

Table 3.7: Compost Quality Standards as per Solid Waste Management Rules, 2016; Fertiliser Control Order, 2009; and Fertiliser Control Order, 2013

PARAMETERS	ORGANIC COMPOST	PHOSPHATE RICH ORGANIC MANURE (PROM)
	FCO 2009	FCO (PROM) 2013
Arsenic (mg/kg)	10.00	10.00
Cadmium (mg/kg)	5.00	5.00
Chromium (mg/kg)	50.00	50.00
Copper (mg/kg)	300.00	300.00
Lead (mg/kg)	100.00	100.00
Mercury (mg/kg)	0.15	0.15
Nickel (mg/kg)	50.00	50.00
Zinc (mg/kg)	1000.00	1000.00
C/N ratio	<20	less than 20:1
pH	6.5 - 7.5	(1:5 solution) maximum 6.7
Moisture, % by weight, maximum	15.0-25.0	25.0
Bulk density (g/cm ³)	<1.0	Less than 1.6
Total organic carbon, % by weight, minimum	12.0	7.9
Total nitrogen (N), % by weight, minimum	0.8	0.4
Total phosphate (P ₂ O ₅), % by weight, minimum	0.4	10.4
Total potassium (K ₂ O), % by weight, minimum	0.4	—
Colour	Dark brown to black	—
Odour	Absence of foul odour	—
Particle size	Minimum 90% material should pass through 4.0 mm IS sieve	Minimum 90% material should pass through 4.0 mm IS sieve
Conductivity [as dsm ⁻¹], not more than	4.0	8.2
Note: • Tolerance limits as per FCO: i. For compost- A sum total of nitrogen, phosphorus and potassium nutrients shall not be less than 1.5% in compost ii. For PROM- No such directive • “—” Not applicable		

Table 3.8: Vermicompost Standards as per Fertilizer Control Order, 2009

S.NO	CRITERIA	VALUE
1.	Moisture % by weight	15.0-25.0
2.	Colour	Dark brown to black
3.	Odour	Absence of foul odour
4.	Particle size	Minimum 90% material should pass through 4.0 mm IS sieve
5.	Bulk density	0.7-0.9
6.	Total organic carbon, % by weight, minimum	18.0
7.	Total nitrogen (N), % by weight, minimum	1.0
8.	Total phosphates (P_2O_5), % by weight, minimum	0.8
9.	Total potash (K_2O), % by weight, minimum	0.8
10.	Heavy metal content (mg/kg) by weight, maximum	
	a. Cadmium (Cd)	5.00
	b. Chromium (Cr)	50.0
	c. Nickel (Ni)	50.0
	d. Lead (Pb)	100.0
Note: Tolerance Limit for vermicompost. The sum total of Nitrogen, Phosphorus and Potassium nutrients should not be less than 2.5 % in the case of vermicompost.		

3.2.12 INTEGRATION OF THE INFORMAL SECTOR

Integrating waste pickers into organised or formal waste management programmes can improve the quality of their working conditions and their earning. Waste pickers could be trained and employed in the pre-processing facility at the compost plant. Since they are already used to work with waste material, they have good acumen and aptitude for such work. Refer to Section 3.1.6 and Section 1.4.5.9 of Part II for further details on integrating the waste pickers into formal systems.

3.2.13 HUMAN RESOURCE REQUIREMENT

Compost plant operators shall ensure that all personnel assigned to the operation shall be trained in subjects pertinent to operation and maintenance (O&M), physical contaminants, and hazardous material recognition and screening, with emphasis on odour impact management and emergency procedures. A record of such training shall be maintained on the site.

The level and nature of staffing and training should be adequate for environmentally responsible and safe management of the composting facility. Staffing levels should be high enough to ensure that the facility can comply at all times with provisions of the SWM Rules, 2016 and other applicable guidance or consent.

Composting plants can provide livelihood opportunities to the informal sector

Training and capacity building of all staff in waste management plants is essential

Staff training should be effective enough to ensure the following:

- all operators of the plant and its equipment are skilled at undertaking all the tasks required of them;
- all personnel who inspect incoming waste are skilled at identifying unacceptable waste and recording data accurately;
- laboratory staff is well informed of sampling practices and requisite analysis. They should be conversant with the impacts of different parameters to be able to suggest process modifications based on an analysis of the results. Constant communication with plant operating staff on related matters is crucial;
- compost quality should be regularly checked through NABL accredited laboratories, at least once a month or as per direction of the State Pollution Control Board (SPCB).

