CLEAN IT RIGHT

DUMPSITE MANAGEMENT IN INDIA

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Background

In the 18th century, the famous French scientist Antoine Lavoisier stipulated, '*Rien ne se perd, rien ne se crée, tout se transforme*', meaning 'Nothing is lost, nothing is created, everything transforms'. At its core, this means that no element is created out of nothing, none of it disappears, and that natural elements on this planet are 100 per cent used and reused.

The problem associated, however, is with the process of transformation. The energy, time and resources used to ignite this transformation are huge.

Quality of life is linked inextricably to the overall quality of environment. The early belief that we had an unlimited abundance of land and resources created a problem that will possibly take decades to undo.

It is said that the way you treat yourself sets the standard for others for how others treat you. I would add: How you treat your garbage sets the standards for how garbage treats you.

Our negligence over decades in using resources, treating and respecting garbage generated in the process and faulty policies has created around 3,159 dumpsites in India. The size and quantity of the legacy waste in these dumpsites have become a ticking time-bombs, with associated environment impacts, including air, water and soil pollution.

In 2000, the then legal framework for managing solid waste in the country, the Municipal Solid Wastes (Management and Handling) Rules, 2000 advocated landfilling of mixed waste under unavoidable circumstances or till installation of alternative facilities.

With the alibi of no installed facility in India for handling solid wastes, the municipal corporations, municipal councils and nagar panchayats opted for creating man-made garbage hills. These dumpsites were developed in the outskirts of cities but with the expansion of the cities over decades, the dumpsites are now in the heart of cities. Delhi is a classic example, with travellers entering Delhi from adjacent states greeted by the sight of a dumpsite.

As production and consumption rise with economic and population growth, the quantity of garbage concomitantly increases. While on the one hand, the national aspiration of a $5 trillion economy is a positive sign, the associated increased waste generation is a concern. **Indians on average annually generate three and half times their weight as waste**, which makes space in landfills difficult to find. The best way to deal with quantity and toxicity is to hold back as much as possible what we consider waste before sending it to a dumpsite.

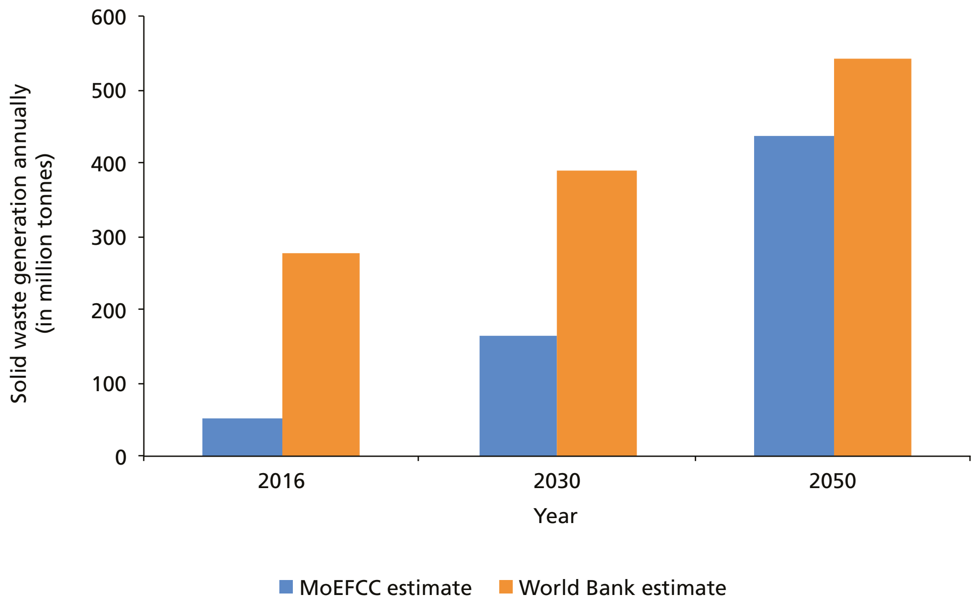
The average Indian annually generates solid waste equivalent to 3.5 times their weight.

Engineered sites designed to receive only inert materials from processed waste are termed as landfills. This report considers areas of land where mixed waste with no preprocessing is dumped as dumpsites.

How much waste does India generate?

The total waste generated by country is calculated on the basis of per capita waste generation. We go by a standard per capita waste generation of 0.3 kg per day for small cities and 0.5 kg per day for large cities. Based on this, we arrive at 53 million tonnes of waste annually, which is equivalent to 1.5 lakh tonnes of waste generation per day (the latest estimate by the Ministry of Environment, Forest and Climate Change). Independent research, however, shows comparatively large numbers. In 2018, the World Bank estimated waste generation to be five times what is claimed by government authorities (see *Graph 1*: *Comparative analysis of waste generation figures by CPCB and World Bank*).

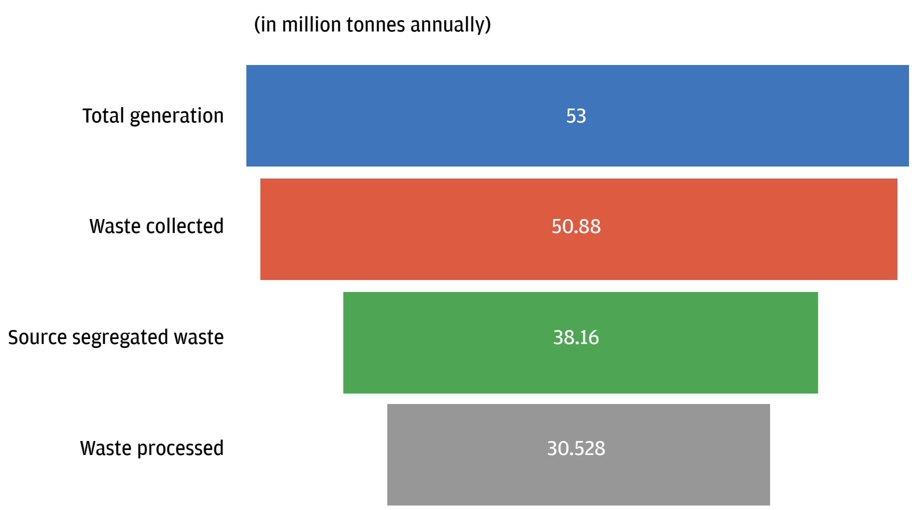
GRAPH 1: COMPARATIVE ANALYSIS OF WASTE GENERATION FIGURES BY CPCB AND WORLD BANK



Source: CSE, 2020 (compiled from MoEFCC and World Bank estimates)

As per the latest Swachh Bharat Mission (SBM) dashboard, municipalities collect waste door to door from 96 per cent of households—around 75 per cent of the households follow source segregation and of the collected waste 60 per cent is processed (see *Figure 1: Where does my waste go?*).

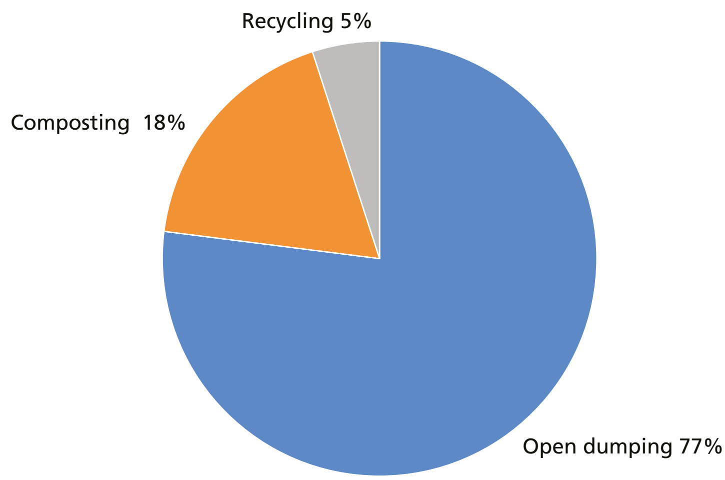
FIGURE 1: WHERE DOES MY WASTE GO?



