sector into the system: Understanding that every city is different and what might work in one place might not necessarily work in another place is also crucial. This forces the administration (and other stakeholders) to think carefully about the problem at hand so that tailor-made solutions can be crafted. In **Bhopal**, for example, the municipal corporation took a unique approach by integrating the informal sector in the system for collection of dry waste. Waste pickers organized under SHGs are issued identity cards establishing their right to collect waste from particular areas. By facilitating the work of informal recyclers rather than displacing them with the workforce of new contractors, the city continues to save itself a vast amount of money. It also provides a stable source of income to these waste pickers, making it a win–win situation.

Greater Hyderabad Municipal Corporation (**GHMC**) has also integrated 2,500 waste collectors into mainstream primary collection of waste. It has provided 'swacch auto tippers'—auto-rickshaws with partitions for keeping waste segregated—to the waste collectors. These autos are brought through bank loans and GHMC pays the EMI.

Greater Warangal Municipal Corporation (**GWMC**) is learning to manage its dry waste through 25 dry waste collection centres (DWCCs). Women SHGs have been made responsible for running these centres. Although the segregation percentage in the city continues to be low, DWCCs are a bright spot in the city's waste management.

Introduction of decentralized waste management: In just three years, **Muzaffarpur** became the first city in Bihar to achieve 80 per cent source-segregation of waste under CSE's 'Swachhata Swastya Samridhi' programme. The programme, unlike public–private partnerships (PPPs), is run on the belief that capacity building of urban local bodies and making them the real

owners of waste management initiatives is the key to success. CSE has acted as a technical support provider for the programme and the municipal corporation is its face. Partially funded by CSR monies, the programme started with a basic estimate of waste generation in the city by profiling commercial and domestic establishments. From there, it has moved to creating a roadmap for decentralized management of waste in the city.

It is alright to succeed on one key parameter, which might be good advertisement, but a wholesome approach is necessary in the long-run: In the recent past, plastic waste has been identified, and rightly so, as a bane of civilization that needs to be curbed. But it must be part of a larger movement towards better overall solid waste management and not a standalone. To illustrate, **Tirupati** has made progress in leaps and bounds towards the implementation of ban on plastic carry bags, which has won it state and national recognition. But despite having created the infrastructure for better waste management, the city still lacks awareness on segregation of waste. Open dumping and littering are common, and there is no engineered landfill in the city. This lopsided attitude is not a sign of a sustainable waste management system.

Despite interventions, waste management systems may still be found wanting: In **Vijayawada**, one attempt to set up a waste-to-energy (WtE) plant has already failed, but the state government is planning to commission 10 WtE plants in a cluster mode of operation. This despite the fact that segregation of waste is low and waste from wards that do segregate is mixed again after collection and dumped at Patapadu village. Authorities need to focus more on assessing why the technology didn't work and choose a treatment technology based on the composition of the waste available. Moreover, basics like segregation need to be sorted out before we can move to more complex practices like WtE.

Similarly, **Kumbakonum** municipality still relies on a centralized facility that operates on unsegregated waste. Waste is also burned and dumped haphazardly in the city. The city is also sliding back on the implementation of plastic waste ban. This only goes to show that the price of a better waste management system is constant vigil.

Transparency of data and economics of waste management: States and local authorities need to be transparent regarding waste generation and management data. It should be made available to be analyzed and critiqued by the general public. This is important because it helps inform the masses about the waste profile of an urban centre as well as its waste management system, so that they can be more willing and able partners in improving these systems. It also makes it easier to involve a wider community of experts and stakeholders in the improvement of waste management in cities.

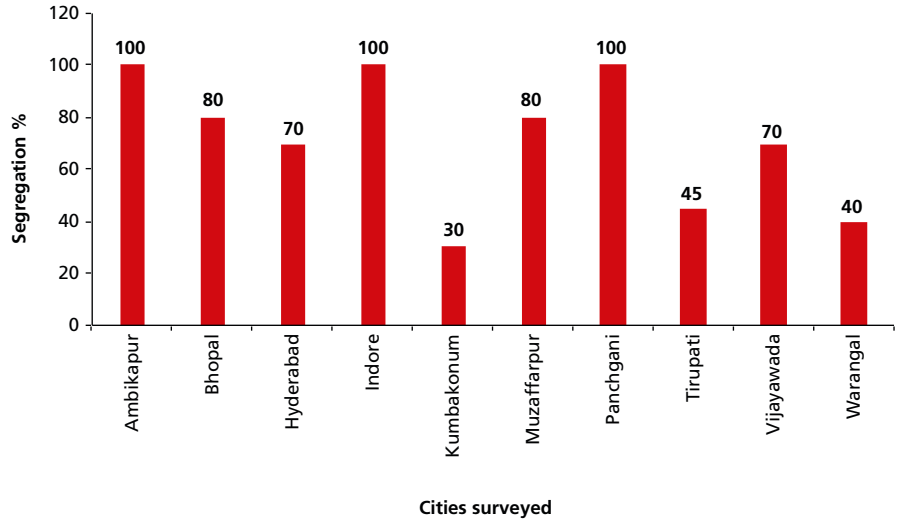
There are inconsistencies in the data provided by different authorities, which creates confusion and suspicion. National and state governments and ULB administrations need to ensure that datasets are streamlined and cross-checked.