Staffing requirements will vary as a function of the size of the facility, the type of waste input, and the diversity and complexity of site operations.

Indicative staff requirement for a 300 TPD windrow composting plant is given in Table 3.9:

Table 3.9: Indicative Staff Requirement for a 300 TPD Compost Plant (Windrow)³¹

S. NO.	GRADE	QUALIFICATION	EXPERIENCE	NUMBER
1.	General manager	Bachelor of Engineering (BE)	2-3 years	1
2.	Shift in-charge	Diploma	1 to 2 years	2
3.	Mechanic	Industrial Training Institute (ITI)	3 years	2
4.	Plant operator	Higher Secondary School	1-2 years	3
5.	Chemist	Bachelor of Science	3 years	2
6.	Accounts officer	Bachelor of Commerce	3 years	1
7.	Skilled worker	-	2-3 years	4
8.	Semi-skilled workers	-	-	6
9.	Unskilled worker	-	-	12
10.	Drivers	-	3-4 years	20
11.	Contractual labour	-	-	24

3.2.14 GREENHOUSE GAS EMISSION AVOIDANCE THROUGH COMPOSTING

MSW contains large fractions of organic waste, which is a potential source of methane and other greenhouse gas (GHG) emissions. Methane is a highly polluting GHG with a global warming potential 21 times more than that of carbon dioxide. Composting, an aerobic process, transforms a

31 Inter-Ministerial Task Force on Integrated Plant Nutrient Management Using City Compost [2005].



range of organic substrates into stable humus like material through microbial decomposition. In the process, methane emissions to the atmosphere are avoided, which would otherwise result from anaerobic decay of waste in a disposal site, e.g., open waste disposal site or landfills.

Composting is acknowledged by the United Nations Framework Convention on Climate Change (UNFCCC) as one of the emission reduction methodologies in waste management. However, the potential for realising financial gain through sale of carbon credits is rather limited in the current global climate regime.

3.3 WASTE TO ENERGY

Waste to energy (WtE) refers to the process of generating energy in the form of heat or electricity from MSW. Energy from MSW can be achieved through:

1. thermal processes like incineration or combustion of refuse derived fuel (RDF); and
2. biological processes like biomethanation and further conversion into electrical power or automotive fuel (compressed biogas).

3.3.1 SOLID WASTE MANAGEMENT RULES, 2016: GUIDANCE ON WASTE TO ENERGY

As per SWM Rules, 2016:

Clause 15: Duties and responsibilities of local authorities:-

(v) facilitate construction, operation and maintenance of solid waste processing facilities and associated infrastructure on their own or with private sector participation or through any agency for optimum utilisation of various components of solid waste adopting suitable technology including the following technologies and adhering to the guidelines issued by the Ministry of Urban Development from time to time and standards prescribed by the Central Pollution Control Board. Preference shall be given to decentralised processing to minimize transportation cost and environmental impacts such as-

- b) waste to energy processes including refused derived fuel for combustible fraction of waste or supply as feedstock to solid waste based power plants or cement kilns;

Clause 18: Duties of the industrial units located within one hundred km from the refused derived fuel and waste to energy plants based on solid waste- All industrial units using fuel and located within one hundred km from a solid waste based refused derived fuel plant shall make arrangements within six months from the date of notification of these rules to replace at least five percent of their fuel requirement by refused derived fuel so produced.

It is assumed that at least 65 to 80% of energy content of waste can be recovered as heat energy through waste to energy technologies