Source: Swachh Bharat Mission (Urban) dashboard

By means of a simple calculation, we infer that around 22.5 million tonnes of waste is dumped annually. This is at variance with Central Pollution Control Board's (CPCB's) figure—data from Assam, Andhra Pradesh, Bihar and Lakshadweep is not available—of 23.35 million tonnes. According to the World Bank 2018 report *What a Waste 2.0*, 77 per cent of the waste generated in India is disposed of in open dumpsites (see *Graph 2: Waste disposal in India*)

GRAPH 2: WASTE DISPOSAL IN INDIA



Source: World Bank, *What A Waste 2.0* (2018)

Status of existing dumpsites

In 2016, India added 31 million tonnes of waste to the legacy waste in its dumpsites. As per the Central Pollution Control Board (CPCB's) Annual Report 2018–19 on solid waste management,[1] despite four years of the Swachh Bharat Mission (SBM) in 2019, India dumped 23.35 million tonnes of waste in existing dumpsites (see *Table 1: Status of dumpsites in India*).

TABLE 1: STATUS OF DUMPSITES IN INDIA

State	Number of dumpsites*	Quantity of waste dumped annually in tonnes**
Uttar Pradesh	609	4,640,610
Madhya Pradesh	378	511,000
Maharashtra	327	4,034,126
Karnataka	215	2,006,040
Rajasthan	195	2,133,564
Gujarat	170	1,511,830
Bihar	156	
Punjab	150	1,334,940
Tamil Nadu	140	2,063,710
Odisha	112	24,769
Andhra Pradesh	110	
West Bengal	88	121,910
Assam	76	
Telangana	73	636,560
Haryana	65	1,319,227
Kerala	52	122,089
Jharkhand	42	0
Uttarakhand	42	191,260
Arunachal Pradesh	31	13,556
Himachal Pradesh	27	69,350
Manipur	21	16,746
Tripura	17	87,366

State	Number of dumpsites*	Quantity of waste dumped annually in tonnes**
Nagaland	13	12,392
Goa	9	544
Jammu and Kashmir	9	53,345
Chhattisgarh	8	41,975
Meghalaya	6	59,097
Delhi	3	1,907,125
Puducherry	3	175,565
Sikkim	2	18761
Andaman Nicobar	1	13833
Chandigarh	1	131,867
Daman Diu	1	34,310
Mizoram	1	67,079
Lakshadweep	0	
Total	3,159	23,354,546

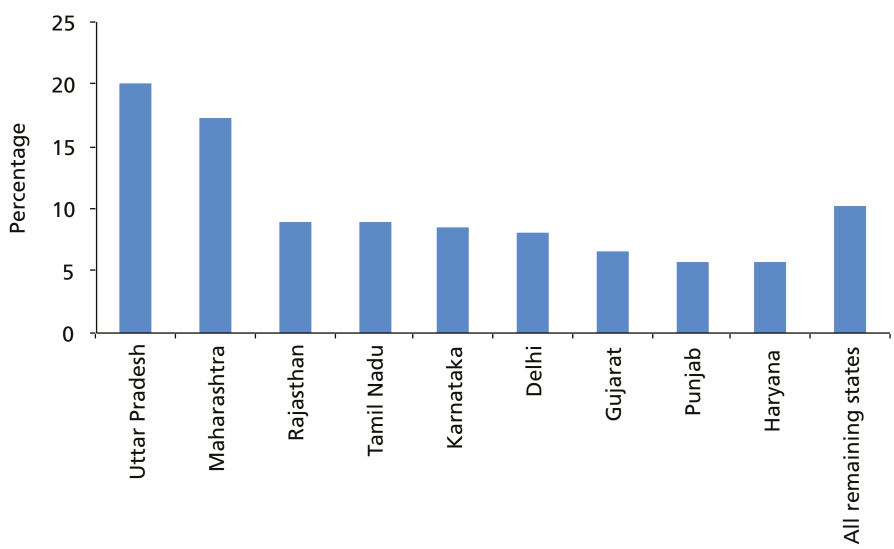
Source: CPCB's latest data on dumpsites, August 2019* and Annual Report 2018–19** on solid waste management

Contribution of states to what is dumped annually

As per CPCB's latest data on dumpsites, India still has 3,159 operational dumpsites. Uttar Pradesh tops the charts, with 609 dumpsites, followed by Madhya Pradesh, with 378, and Maharashtra, with 327 dumpsites.

The top states that dump waste unprocessed in dumpsites are Uttar Pradesh, Maharashtra, Rajasthan, Tamil Nadu, Karnataka and Delhi (see *Graph 3: Percentage contribution by states to annual total waste dumping by the country*).

GRAPH 3: PERCENTAGE CONTRIBUTION BY STATES TO ANNUAL TOTAL WASTE DUMPING BY THE COUNTRY



Source: Annual report 2018-19 on solid waste management by CPCB

This is proportional to the number of dumpsites operated by the state. However the state of Madhya Pradesh witness drastic decrease in the quantity of waste dumped in the dumpsites in FY 2018–19 compared to FY 2017–18. The state reported dumping 1.6 million tonnes in 2017–18 and 0.5 million in 2018–19.

Status of major dumpsites

The status Mumbai's and Delhi's dumpsites show their dependence on dumping in spite of increased segregation. The respective municipal corporations have repeatedly requested the judicial bodies to extend the time period to dump waste in these major dumpsites in spite of them reaching their threshold limit. Delhi has four such sites currently in operation (three dumpsites and one landfill), three of which are overdue for closure. On an average day, unsegregated waste is dumped and distributed to each of these dumpsites, with numerous fires active in these dumpsites, leading to increased and continuous air pollution. Mumbai has two operational dumpsites, including Deonar.

Deonar dumpsite:

The Deonar dumpsite is the India's oldest and the largest dumpsite. Set up in 1927, it spreads over 326 acres (131.92 hectares), which is almost the size of 247 football fields.

As in November 2019, Mumbai's 12.4 million citizens send 3,000 metric tonnes of waste to Deonar every day. As per estimates, the dumpsite holds 12 million metric tonnes of waste. The Deonar dumping ground often makes news, especially when methane gas—which is extremely flammable—generated from the mixed waste causes intermittent fires. This is in addition to the regular odour and liveability issues due to rapid urbanization in this part of the city that attracts great public opposition.

In April 2019, the Bombay High Court extended permission to BMC—calling it a last extension— to continue dumping of 3,000 metric tonnes of solid waste at Deonar ground till 31 December 2019. The Brihanmumbai Municipal Corporation (BMC), the civic body that operates the dumpsite, has plans to establish two waste-to-energy (WtE) plants, each with capacity of 10 MW, for treating the legacy waste. However, the calorific value (CV) of the waste in the decades-old dumpsite is not yet estimated. A geological survey to analyse the CV is under operation with a whopping cost of Rs 77 lakh. In 2018, the Union government sanctioned Rs 571 crore for WtE plants to be established at the Deonar dumpsite.

BMC has been planning scientific closure of the dumpsite since 2005. Following a fire in 2016 at the dumpsite, with smoke spreading 10 km and lasting for weeks, the BMC had first floated a tender for a WtE plant with a capacity of 24 MW. In past three years, however, the civic body has faced challenges such as lack of available technology and suitable contractors which created a roadblock. Even after floating two tenders separately, each with a WtE plant of 10 MW capacity, reduction in quantity of waste to be processed, and four extensions, none of the bidders has shown interest in handling waste at Deonar.

Mulund dumpsite:

The Mulund dumpsite is the second largest dumpsite of Mumbai and has been operated by BMC since 1967. The dumpsite is spread over 59 acres (23.87 hectares) (almost the size of 45 football fields). The dumpsite received around 1,500 tonnes of mixed waste for around four decades and was finally shut down in October 2018 following the Bombay High Court order in February 2016. BMC estimates show that the legacy waste in the dumpsite is around 19 million tonnes and it is set to spend around Rs 731 crore in processing of waste of the dumping ground.

In June 2018, BMC has decided to implement biomining at the dumping ground and recover 24 hectares of land by July 2024. The contract was allotted to Prakash Constrowell Ltd, Infotech International Ltd and EB Enviro Biotech Pvt Ltd. BMC has made provision for Rs 43 crore for biomining in the 2019–20 budget.