Financial sustainability: Solid waste management budgetary allocations largely come from national governments, but they are limited and may not be able to finance the large-scale overhauls and new infrastructure that are needed. This leaves international financial institutions and private investors, who bring a range of conditions and prerequisites with them—most, if not all, require 'international' standards on which ULBs are not allowed to compromise, and which are not affordable to the recipients.

There is, therefore, a need to make waste management systems as financially self-sufficient as possible. In this context, affordability is crucial.

Segregation efficiency: Among the cities surveyed, segregation efficiency is the highest in **Ambikapur**, **Indore** and **Panchgani**, all with more than 95 per cent segregation, and lowest in **Kumbakonum**, with only 30 per cent segregation (see *Graph 1: Segregation at source in the cities surveyed*).

Graph 1: Segregation at source in the cities surveyed



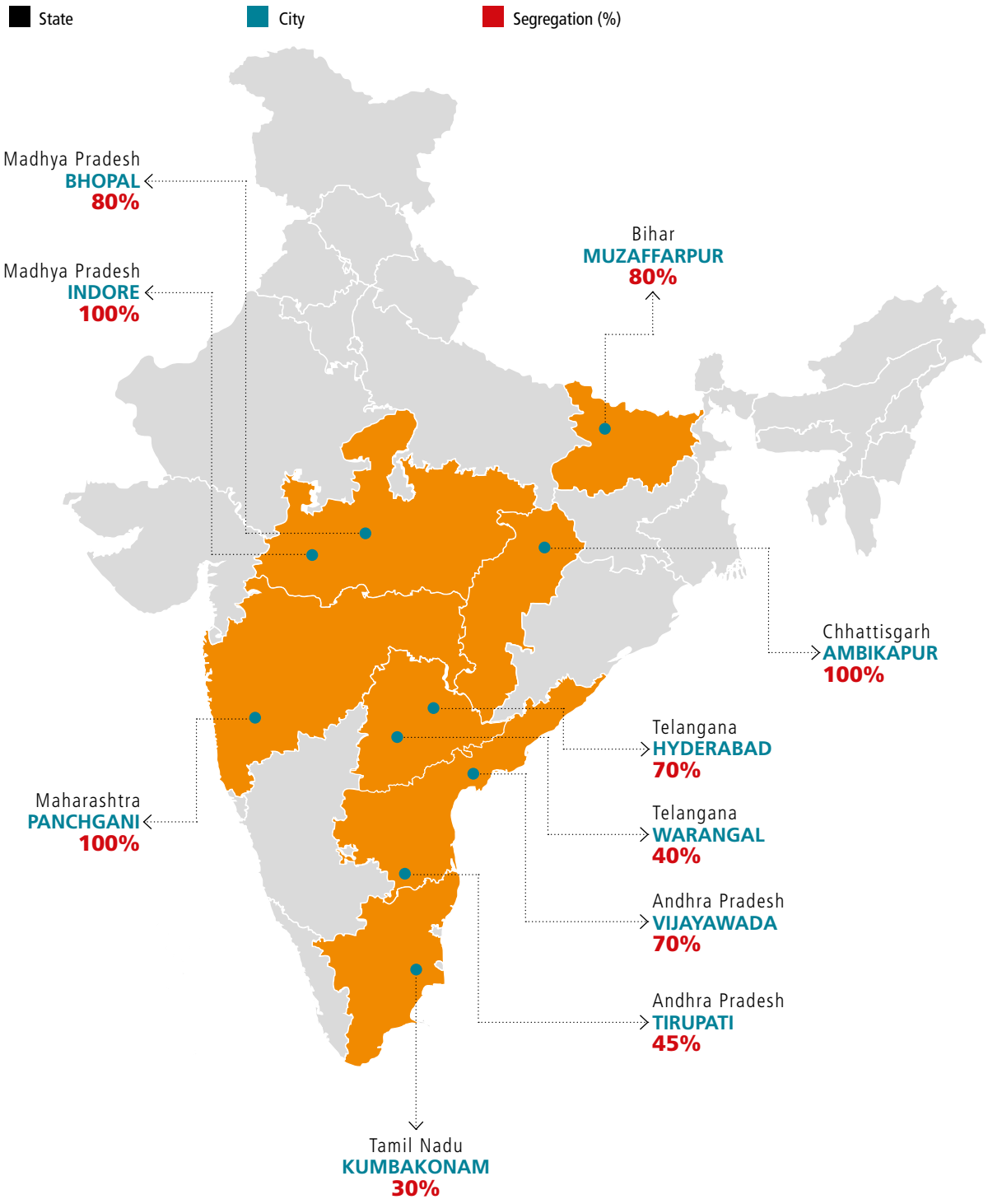
Source: Centre for Science and Environment