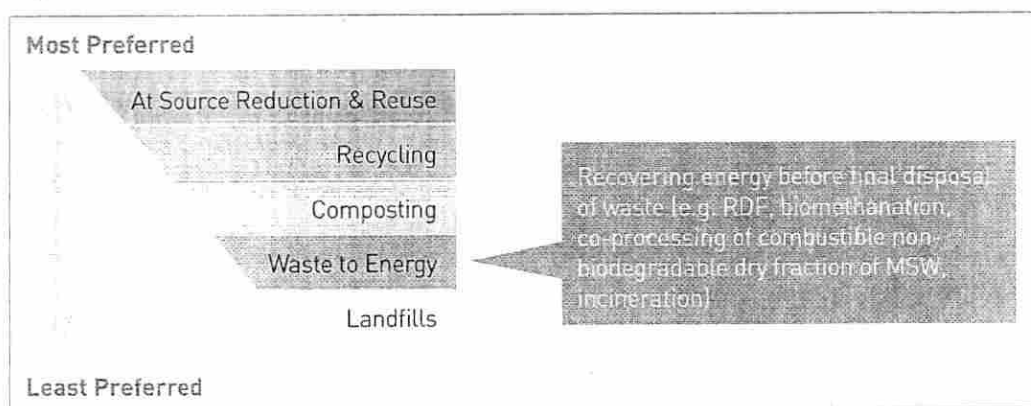
Clause 21. Criteria for waste to energy process.-

- (1) Non recyclable waste having calorific value of 1500 K/cal/kg or more shall not be disposed of on landfills and shall only be utilised for generating energy either or through refuse derived fuel or by giving away as feed stock for preparing refuse derived fuel.
- (2) High calorific wastes shall be used for co-processing in cement or thermal power plants.
- (3) The local body or an operator of facility or an agency designated by them proposing to set up waste to energy plant of more than five tones per day processing capacity shall submit an application in Form-I to the State Pollution Control Board or Pollution Control Committee, as the case may be, for authorisation.
- (4) The State Pollution Control Board or Pollution Control Committee, on receiving such application for setting up waste to energy facility, shall examine the same and grant permission within sixty days.

3.3.2 WASTE TO ENERGY (WtE) IN THE INTEGRATED SOLID WASTE MANAGEMENT HIERARCHY

The integrated solid waste management (ISWM) hierarchy indicates that recovery of energy from waste is preferable only after considering the potential for recovery of material. Valuable energy is sought to be recovered after ensuring that all possible reduce, recycle, and recover mechanisms have been adopted.

Figure 3.22: WtE in the Integrated Solid Waste Management Hierarchy



Since recovering energy value in waste prior to final disposal is considered preferable to direct landfilling, WtE option lies above landfilling in ISWM hierarchy

Proven WtE technologies include incineration of MSW with recovery of energy, either as heat or converted to electricity and production of high calorific value RDF, which is fast gaining acceptance. However, stringent norms specifying quality standards and conditions for its utilisation are awaited from the Ministry of Environment, Forest and Climate Change (MoEFCC). There are various other technologies under discussion, such as pyrolysis and gasification, which are not yet proven under Indian conditions for treatment of MSW.

Combustion technologies in India have to cope with the comparably high moisture and inert content, as is common in Indian waste. However, doorstep segregation of waste, segregated management of inert wastes, and pre-treatment to separate the high calorific fraction (RDF) can enable efficient thermal processes (refer to Section 3.5 of Part II).

Application of technologies like pyrolysis and gasification to treat MSW is at a very nascent stage in the country, with one or two experimental plants in the process of being set up. Nevertheless, Section 3.6 of Part II provides an overview of these technologies.

WTE plants are an expensive option for managing MSW, requiring skilled staffing and adoption of high-level technologies. They also have the potential to cause significant environmental impacts through emissions and fly ashes if plants are not operated efficiently and if appropriate emission control mechanisms are not adopted.

Guidelines by the Task Force Constituted By Planning Commission on Waste to Energy (WtE)

It is essential to explore ways and means to promote integrated waste processing optimally to manage the ever growing waste quantities. The draft guidelines by the Task Force constituted by the Planning Commission (2014) for establishing Waste to Energy plants include the following:

- The appropriateness of WtE for a community must be evaluated on a case-by-case basis and should only be considered after waste reduction and responsible recycling programs are implemented
- Minimum eligibility criteria for getting financial support to set up WtE plants are the following:
 - Municipal authority must select a suitable concessionaire through a competitive bidding to set up, operate and maintain the waste processing facility for a long term not below 20 years;
 - The applicant must be a developer or technology provider who will actually construct, operate and maintain the plant;
 - The developer must have critical staffing on board on full time basis or on long term contract;
 - The developer must have past experience of operation and maintenance (O&M) of at least one such plant.