The phase-wise processing of waste is planned as below:

a. First year: Project commissioning
b. Second year: 1.1 million tonnes
c. Third year: 2.4 million tonnes
d. Fourth year: 3.8 million tonnes
e. Fifth year: 5.3 million tonnes
f. Sixth year: 7.0 million tonnes

Kanjurmarg dumpsite:

After the shutdown of the Mulund dumpsite, the city's youngest dumpsite, Kanjurmarg has become the main dump yard for the city. Started in 2004 as dump yard for the city's construction debris, it now handles 80 per cent of the waste generated. The dumpsite stretches in 292 acres (118.16 hectares) (approx. size of 221 football fields) and handles 5,500 tonnes of mixed waste per day. The dumpsite on papers processes mixed waste scientifically through bioreactor-landfills and material-recovery facilities. It operates seven cells of bioreactor, each 35 metres high.

A bioreactor landfill is a solid waste landfill in which liquids are added to help bacteria break down the waste. The increase in waste degradation and stabilization is accomplished through the addition of liquid and air to enhance microbial processes. This bioreactor concept differs from the traditional 'dry tomb' municipal landfill approach. The bioreactor accelerates the decomposition and stabilization of waste. At a minimum, leachate is injected into the bioreactor to stimulate the natural biodegradation process. Bioreactors often need other liquids such as storm water, wastewater and wastewater treatment plant sludges to supplement leachate. This enhances the microbiological process by purposeful control of the moisture content and differs from a landfill that simply recirculates leachate for liquids management.

However, the technology is not liberally used in the Kanjurmarg dumpsite and the scientific approach is flawed with mixed waste. Many instances of leachate flowing in the mangroves is reported. The following is the summary of the status of dumpsites in Mumbai (see *Table 2: Status of dumpsites in Mumbai.*

TABLE 2: STATUS OF DUMPSITES IN MUMBAI

Name of the dumpsite	Year of start	Status of operation	Daily waste intake in tonnes	Area in acres	Total legacy waste in tonnes
Deonar	1927	Yes, allowed till 31 December 2019	2,500	326	12 million
Mulund	1967	Closed on 1 October 2018	0	59	19 million
Kanjurmarg	2004	Operational	5,500	292	Not available

Source: CSE 2019, as on November 2019

Ghazipur dumpsite:
The Ghazipur dumpsite was set up in 1984 and reached its capacity in 2002. According to the authorities, about 2,000 tonnes of garbage is currently dumped at Ghazipur each day. The dumpsite is now 65 metres high and is rising at the rate of nearly 10 metres a year.

Okhla dumpsite:
The Okhla dumpsite was commissioned in 1996. The South Delhi Municipal Corporation (SDMC), the civic body that operates the dumpsite, was dumping 1,200 tonnes of waste until 2018. It is 40 acres (16.2 hectares) in area and 58 metres high, which is thrice the permissible limit. The civic body officially shut the dumpsite in 2018.

Bhalswa dumpsite:
The Bhalswa dumpsite was commissioned in 1994 and is spread over 42 acres (17 hectares) in north-west Delhi. The dumpsite exhausted its capacity in 2002. The legacy waste at Bhalswa site is estimated to be 80–90 lakh tonnes. Trommel machines have been installed at the site for bio-mining and bioremediation, a major step towards clearing the legacy waste (see *Table* 2: *Status of dumpsites in Delhi*)

TABLE 3: STATUS OF DUMPSITES IN DELHI

Name of the dumpsite	Ghazipur	Bhalswa	Okhla	Narela Bawana
Height in metres	45	40	48.5	15–20
Land mass in square metres	280,000	206,000	161,000	404,000

Source: Yamunariverproject.org report, 2016.

Conflicts around dumpsites

Dumpsites have been at the centre of public ire and agitations for decades. Public awareness of the NIBMY[2] syndrome has led to several Public Interest Litigations (PILs) against having dumpsites in residential areas and various courts have viewed the matter of sanitation seriously (see *Table 4: PIL filed and their implementation status*).

TABLE 4: PIL FILED AND THEIR IMPLEMENTATION STATUS

Starting year of dispute	PIL filed on	Dumpsite	Land area		Land area affected (hectare)	Present status
			Village/ town	State		
1980	September 2014	Pirana	Ahmedabad	Gujarat	34	Companies appointed to use legacy waste as well as the daily solid waste to generate electricity at two out of three garbage hills. Looking for an alternative solution at Ajmeri Hill.
1991	NGT directive on June 2017	Kullu	Pirdi	Himachal Pradesh	4	While no instances of garbage dumping have been recorded in Pirdi since 2 January 2019, older garbage continues to lie there, posing health hazards.
2011		Kodungaiyur	Chennai	Tamil Nadu	100	In operation
2012	September 2012	Mohuda	Berhampur	Odisha	31.62	Planned (decision to go ahead)
2013	September 2015	Khajod	Khajod, Surat	Gujarat	188	Not available
2014	July 2014	Achan	Srinagar	Jammu and Kashmir	26	The dump would be closed after one and a half years as decided on 10 April 2019
2014	August 2017	Sakri	Sakri, Raipur	Chhattisgarh	27	Work at the newly allotted trench ground in Sakri will be completed by December 2019 as per Raipur Municipal Corporation (RMC) officials
2014	August 2014	Sultanpur Dabas Village	Sultanpur Dabas Village	Delhi	40	Looking at the shortage of landfill sites in the National Capital Territory (NCT), the Delhi High Court instructed Delhi Development Authority (DDA) to acquire new sites for urban waste disposal
2014		Bhagtanwala	Amritsar	Punjab	10	The Amritsar Municipal Corporation will soon start garbage processing work at Bhagtanwala, as per officials
2015		Phursungi	Pune	Maharashtra		Not available
2017	October 2018	Vellalore	Coimbatore	Tamil Nadu	263	Not available
2017		Bandhwari	Gurgaon	Haryana	12	NGT directed Gurgaon Municipal Corporation to clear waste
2018	March 2018	Naregaon	Aurangabad	Maharashtra	8.9	Working for restoration
2018	September 2018	Olpad	Surat	Gujarat	20	Not available
	February 2014	Kanjurmarg Dumping Site	Mumbai	Maharashtra	132	Bombay High Court (HC) in September 2019 directed a stay on its expansion
	July 2015	Kolhapur	Kolhapur	Maharashtra		Allotment of waste dumpsite within limits of village
	July 2015	West Boragaon landfill site	Guwahati	Assam	-	Shifted dumping to Chandrapur following the order of NGT
	September 2017	Ghazipur	East Delhi	Delhi	70	The waste processing started in September 2019
	December 2017	Shillong Landfill	Shillong	Meghalaya	18	Scheme of utilization of the same dumpsite for establishment of comprehensive solid waste treatment
	April 2019	Gurugram	Gurugram	Haryana		The NGT directs the chief secretary of the state to take action against officers
	July 2019	Pirana	Ahmedabad	Gujarat	34	NGT directs to take remedial action to check air pollution in Ahmedabad city in the interest of public health and the rule of law
	August 2019	Landfill at SEPPL, Kutch	Kutch	Gujarat	-	NGT directs CPCB to conduct a study within three months and GPCB has been asked to ensure that the unit maintains the norms of disposal of salt generated in the process of leachate treatment

Who will bell the cat?

Need for managing dumpsites

A dumpsite is land set aside for final disposal of solid waste. Ideally, people and animals should be prevented from entering a dumpsite, and the deposited waste covered with soil to isolate it from the environment.

Uncontrolled dumping of mixed municipal waste, aided by flawed laws, has created around 3,159 dumpsites in the country. These dumpsites have become a ticking time-bombs, with all possible associated environment impacts, including air, water and soil pollution. A few of these dumpsites are locations designated by the municipal authorities to dispose of mixed waste, while others are not designated and created by the accumulation of waste dumped in the outskirts of the city.

Waste gradually decomposes by a combination of biological, chemical and physical processes. During the process of decomposition, two major emissions of primary concern—leachate and landfill gas—affect the environment in the following ways:

1. Leachate is polluted water that emerges at the base of dumpsite waste. It is formed in two ways. Rainwater landing on the waste flows over and through the waste and soluble substances are dissolved in the water. Also, some of the decomposition reactions in the waste produce liquid that is acidic. Some substances, such as toxic metals, tend to dissolve more easily in acids, making the final leachate more harmful. Leachate enters watercourses and may be consumed by humans in drinking water, for domestic purposes or irrigation, exposing users to these pollutants.