We also found that overall people have become more aware of segregation and recognize it as a basic pillar of a good waste management system. Swachh Bharat Mission has had a big role to play in this. Now it is time to translate the increased awareness into better practices and support for more stringent measure and innovative solutions. We should focus on achieving behavioural changes and incentivizing stakeholders to maximize collection, composting and recycling, and minimize dumping.

Our key conclusion

Creativity and innovation are the most important factors. Cities need to take stock of their unique position, their weaknesses and strengths, and work towards tailor-made solutions to their problems, chosing from an array of solutions rather than putting all their waste management eggs in one basket.

Segregation at source in the cities surveyed



4. Global perspectives on incentivizing segregation

Success or failure of any waste management system largely depends on public attitude towards it and participation in it. This is particularly true of systems trying to promote segregation at source. People may chose to forego segregation at source for a variety of reasons—clubbing all waste together might seem more convenient or effortless, or people might lack proper know-how about segregation of waste, or there might be a shortage of space to set up segregated bins. Understanding the underlying factors and impediments and addressing them properly can help achieve the goal of total segregation at source. But there is no doubt that this is less a question of means, methods and mechanics and more about bringing behavioural changes in people. Policy must incentivize the habit of segregation.

In India, the Solid Waste Management (SWM) Rules of 2016 include a provision that makes segregation of waste into three categories—wet dry and domestic hazardous—the responsibility of the generator. A spot fine for non-segregation has also been introduced. However, implementation of these rules is far from ideal. This vital issue drives us to look for successful policies and protocols around the world that could be adopted by Indian urban centres.

Many countries in the European Union apply the **pay-as-you-throw** (PAYT) system, an important economic instrument for waste management that applies the 'polluter pays' principle by charging the inhabitants of municipalities according to the amount of residual, organic, and bulky waste they send for third-party waste management. In PAYT programmes, the fees are based on the weight or volume of the waste generated. This is done as an economic incentive for households to recycle their waste, making the producer of the waste financially responsible for the collection and treatment of the waste produced. The part of the fees related to the choice or behaviour of residents can be linked to any of the following: 1) Size of the container chosen by the household; 2) Frequency of collection of waste from a given container, 3) Number of sacks used, 4) Weight of the waste set out for collection, or 5) A combination of these factors.

Variants of PAYT are used by local authorities in Belgium, Luxembourg, and the Netherlands. In **Belgium**, citizens are charged based on the manner in which waste is disposed of—different taxes for different materials, the lowest for plastic. These taxes act as financial incentives to separate wastes rather than allow collection in bulk. Likewise, in the **County of Aschaffenburg in Germany**, the introduction of a weight-based PAYT system in 1997 was followed by a significant increase in the collection of recyclable waste and a large decrease in residual waste disposal. The county achieved an overall collection rate for recyclables of up to 86 per cent, which is a significant improvement on the average performance of PAYT systems, with typical recycling rates

of around 70 per cent. The 86 per cent recycling rate in Aschaffenburg is considered to be a benchmark of excellence for the waste management sector.[1]

In the town of **Capannori** and the city of **Treviso, Italy** the rates of domestic waste segregation for recycling have now exceeded 80 per cent. In both areas, residents segregate their recyclable waste into multiple streams. They are incentivized by PAYT systems, which charge them according to the weight of non-recyclable waste. Incentives are also provided in both municipalities to encourage composting. Transparency and communication are considered to be crucial to the success of such schemes. In Capannori, residents were extensively consulted and provided with information prior to the introduction of the measures; and in Treviso, an online database allows residents to track what waste has been collected from them and to understand how their charges have been calculated.[2]

The **Nordic region** includes some of the most developed and mature waste management systems in Europe, with various aspects of the waste and resource management industry in Denmark, Finland, Norway and Sweden rightly being seen as world-leading.