3.3.3 INCINERATION

Incineration is a waste treatment process that involves combustion of waste at very high temperatures in the presence of oxygen and results in the production of ash, flue gas, and heat. Incineration is a feasible technology for combustion of unprocessed or minimum processed refuse and for the segregated fraction of high calorific value waste.

Incineration of municipal solid waste (along with energy recovery) can reduce the volume of waste to be landfilled by 90%



The potential for energy generation depends on the composition, density, moisture content, and presence of inert in the waste. In practice, about 65%–80 % of the energy content of the organic matter can be recovered as heat energy, which can be utilised either for direct thermal applications or for producing power via steam turbine generators.

Besides the potential for energy use, incineration of MSW helps to reduce landfill volumes. Incineration is an option especially where other better options of processing of waste are not feasible and land for landfilling and other waste processing methods is scarce.

3.3.3.1 KEY CRITERIA FOR MUNICIPAL SOLID WASTE INCINERATION

MSW incineration projects are appropriate only if the following overall criteria are fulfilled:

- a mature and well-functioning waste management system has been in place for a number of years;
- incineration is especially relevant for the dry bin content in a two-bin system. For unsegregated waste, pre-treatment is necessary;
- the lower calorific value (LCV)³² of waste must be at least 1,450 kcal/kg (6 MJ/kg) throughout all seasons. The annual average LCV must not be less than 1,700 kcal/kg (7 MJ/kg);³³
- the furnace must be designed in line with best available technologies to ensure stable and continuous operation and complete burnout of the waste and flue gases. MSW is usually incinerated in a grate incinerator. Uniform combustion of waste is dependent on the grate design. Please refer to section 3.3.3.6.1 for further detail;
- the supply of waste should be stable and amount to at least 500 TPD of segregated waste;
- produced electricity or steam can be sold on a sustainable basis (e.g., feeding into the general grid at adequate tariffs).
- it is possible to absorb the increased treatment cost through management charges and tipping fees.
- skilled staff can be recruited and maintained.
- since the capital investment is very high, the planning framework of the community should be stable enough to allow a planning horizon of 25 years or more.
- pre-feasibility study for the technology lead to positive conclusions for the respective community.
- strict monitoring systems are proposed and followed.

The success of waste incineration projects depends entirely on incoming waste feed characteristics and quantity

32 LCV or net calorific value (NCV) is determined by subtracting the heat of vaporization of the water vapor in the combustion reaction products from the higher heating value or gross calorific value (GCV), giving a lower value than the GCV.

33 Decision Maker's Guide to Municipal Solid Waste Incineration, The World Bank, 1999





To ensure financial viability of incineration plants, the supply of waste feed should be at least 1000 TPD of mixed waste

3.3.3.2 KEY CONSIDERATIONS FOR INCINERATION OF MUNICIPAL SOLID WASTE

Incineration of municipal solid waste should meet with the following criteria:

- minimum gas phase combustion temperature of 850°C and a minimum residence time of the flue gases, above this temperature, of two seconds after the last incineration air supply;
- optimum oxygen content (lower than 6%) should be maintained to minimise corrosion and ensure complete combustion. The carbon monoxide content of the flue gas is a key indicator of the quality of combustion;

Operational Incineration Plants in India (as of January 2015)³⁴

Currently, five waste to energy (WtE) plants are operational or under construction, which are expected to receive grants from the Ministry of New and Renewable Energy (MNRE) as per their Programme on Energy from Urban, Industrial and Agricultural Waste or Residues. MNRE is aiming at compliance with international emission standards for WtE plants in India. Some details of the plants supported by MNRE are given below:

Delhi: Timarpur-Okhla Waste Management Company is an initiative of Jindal ITF Ecopolis. The incineration plant was commissioned in January 2012 and is processing about 1,600 TPD of waste. The MSW after pre-processing is being fed into the incineration plant and is generating about 16 megawatts (MW) of electricity.

Delhi, Ghazipur: Of the 2,000 TPD of waste received at the landfill, the facility will process about 1,300 TPD to generate 433 TPD of RDF which will be utilised for generation of 12 MW power. The project is under construction. The public private partnership (PPP) operator is Infrastructure Leasing and Financial Services (IL&FS).

Bengaluru: An 8-MW power plant is in the process of being set up in Bangalore. This initiative is carried out under a PPP framework between M/s Srinivasa Gayithri Resources Recovery and Bruhat Bengaluru Mahanagara Palike (BBMP). The plant is not yet operational.