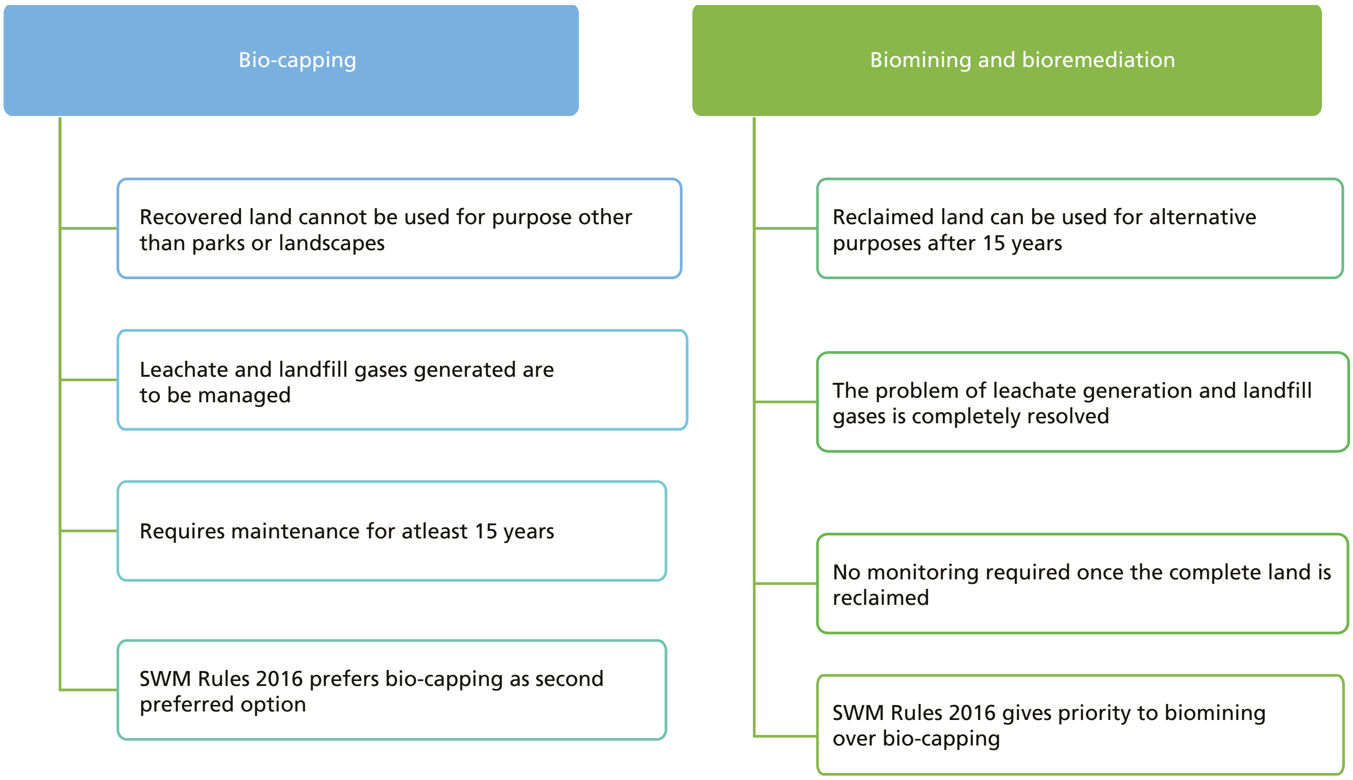
2. Dumpsites in general receive mixed waste. The process of decomposition creates anaerobic conditions due to the presence of plastic and other large-surface-area materials. These anaerobic conditions lead to the formation of landfill gas, comprising a mixture of carbon dioxide and methane, both of which are greenhouse gases that contribute to global climate change. Methane is known to be more potent as a heat-trapping gas. Methane produced at solid waste disposal sites it contributes approximately 3–4 per cent to the annual global anthropogenic greenhouse gas emissions as per *Climate Change 2001: The Scientific Basis* by the Intergovernmental Panel on Climate Change. These dumpsites are the third largest source of methane emissions. It is also flammable with slight exposure to flame or high temperatures. In extreme cases, the gas can build up in a landfill and explode, with risk of devastation.

Technologies for reclaiming dumpsites

Dumpsites are reclaimed in two possible ways. The first is by bio-capping the dumpsite, used where reclaiming waste separately from the dumpsite is expensive because of large quantities of legacy waste, high levels of contamination or unpredictable material that would come out of the legacy dumpsite. The second way is by biomining and bioremediation, a process in which soil is recovered along with recyclable materials. The dumpsite is reclaimed in this process for secondary usage of the land. As per Solid Waste Management Rules, 2016 (SWM) Clause J of Schedule-I, capping is not the first option in order of priority for environmentally safe legacy-waste management. Capping should only be considered for a maximum of 10 per cent residual rejects after biomining of stabilized waste.

SWM Rule 15 (zk) permits capping only where biomining and bioremediation are not possible. Perhaps the only places where this is so is in steep and narrow inaccessible valleys. Clearing by biomining recovers the entire base area of a dump at almost ground level while capping gives only one-third of the base area as usable area at an inconvenient height (see *Figure 2: Bio-capping versus biomining and bioremediation*).

FIGURE 2: BIO-CAPPING VERSUS BIOMINING AND BIOREMEDIATION



Source: CSE 2019

1. Bio-capping of dumpsites

Dumpsites are large areas of derelict land in cities that were previously on the outskirts. Due to rapid urbanization and expansion of cities, these areas are now part of cities in densely populated agglomerations and act as large garbage-receptacles. The last few years have seen an increased interest in reclaiming these areas for recreational purposes, such as large parks, because of the size and price of land in cities. An additional reason is that they are too unstable and toxic to allow for any other type of activity.

Bio-capping (hereafter referred to as capping) is the process of transforming a dumpsite from a wasteland to a natural environment such as a park or woodland by successfully turning garbage into resilient landscapes. It involves placing a cover over contaminated material and is the traditional method for isolating dumpsite wastes and contaminants to prevent contact with natural environment. It is used to address large volumes of waste with low levels of contamination. Capping made of layers of soil planted with grass can allow some sites to be reused. It does not destroy or remove contaminants; instead it isolates them and keeps them in place to avoid the spread of contamination.

The major issues that must be dealt with while capping a dumpsite project are:

a. Subsidence
Subsidence is the settling of ground when garbage begins to compact and shift. It can be very severe, i.e. 5–20 per cent of landfill depth over the course of 20–30 years, causing significant damage to any built environment such as foundations, irrigation and gas pipes. The percentage of subsidence needs plays a major role in identifying the technology of dumpsite reclamation.

b. Leachate and water contamination
Leachate percolates through the solid waste of a dumpsite and results in hazardous substances entering groundwater. To prevent infiltration of water, sites are to be capped by creating layers of compacted clay topped with an erosion cover layer that is capable of sustaining vegetation. Several factors may cause a flaw in the cap, which would then allow leaching—these include settlement or dryness cracking the cap or tree roots piercing through the cap. Leachate needs to be collected in wells for further processing.

c. Soil
Waterlogging as well as release of toxic gases (methane and carbon dioxide) produced by degrading waste is problematic because it causes conditions in the soil that could be devastating for plants and trees. A layer of drainage material should be laid down, then subsoil should be placed on top, followed by topsoil to allow a vegetative cover. Topsoil is a precious component of the environment that, within a few millimetres of soil, contains much of the growth capacity that sustains life.

d. Plantation
Planting up a site has several benefits. Vegetation provides an erosion defense by protecting the cap from wind as well as ensuring slope stabilization. A vegetative cover above the cap slows down absorption rates of water into the soil. It is particularly advantageous when the soil layer is shallow as the clayey material of the cap generally encourages waterlogging. It is the first defense for storm-water management.

e. Capture of gases
The landfill gases are to be managed through vent pipes that allow the gas to get out of the waste and be released to the air or burned in a controlled way.