In **Sweden,** segregation was incentivized through penalties on failure to do so. As per the Swedish Environmental Code, violations of the waste management scheme can land a person in jail for a year. A fine can also be slapped on violators. The monthly fee for waste that a household pays typically ranges between SEK 1,260 (approximately Rs 10,000) for an apartment to around SEK 2,000 (Rs 15,000) for a house. In order to incentivize segregation, the more a household segregates, the less a municipality will charge it, as the fee is based on weight: more the segregation, lesser the weight.

Material recycling is the top priority and source-separation of waste is carried out in a majority of Swedish households. The awareness and dedication of citizens of Sweden is the factor that has led to Sweden becoming one of the global leaders in sustainable waste management. Households in Sweden separate waste into the following fractions: Food waste, packaging of metal, plastic, paper and glass, newspapers, electronics, tires and batteries. Reuse and repair of goods is performed as much as possible. In 1994, Extended Producer Responsibility (EPR) was first introduced, making the producer responsible for the collection, disposal and recycling of their discarded products. It is intended to reduce waste volumes and encourage cleaner production and environmentally sound product development, thereby creating incentives for the producer to decrease waste generation and increase material recycling. Other milestones of the Swedish waste development programme are the landfill tax (1999), and bans on land-filling of combustible waste (2002) and organic waste (2005). The landfill tax helped divert municipal waste from landfills in favour of recycling and incineration.[3] Augmentations in the taxation in 2002, 2003 and, finally, 2006 increased material recycling of municipal solid waste (MSW). In 2016, the landfill tax stood at SEK 500 (Rs 4,000) per tonne of waste. Taxation on landfills was followed by a tax on incineration in 2006, in order to further boost material and organic recycling, but this tax was repealed in 2010.

Catalonia introduced the **landfill and incineration tax** in 2004 (updated in 2008), incentivizing waste prevention and recycling, while keeping landfilling the least preferred waste management option. Investments in waste infrastructure and separate collection schemes were made from the tax. Catalonia also introduced mandatory separate collection of biowaste in all municipalities in the region. These legislations encourage local authorities to enhance separate collection, while discouraging disposal and incineration of mixed waste by making it more expensive than separate collection. A tax refund criteria for municipalities was introduced as well, to provide a financial incentive for better management of biowaste. The refund is one-of-a-kind in EU affecting municipal solid waste, allowing return of revenue to taxpayers according to their performance.[4]

In 1995, in an attempt to reduce the quantity of waste and increase the rate of recycling, **South Korean** government implemented a countrywide **volume-based waste disposal fees** (VBWF) system. VBWF system had two-fold objectives: To impose waste treatment costs on each polluter based on the amount of waste generated, and to provide free collection service for recyclable wastes, thereby inducing reduction in generation of wastes at source and encouraging the collection of recyclable wastes. After eight years of implementation, the VBWF system has proved to be very successful in reducing MSW generation in South Korea. The system led to a 17.8 per cent reduction in MSW generation and 21 per cent increase in recyclable wastes in the first year (1995) itself. Between 1994–2001, MSW generation decreased by 16.6 per cent, and at the same time, the recycling rate increased from 15.7 per cent in 1994 to 43 per cent in 2001. In all, 142 out of 145 local governments are participating in the VBWF. The RFID system has been expanding in earnest since 2012. Local governments, along with environmental groups, played an important role in successfully implementing the VBWF system across the nation, by conducting feasibility studies and coordinating public hearings. The programme has had a far-reaching effect on the reduction of waste generation and recycling in the MSW sector. It has also changed the pattern of waste generation, awareness of the public towards waste disposal, as well as the behaviour of consumers and producers. In 2003, an EPR was imposed on manufacturers, which replaced the deposit refund scheme and held the manufacturer responsible for the costs of managing their products at end of life. The EPR's coverage was also extended to include paper packs, plastic containers, scrap metals (including steel cans), glass bottles, large and small home appliances, discarded fluorescent lamps, and used batteries. This dramatically improved the supply and demand situation.[5]

In 2007, **government of Malaysia** passed a new Solid Waste and Public Cleansing Management Act, transferring executive authority on solid waste management and public cleansing in Peninsular Malaysia from local authorities to the federal government. New federal institutions have been established to manage the new tasks. The institutions include the Department of National Solid Waste Management and the Solid Waste Management and Public Cleansing Corporation, the latter being the operational arm with offices being established throughout Peninsular Malaysia. However, not all

states agreed to the federalization of solid waste management, notable among the dissenting states being Penang.