Pune: A 10-MW WTE plant based on gasification technology is being set up in Pune by Rochem Separation Systems as one of the pilot projects. The plant will utilize 700 TPD of waste for production of 10 MW of electricity. The plant is not yet operational.

Hyderabad: An 11-MW power plant will utilize 1,100 TPD of MSW. It is being installed in the Nalgonda district of Telangana by RDF Power Projects. The plant will produce refuse-derived fuel (RDF) for in-house incineration and power generation. The plant is under construction.

³⁴ Waste incineration for urban India: valuable contribution to sustainable MSWM or inappropriate high-tech solution affecting livelihoods and public health? Dube, R, Nandan, V & Dua, S (2014). Int. J. Environmental Technology and Management, Vol. 17, Nos. 2/3/4 and further updated information by MNRE [2015].



- fly ash acts as catalyst for de novo synthesis (at 200°C–450°C) of dioxins and furans. In order to reduce formation of dioxins and furans, it is imperative that maximum fly ash is removed before gases cool to the range of 200°C–450°C;
- the flue gases produced in the boilers should be treated by an elaborate flue gas treatment system.

3.3.3.3 OVERVIEW OF THE INCINERATION PROCESS

The following general description of an incineration plant includes the crucial processing steps and aspects:

- siting of an incineration plant;
- waste reception and handling (storage, on-site pre-treatment facilities);
- combustion and steam generation system;
- flue gas cleaning system;
- energy generation system (steam turbine and generator in case the unit is equipped for WTE recovery);
- residual hauling and disposal system; and
- monitoring and controlling incineration conditions.

In designing each of these process steps, the type(s) of waste that are treated in a concrete installation has to be reflected.

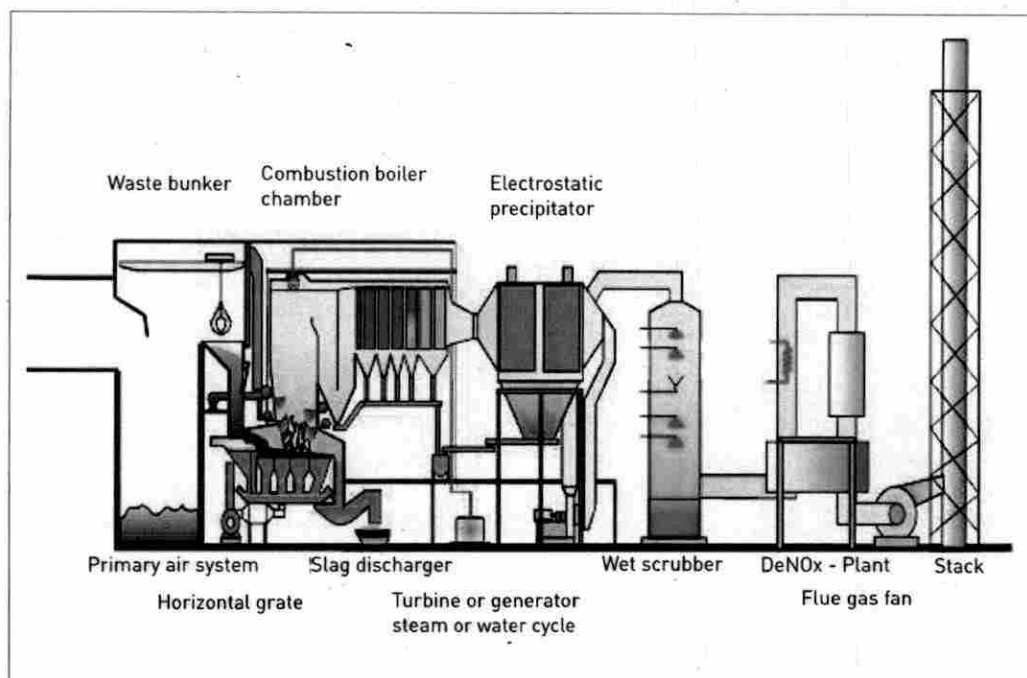
3.3.3.4 SITING OF INCINERATION PLANT

The location of a MSW incineration plant should always be determined with respect to both economic and environmental issues. Some of the key criterias for siting an incineration facility are the following:

- a controlled and well-operated landfill must be available for disposing residues (bed and fly ash);
- MSW incineration plants should be located in land-zones dedicated to medium or heavy industry;
- MSW incineration plants should be at least 300–500 meters from residential zones;
- in case of steam production, the plants should be located near suitable energy consumers.