2. Biomining and bioremediation of dumpsites

Biomining is the process of using microorganisms to extract materials of economic interest from legacy waste. The prime process, however, is to recover soil from decomposed mixed waste. Biomining can also be seen as a technique of extracting and segregating valuable resources from mounds of waste.

The major resources extracted from legacy waste are:

a. Plastic
b. Rubber
c. Metal
d. Textiles
e. Glass
f. Soil
g. Construction and demolition (C&D) waste

In other words, biomining is a process by which previously dumped waste is dug up after loosening by harrowing and then processed to recover valuable recyclable scrap while also recovering landfill space. The end product, likely to be soil, is rid of toxic materials and hence becomes reusable.

The process of biomining can be explained as below:

PROCESS OF BIOMINING

Source: CSE, 2019.

Biomining is done in three phases:

Phase 1: Stabilization
The dumping site is converted into equal-sized windrows and turned frequently, bio-culture is added and de-odourizer (an odour-controlling agent) sprayed. This phase removes stench, reduces moisture and flies, and eliminates pathogens. The addition of bio-culture speeds up the decomposition of waste to carbon dioxide and water vapour and creates biological heat within it, helping to dry it out and reduce its volume by 35–40 per cent. This process, called bioremediation, dries the waste enough for screening. The waste is considered stabilized when there is no more generation of heat, landfill gas or leachate. A germination test is done by collecting samples from the heap to ensure proper stabilization of the waste.

Phase 2: Sorting and segregation

In this phase, excavated landfill waste that is stabilized is separated to collect soil, stones and combustibles. Series of trommels and manpower is used to segregate the aggregates and other heavy construction waste and debris.

Phase 3: Disposal

In this phase, the non-combustible fractions such as soil and stones are disposed of for further processing into finer aggregates or for earth filling. The combustible fractions are called refuse-derived fuel (RDF) and are in general sent for co-processing in cement industries.

Biomining is a low-cost solution compared to capping to remove the garbage hills and their lingering ill effects. It achieves permanent near-zero emission of harmful gases (such as methane, hydrogen sulphide and ammonia) and leachate.

Various states have adopted either capping or biomining and remediation based on the technological feasibility (see *Table 5*: *Status of actions by the states and Union territories*).

TABLE 5: STATUS OF ACTIONS BY THE STATES AND UNION TERRITORIES

State/Union territory	Action taken
Andhra Pradesh	Dumpsite management taken up in six out of 110 ULBs Bio-capping of dumpsite completed in Kadapa Biomining process under operation in Visakhapatnam, Vijayawada and Tirupati. Work order issued in Machilipatnam and being finalized for Guntur
Chhattisgarh	Legacy waste remediation completed in 160 ULBs and to be completed by March 2021 in remaining eight ULBs
Daman Diu	Plans to convert dumpsites holding 116,800 tonnes of legacy waste into scientific landfill site by December 2019. Work order issued to the bidder. Dumpsite in Diu cleaned
Delhi	Bioremediation of Ghazipur dumpsite in progress. The National Green Tribunal (NGT) on 17 July 2019 directed the Delhi government and civic bodies to deposit Rs 250 crore to an escrow account for a bioremediation and biomining project that is to be undertaken to deal with the Okhla, Ghazipur and Bhalswa landfill sites.
Goa	157,721 tonnes of legacy waste has been remediated till August 2019 and work is in progress to remediate an additional 450,000 tonnes.
Gujarat	Bioremediation: Pirana dumpsite completed; Vadodara under process Capping: Khajod dumpsite and tendering under process for Bhatar dumpsite Gujarat has plans to remediate 98 lakh tonnes in eight ULBs and 19 lakh tonnes in 162 nagar palika within 36 months
Haryana	Only one out of 65 dumpsites has been reclaimed/capped. Request for proposal being prepared for five dumpsites.
Karnataka	Bioremediation partially done in Davangere and Mysore
Kerala	Bioremediation work being taken up in six dumpsites. One of them is capped, three are expected to be completed by March 2020 and waste-to-energy plants are expected to be set up in the other two sites.
Madhya Pradesh	Out of 378 dumpsites, remediation is complete in Indore and under process in 32 ULBs and 187.9 acres of land has been reclaimed.
Maharashtra	Biomining complete in 13 cities and has started in 195 cities.
Tamil Nadu	Reclamation under progress in 116 dumpsites. The timelines for completion are (62 to be completed by 31 December 2019; 26 by 31 March 2020; 23 by 30 June 2020; five by 31 December 2021)
West Bengal	Bioremediation project in Dhapa on the verge of completion

Source: CPCB's Latest report on dumpsites, 2019.

Economies of managing dumpsites

Operational expenditure of biomining and bioremediation depends on the size of dumpsite. As per CPCB's *Guidelines for Disposal of Legacy Waste*,[3] the cost of on-site bioremediation-cum-biomining is Rs 400–700 per cubic metre, irrespective of capital cost. In current working models in the country, it is observed that the companies are operating biomining sites through mobile equipment. The capital cost of equipment is transferred partially to the user of the services. The major players in biomining use PLA (programmable logic array)-based systems to regulate the flow of stabilized waste from one trommel to another. The capital cost of the mobile equipment with a capacity of 700 tonnes per day is estimated to be around Rs 10 crore.

The processing of waste in the tendering process of biomining in the country is, however, not based on cubic metre of waste since predicting the composition of legacy waste is challenging. It is based on the quantity of waste excavated and processed. The average cost of processing one tonne of legacy waste is Rs 750–900, depending on the age of dumpsite.

The operational cost includes manpower cost and moving the screened fractions off-site and is variable from city to city. The cost of moving the combustible fractions depends on the distance of the cement industries from the biomining site.

Major players of biomining

Very few private organizations are involved in the process of bio-mining and remediation of solid waste (see *Table 6: Some registered organizations operating in biomining*).

TABLE 6: SOME REGISTERED ORGANIZATIONS OPERATING IN BIOMINING

Name of company	State of operation
Zigma Global Environ Solutions Pvt Ltd	Tamil Nadu
Prakash Constrowell Ltd	Maharashtra
Bhavani Bio Organics-Coromandel International Ltd	Andhra Pradesh
Chempure Technologies	Tamil Nadu
Sri Biotech Laboratories	Telangana
Organica Biotech Private Ltd	Maharashtra
Jai Biotech Industries	Maharashtra
Sanzyme Ltd	Telangana
VNS Enviro BiotechQ Pvt Ltd	Tamil Nadu

Source: CSE, 2020.

Case studies: Initiatives by cities

A Centre for Science and Environment (CSE) study of bio-capping and biomining in India shows that a dumpsite can be managed either by tendering it to a private party or by the civic body directly. The Hyderabad case studies explain how the municipal corporation does bio-capping. The Kumbakonam, Tirupati and Vijayawada case studies showcase civic body initiatives in biomining, with private parties reclaiming the land completely.