Penang's waste segregation at source policy was enforced on 1 June 2017, under the regulations in the Local Government Act 1976—Separation of Waste and Licensing of Recyclable Waste Collection Services Bye-Laws, 2016. Under the policy, residents of landed properties have to place recyclables such as paper, plastic, used glass containers, and aluminium tins beside their rubbish bins for collection. For landed properties, the collection is done every Saturday by the Penang Island City Council on the island and Seberang Perai City Council on the mainland. For high-rise dwellers, the duty falls on the joint management bodies (JMBs) or management corporations (MCs). They have their own right to sell recyclable items. A compoundable fine of RM 250 (Rs 4,368) would be imposed on the MCs or JMBs of high-rise buildings, or individuals of landed housing areas who are found to be in violation of these rules.[6] Repeat offenders face a fine of upto RM 2,000 (~Rs 35,000), or a jail term of up to one year, or both.

Japan has a strict and complex waste separation system. Numerous norms guide citizens to comply with segregation practices. One such example is of **Kamikatsu**, Japan's first municipality to make a 'zero waste declaration', the town is well on its way to becoming fully zero-waste by 2020.

The city encouraged residents to recycle and reuse their waste, not to purchase or use products that might end up as waste, and requested manufacturers to produce products that could easily and safely be disposed of to stop waste generation at its origin. In 1995, subsidies for the purchase of electric composters and compost bins made it possible for home-generated organic waste to be composted. The subsidies were worth ¥ 42,000 (US $385 or ~ Rs 30,000) and ¥ 52,000 (US $476; ~Rs 37,000). Non-organic waste in Kamikatsu was (and is) washed at home and brought to the Hibigatani Waste and Resource Station in the town, where it was further segregated by local residents themselves.[7]

In 2016, Kamikatsu also developed a **'Zero Waste Accreditation System'** to further control waste generation. This system certifies stores, particularly food and beverage establishments, to heighten zero waste consciousness and encourages customers to reward certified businesses with their patronage. Efforts made by stores to reduce waste through segregation and when procuring ingredients are made visible to customers. Proposals for the use of environmentally-friendly products and methods to reduce waste are made to businesses to further encourage zero waste efforts. The aim of this system is to increase the number of businesses (retailers, food and beverage establishments, inns, etc.) participating in the promotion of zero waste to spread the programme globally.[8]

Not far from home, '**incentive payment**' models are used to encourage separation of waste at source by changing household behavior in the city of **Ningbo in China**. Ningbo's municipal government's initiation of a waste

separation programme, started in 2013, includes a project which incentivizes solid waste separation at the household level. This is organized by involving Neighbourhood-level Residents Committees (NRCs), the lowest level of governance in China. Functioning as an output-based programme, the project awards cash to NRCs if their respective localities are able to successfully separate waste into four different streams. The programme functions with the help of three factors: the Neighbourhood Overall Score (NOS), the Potential Neighbourhood Incentive (PNI), and the minimum score (MS), of each NRC. While MS ensures a minimum level of quality and quantity of source-separated waste before any incentive is paid, PNI, or the maximum incentive received at the topmost score, would be set by the municipal government at less than the savings from waste disposal costs that the municipality would achieve through this programme. NOS is the score assigned to a particular neighbourhood after evaluation of its waste based on pre-determined quality and quantity measures, which would further assist in deciding the quantum to be paid.

Following the commencement of the project announced by the Ningbo Municipal Project Management Office, interested NRCs would formally sign up to be part of the project. Out of the six months that the project is comprised of, the first month can be used by an NRC to educate its tenants about the practices that they are to follow. The waste generated is then evaluated during the following four months by district level PIUs (Project Implementation Units) through random neighbourhood visits made to physically inspect and determine waste quality. After completing an evaluation period, final scores and incentives are calculated and formed into a report by the PIUs which are reviewed by Ningbo's Municipal Solid Waste Separation Management Office and Ningbo's Municipal Project Management Office, that sends it to the municipal government, which finally transfers the payment to the NRC.[9]

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In 2016, CSE published *Not in My Backyard: Solid Waste Management in Indian Cities.* Presenting the results of a survey of waste management and best practices in 14 Indian cities, it has become a seminal work in the field. The big takeaway was that basics like door-to-door collection and segregation were key to a good waste management system.

Subsequently, CSE launched the 'Forum of Cities that Segregate' and published an *Assessment Report* rating select cities from the forum that manage and segregate their municipal waste most efficiently.

Following in the footsteps of these publications, CSE has carried out a fresh survey of 10 ranked Indian cities. How are Indian cities faring now compared to where they were at the beginning of the Swachh Bharat Mission? Have new lessons been drawn or have old ones been reiterated? Read the report to discover answers to these and many more questions.

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