The siting of incineration plants should consider all the following: proximity to waste generation point, traffic and transport, air quality, noise impact, proximity to energy distribution networks, utilities and landfills



Figure 3.23: Typical Mass Burn Incinerator³⁵

3.3.3.5 WASTE RECEPTION AND HANDLING

Figure 3.23 provides an overview of the design of an incineration plant. The incoming waste reception area is usually a waterproof concrete bed which receives waste from vehicles usually after visual control and weighing. Enclosure of the delivery area can be one of the effective means of avoiding odour, noise, and emission problems from the waste.

The waste is piled and mixed in the bunker using cranes equipped with grapples. The mixing of waste helps to achieve a balanced heat value, size, structure, composition, etc. of the material dumped into the incinerator filling hoppers. The bunker must have a storage capacity for at least 3–5 days depending on the plant's operational capacity. The storage area will also depend on local factors and the specific nature of the waste.

Waste Feeder: The key objective behind the waste feeder system is to supply exactly the right amount of fuel to the grate that is necessary to achieve minimum negative pressure and desired temperature for stable combustion and energy generation. The feed rate must be constantly and continuously adapted to the transport capacity of the grate to obtain a uniformly distributed layer of fuel on the grate and thus achieve uniform energy generation. Consistent feeding also ensures minimal environmental pollution, especially as it fosters optimal controllable combustion.

Waste reception and storage area should be designed in such a way as to allow for daily and weekly variations in the waste quantities and for mixing of waste to achieve balanced heat value, size, composition etc.

Removal of inerts and C&D waste is essential to ensure combustion efficiency

³⁵ Waste-Non-Hazardous Waste-Municipal Solid Waste, USEPA (2013).

The waste is discharged from the storage bunker into the feeding chute by an overhead crane, and then fed into the grate system by a hydraulic ramp or other conveying systems. The grate moves the waste through the various zones of the combustion chamber in a tumbling motion. The filling hopper is used as a continuous waste supplier. It is filled in batches by the overhead crane. As the filling hopper surface is exposed to great stress, material with high friction resistance are selected (e.g., boilerplates or wear-resistant cast iron). The material must survive occasional hopper fires unscathed. The waste hopper may sometimes be fed by a conveyor. In that case, the overhead crane discharges waste into an intermediate hopper that feeds the conveyor.



Waste feeder systems should be designed to maintain optimum combustion, resulting in minimal environmental pollution

It is recommended to divide the total plant capacity into two or more identical incineration lines, thus improving the plant's flexibility and availability—e.g., when one line is closed for maintenance. This is required since the plant needs to be shut down for mandatory maintenance and inspection of boilers for a minimum of 4–6 weeks.

3.3.3.6 COMBUSTION AND STEAM GENERATION SYSTEM

Combustion takes place above the grate in the incineration chamber. As a whole, the incineration chamber typically consists of a grate situated at the bottom, cooled and non-cooled walls on the furnace sides, and a ceiling or boiler surface heater at the top. As MSW generally has a high volatile content, the volatile gases are driven off and only a small part of the actual incineration takes place on or near the grate.

The design of the incineration chamber depends on the following:

- Form and size of the incineration grate. The size of the grate determines the size of the cross-section of the incineration chamber.
- Vortexing and homogeneity of flue gas flow. Complete mixing of the flue gases is essential for good flue gas incineration.
- Residence time for the flue gases in the hot furnace. Sufficient reaction time at high temperatures must be assured for complete incineration.
- Partial cooling of flue gases. In order to avoid fusion of hot fly ash at the boiler, the flue gas temperature must not exceed an upper limit at the incineration chamber exit.



Typical incineration chamber consists of:

- grate at the bottom
- cooled and non-cooled walls
- ceiling or boiler surface heater at the top

The detailed design of a combustion chamber is usually linked to the grate type. Its precise design demands certain compromises as the process requirements change with the fuel characteristics.