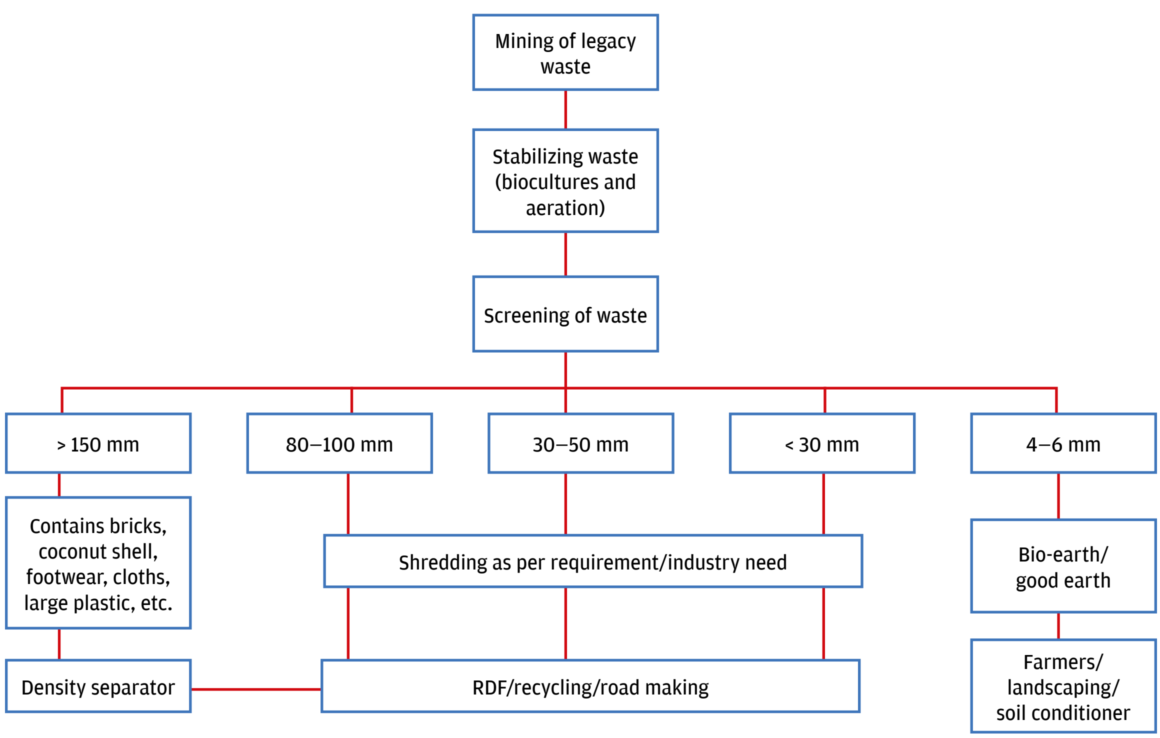
However, biomining is also an expensive process, and the corporation ends up paying a fee for processing every tonne of legacy waste mined, stabilized and processed. During the visits it was observed that Ambikapur Municipal Corporation studied the process of biomining, executed the process themselves and reduced the cost of managing the landfill.

Delhi

The Bhalswa landfill is situated in north-west Delhi and handles dumping of mixed of around 2,400 tonnes per day. The dumpsite has been operational since 1994 and reached an estimated height of 62 metres by 2019.

The dumpsites stretches in 70 acres (28.3 hectares) with estimated legacy waste of 80 lakh cubic metres above ground level and 8 lakh cubic metres below ground level. The biomining operations started on 1 October 2019. The process is being administered by Delhi Municipal Corporation—North (see *Figure 3: Process flow of biomining operations by North Delhi Municipal Corporation*).

FIGURE 3: PROCESS FLOW OF BIOMINING OPERATIONS BY NORTH DELHI MUNICIPAL CORPORATION



Source: CSE, 2019.

17 trommels are installed at the Bhalswa dumpsite and 15 trommels are currently processing the legacy waste at the Bhalswa dumpsite (14 trommels of 30 mm screen size and 01 trommel of 6 mm screen size).

As on 18 August 2020 around 661,454 tonnes of legacy waste were processed by biomining. Of this about 85,631 tonnes of inert material has been lifted from Bhalswa and dumped at the eco-park site of NTPC at Badarpur and other low-lying areas.

About 97,075 MT of combustible waste or refuse-derived fuel has been sent for co-processing in Jabalpur and the waste-to-energy plant in Bawana. The urban local body had to pay Rs 3,240 per tonne for co-processing the recovered plastic at Jabalpur and Rs 1,800 per tonne for the waste-to-energy plant in Bawana.

The biomining process recovered 10,129 tonnes of construction and demolition waste. Legacy waste of about 52,700 sq. m area and 11 metre height from the first mound and about 6,100 sq. m area and 12 metre height from the second mound have been cleared from the Bhalswa dump.

About 4,200 MT of legacy waste is being processed per day. The corporation plans to install more trommels to increase the processing capacity to 5,500 tonnes per day.

Biomining at Bhalswa dumping site using trommels

Source: CSE 2020.

Hyderabad

The Greater Hyderabad Municipal Corporation (GHMC) stretches over an area of 625 sq. km and has a population of 6.8 million as per the 2011 Census. The rapid growth of IT and ITES has put the city on a global platform and the projected population in 2019 is 7.6 million. The city generates 5,300 tonnes of waste daily, out of which 54 per cent is biodegradable. The waste is processed both centrally and in a decentralized manner and 16 per cent of total waste is sent to sanitary landfill as inerts.

In 2008, GHMC formulated an integrated solid waste management project for collection, transportation, treatment and disposal of municipal solid waste generated in the GHMC area. The project was entrusted to the private operator M/s Hyderabad Integrated Municipal Solid Waste Ltd in 2009 under public–private partnership in Built Operate and Transfer (BOT) mode for 25 years. It was initiated adjacent to the Jawaharnagar dumpsite.

GHMC irresponsibly dumped mixed waste generated by the city in the 135-acre dumpsite, and continued to do so till 2012. The height of the dumpsite is estimated to be 60 metres. The dumpsite is initially excavated to create a slope and the landfill is divided into several cells. A layer of impermeable soil cover was spread over the 135 acres (54.6 hectares) of surface area of the dumpsite. Leachate collection ponds were constructed to collect and process leachate. The final process was spreading a geotextile layer and growing vegetation to prevent soil erosion.

The process of capping started in the August 2018 and is expected to be completed by December 2019. The total project cost of capping the Jawaharnagar dumpsite is Rs 141 crore. It is estimated, however, that the dumpsite would emit landfill gases and leachate for the next 15 years.

Capping of 135-acre Jawaharnagar dumpsite in Hyderabad

Source: CSE 2019.

Kumbakonam

Kumbakonam is a special grade municipal town in Tamil Nadu, well known for its farm-based activities. It is also known as the granary of south India. As per the 2011 Census, the city has a population of 1.4 lakh and stretches over 12.5 sq. km. As per the waste projections carried out by the municipality in 2015, based on population density in all the 45 wards, Kumbakonam generates 70 TPD solid waste out of which the biodegradable content is estimated to be 65 per cent.

Kumbakonam initiated the first bioremediation site in the country. The municipality faced continuous fire at the 30-year-old dumpsite spread over 32.5 acres in Thepperumanallur village. The estimated quantity of waste in the site is around 3.5 lakh tonnes.

The municipality awarded a contract to Zigma Global Environ Solutions Pvt. Ltd in 2015. The company was then two months old and the municipality has plans for bio-capping the landfill and maintain it. Being the first project, the company with its mobile processing unit was able to start its operations in July 2016 and reclaimed the entire 32.5 acres of land. The process was completed in August 2018.

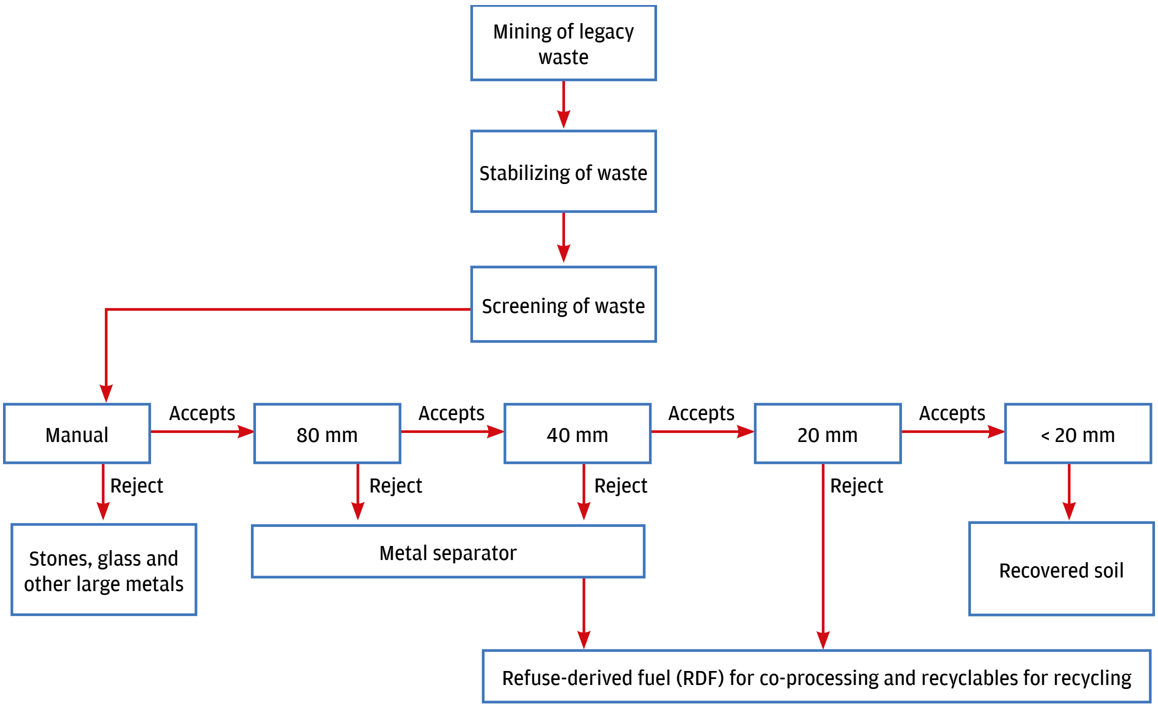
In 2017, a 70 TPD processing unit that handles the mixed waste of the city was established on the reclaimed land. In addition, a 5 TPD capacity biogas unit was also commissioned on the same land.

No residue was left during the process of bioremediation and the 25-metre-high dumpsite is now completely flat. Around 500 tonnes of RDF is left on the site as of now. The RDF, mined from the legacy waste, is sent for co-processing to Dalmia Cement in Dalmiapuram, 70 km from the Kumbakonam.

The excavated legacy waste was initially laid in the form of windrows. The size of the windrows is not standardized and can be based on the quantity of waste excavated. The legacy waste was then stabilized by adding bio-culture at regular intervals of one week, which catalysed the rate of decomposition of the waste. The decomposition levels were checked every week and soil samples collected for germination testing. The waste in general stabilized in 30 days. The stabilized waste was then passed through a series of trommels of various sizes. The rejects at each stage were considered as refuse-derived fuel (RDF) and the accepts acted as inputs to the next trommel.

Density blowers were used to separate soil from the RDF at each stage of waste passing through the trommel. The final product was considered as recovered soil and was fit for landfilling (see *Figure 4: Biomining process followed at the Kumbakonam dumpsite*).

FIGURE 4: BIOMINING PROCESS FOLLOWED AT THE KUMBAKONAM DUMPSITE



Source: CSE 2019.

Stabilization of legacy waste in the Kumbakonam dumpsite

Source: Zigma

Reclaimed land post completion of the biomining process Source: Zigma

Vijayawada

Vijayawada city is a suburb of Andhra Pradesh's state capital Amaravati, and is under the administration of Andhra Pradesh Capital Region (APCRDA). It is a major trading and business centre of the state and hence is also known as the business capital of Andhra Pradesh. According to the 2011 Census, the city has a population of 15 lakh and is estimated to reach a population of 25 lakh by 2025.

The solid waste management (SWM) of the city is the responsibility of the Vijayawada Municipal Corporation (VMC) and is the first corporation in the state to receive ISO 9001 certification for Quality Management Systems. In 2015, VMC conducted a qualitative and quantitative assessment of solid waste as per the Central Public Health and Environmental Engineering Organisation (CPHEEO) manual and the waste generation in Vijayawada was estimated to be 550 TPD from all the possible sources.

However, with the bifurcation of Andhra Pradesh and with the capital city Amaravati close to Vijayawada, Vijayawada has experienced an exponential growth of population in recent years and the waste generation is expected to grow at a faster rate.

Of the total waste generated, the non-biodegradable component is estimated at 57 per cent. Only 16 per cent of the waste is estimated to be inert. Detailed quantitative and qualitative analysis of the physical characteristics of the waste generated shows that about 43 per cent of the total waste generated is biodegradable (including all the sources such as vegetable, mutton, chicken, market waste, waste from residential areas etc.).

The city, known as a pioneer in managing solid waste, has a classic example of failure of a 6 MW waste-to-energy plant. The city started practising source segregation in 2017, prior to which the waste was dumped in mixed form at Ajit Singh Nagar dumpsite. An estimated legacy waste of 3.5 lakh tonnes was dumped until 2018.

In 2018, the municipal corporation started bioremediation of the legacy dumpsite spread across 45 acres. The contract to clear 2.5 lakh tonnes of legacy was awarded to the private company Zigma Global Environ Solutions Pvt. Ltd. The company cleared 2.5 lakh tonnes of waste in nine months and applied for extension of tender to clear the remaining 55,000 tonnes of legacy waste.

The estimated cost of clearing the legacy waste is around Rs 18 crore and 30 acres of land is reclaimed through the process.

Stabilization of legacy waste in the dumpsite

Source: Zigma

Reclaimed land after completion of biomining process

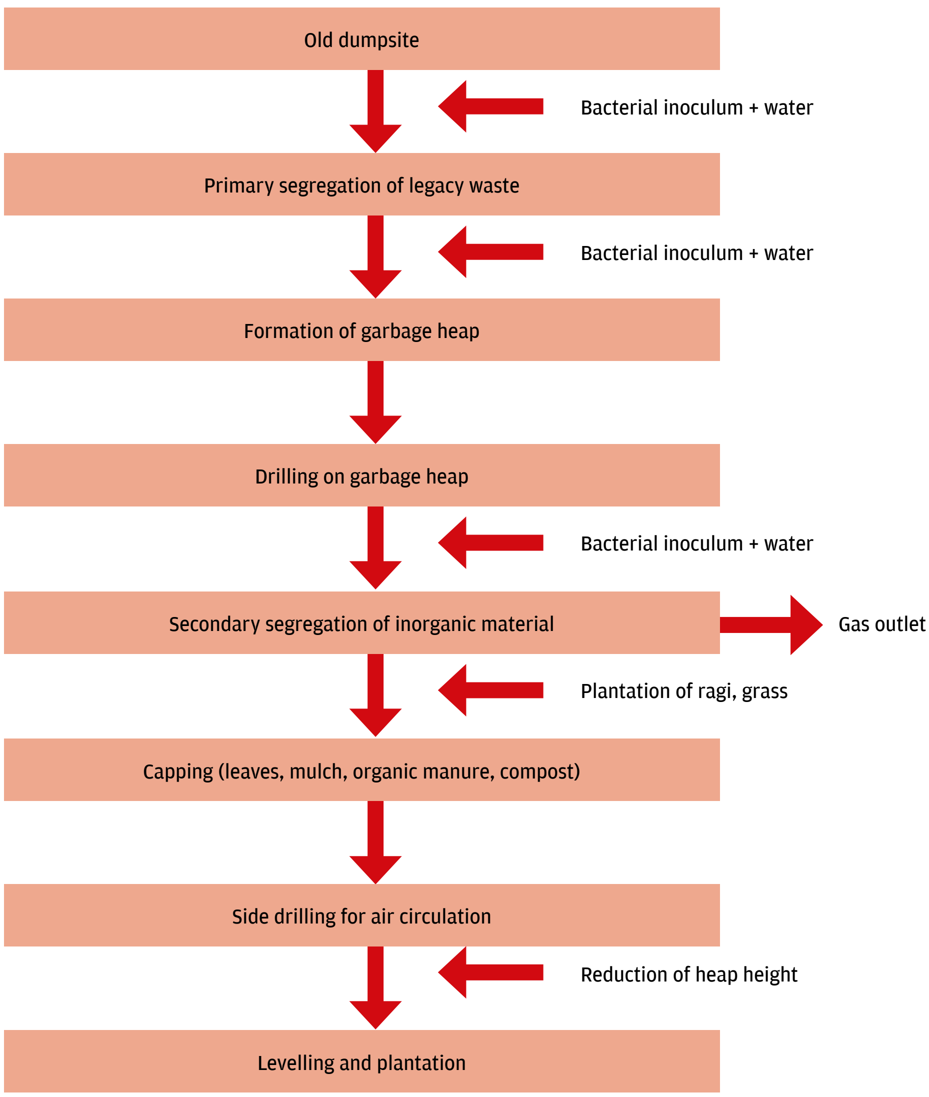
Source: Zigma

Ambikapur

Ambikapur, ranked as the cleanest city in the state of Chhattisgarh, is an example in effective and efficient decentralized waste management.

Before following decentralized systems, however, the waste here was dumped in mixed form. After deciding to clear the legacy waste, spread across 14,000 sq. m, the civic body made a time-bound plan to execute the biomining process to clear the old waste. Women from 20 self-help groups (SHGs) carried out the whole process of reclamation. The cost to the corporation was Rs 14 lakh (see *Figure 5: Ambikapur process flow for dumpsite management*).

FIGURE 5: AMBIKAPUR PROCESS FLOW FOR DUMPSITE MANAGEMENT



Source: CSE 2019.

The mixed waste was made into windrows of 1,000 by 2 metres and inoculum was applied in every half-foot layer on the heap and into the heap by means of hand drills.

Once entire area was cleared, the polluted topsoil was removed and heaped separately. This was further processed with bio-culture. The surface was then covered with capping materials such as leaves, mulch and organic manure. The reclaimed dumpsite was spread with a 2-inch layer of compost and local grass and ragi was cultivated to bind the soil on the surface. The dumpsite reached nearly level ground by natural decomposition in 45 days.

Source: Municipal Corporation, Ambikapur.

Indore

As per the 2011 Census, Indore Municipal Corporation (IMC) has a population of 19.94 lakhs, and a floating population of 3–4 lakh people per day. The city has an area of 275 sq. km under its jurisdiction. The city is working not only on visible cleanliness but on the management of waste by inspiring residents for behaviour change and segregation.

Four years ago, the city corporation emphasized only on the collection and transportation (C&T) of the waste from households, not on source segregation, but now the whole city segregates their waste as well.

Indore transformed its garbage landfill site into a beautiful garden in a very small time-frame. The reclamation project started in 2016–17, when IMC outsourced the work to a contractor and it has already cleared out 2 lakh metric tonnes (MT). In 2018, about 13 lakh MT of waste was dumped on the ground and IMC decided to carry forward the work. This time, IMC did not outsource the work to a contractor as they charged around Rs 500 per cubic metre. It would have cost IMC approximately Rs 65 crore to clear all the waste, which was beyond IMC's financial capacity. That's when IMC decided to hire trommels, screens, excavators and backhoe loaders on rent and operate them by using our their own resources. IMC operated the machinery in two shifts and completed the work in just six months with a budget of only Rs 10 crore for the entire process. After three years, the city has freed 100 per cent legacy waste, which is being remediated. The total reclaimed land is worth about Rs 400 crore, and it is currently under development as a recreational golf course.

BOX: HIGHLIGHTS OF BIO-REMEDIATION SITE

Area of the facility: 4 acres

Processing capacity: 100 MT per day

CAPEX: Rs 2.5 crore

Products obtained: 40 mm and 20 mm maximum size aggregate, sand and sludge which are converted into useful end products.

Source: SWM initiatives in urban India, NIUA, 2019.

During the process, IMC deployed 10 trommels, 15 horizontal screens, more than 50 excavators and backhoe loaders, with 200-plus workers to execute the work. A team headed by Commissioner IMC monitored the progress of work daily. The work was taken up on a war footing and the bioremediation of the legacy waste was completed on 5 December 2018. It also complied with the requirements of

Star Ranking of Garbage Free Cities protocol issued by Ministry of Housing and Urban Affairs, Government of India.

The recyclables recovered from the biomining process were sent for recycling, and recyclable polythene was sent to cement plants and for road making. The soil recovered was used for refilling the ground on the same site where a granary is being developed. The recovered construction and demolition waste was sent to a C&D processing facility to produce building materials. Leftover waste was sent to a secured landfill. Valuable land has been recovered by bioremediation of legacy waste.

Conclusion

India has classic examples of failure of capping dumpsites. The 35-acre Gorai dumpsite was capped by BMC and cost Rs 44 crore. The plan was to collect greenhouse gases. Poor capping, however, led to refund of Rs 15 crore of advance carbon credits.

A gas leak at Malad dumpsite, Mumbai, led to a failure of electronic equipment in the Mindspace IT park, constructed next to the capped dumpsite. It is estimated that sulphur in hydrogen sulphide gas emitted from the capped landfill made the circuit board non-conducting.

Another capping failure is at Bagalur dumpsite, Bengaluru, where leachate extraction wells were constructed in a partially lined pit. The filled pit was capped with green vegetation. Lawn sprinklers added moisture to the waste through tears in the plastic layer covering the legacy waste. Landfill gas and methane vigorously bubbling up in every unemptied leachate extraction well is observed.

In spite of failures in the past, in 2019 Hyderabad capped its 135-acre dumpsite. The city, so far known for its biryani and pearls, will now be recognized for its 12 million tonne man-made garbage hill.

Capping of dumpsites is an expensive and, as evident from the attempted failures, environmentally hazardous. It requires maintenance to handle gases and leachate generated for around 15–20 years. As the SWM Rules, 2016 suggest, civic bodies should attempt to handle legacy dumpsites by biomining and remediation.

Annexure I

Legal framework on dumpsite management

As per the Municipal Solid Wastes (Management and Handling) Rules, 2000, landfilling is allowed only for the following types of waste:[4]

i. Commingled waste (mixed waste) not found suitable for waste processing;
ii. Pre-processing and post-processing rejects from waste processing sites; and
iii. Non-hazardous waste not being processed or recycled.

Landfilling is usually not done for the following municipal solid waste streams:

i. Biowaste/garden waste; and
ii. Dry recyclables.

Solid Waste Management Rules, 2016

Rule 15 of the Solid Waste Management Rules, 2016, prescribes the duties and responsibilities of local authorities and village panchayats of census towns and urban agglomerations. The local authorities and panchayats shall:

(zj) investigate and analyze all old open dumpsites and existing operational dumpsites for their potential of bio-mining and bioremediation and wheresoever feasible, take necessary actions for biomining or bioremediate the sites;

(zk) in absence of the potential of biomining and bioremediation of dumpsite, it shall be scientifically capped as per landfill capping norms to prevent further damage to the environment. The by-laws shall apply to every urban local body, outgrowths in urban agglomerations, Cantonment boards, Panchayat, Industrial and Institutional Townships, railways and defense establishments.

Schedule-I (j) Closure and Rehabilitation of Old Dumps:

Solid waste dumps which have reached their full capacity or those which will not receive additional waste after setting up of new and properly designed landfills should be closed and rehabilitated by examining the following options:

i. Reduction of waste by biomining and waste processing followed by placement of residues in new landfills or capping as in (ii) below.
ii. Capping with solid waste cover or solid waste cover enhanced with geomembrane to enable collection and flaring/utilization of greenhouse gases.
iii. Capping as in (ii) above with additional measures (in alluvial and other coarse-grained soils) such as cut-off walls and extraction wells for pumping and treating contaminated ground water.
iv. Any other method suitable for reducing environmental impact to acceptable level.

References

1. Annual report 2018-19 on solid waste management; available at https://cpcb.nic.in/uploads/MSW/MSW_AnnualReport_2018-19.pdf

2. *Not In My Backyard: Solid Waste Management in Indian Cities*; available at https://csestore.cse.org.in/catalog/product/view/id/470/s/not-in-my-backyard-solid-waste-mgmt-in-

3. Guidelines for disposal of legacy waste; available at https://cpcb.nic.in/uploads/LegacyWasteBiomining_guidelines_29.04.2019.pdf

4. The Municipal Solid Wastes (Management & Handling) Rules 2000; available at http://www.indiaenvironmentportal.org.in/content/257913/the-municipal-solid-wastes-management-and-handling-rules-2000/

A combination of uncontrolled dumping of mixed municipal waste at designated dumpsites as well as at garbage-vulnerable points for decades, aided by flawed laws, has created around 3,159 dumpsites in India. The size and quantity of legacy waste in these dumpsites have become a ticking time-bombs, with associated environment impacts, including air, water and soil pollution.

Landfill capping and remediating dumpsites are two possible solutions for managing dumpsites. While the amended Solid Waste Management Rules, 2016, focused on undoing damage caused by the wrong decision of dumping mixed waste and creating garbage hills, the pace of implementing these rules is lagging even after three years.

This study by the Centre for Science and Environment (CSE) analyses initiatives by various cities in handling legacy waste along with the processes followed and economies involved.

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