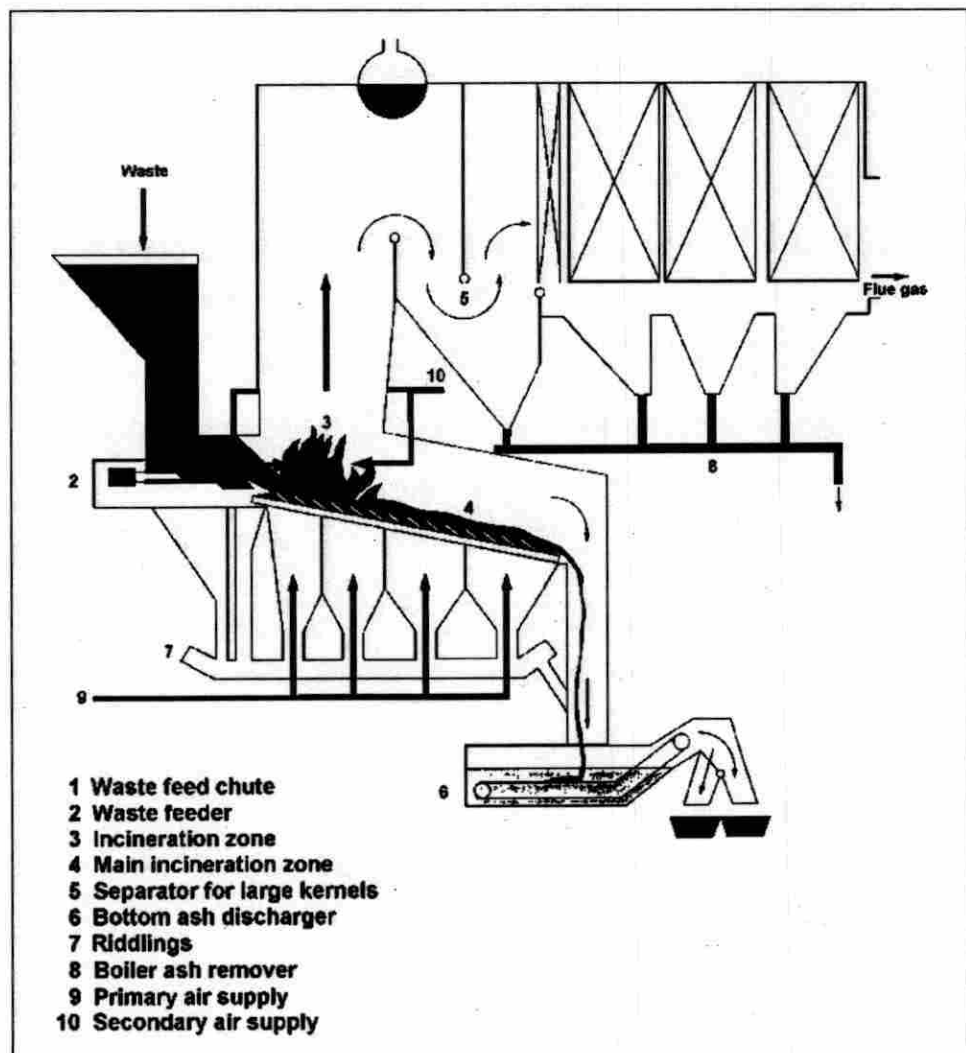
Grate incinerators are best suited for MSW that is mixed, non-homogenous and has low calorific value

3.3.3.6.1 Grate Incinerators

The incineration grate accomplishes the following functions:

- transport of material to be incinerated through the furnace;
- stoking and loosening of the material to be incinerated; and
- positioning of the main incineration zone in the incineration chamber, possibly in combination with furnace performance control measures.

Figure 3.24: Grate Furnace and Heat Recovery Stages of a Municipal Waste Incineration Plant³⁶



Grate incinerators (Figure 3.24) are widely applied for the incineration of mixed municipal wastes and can be used for untreated, non-homogenous, and low calorific municipal waste. An overhead crane feeds waste into the hopper, where it is transported via the chute to the

³⁶ "Reference Document on the Best Available Techniques for Waste Incineration", European Commission (2006). Available at: <http://eippcb.jrc.ec.europa.eu/reference/wi.html>

grate in the furnace. On the grate, the waste is dried and then burned at high temperature with supply of air. The ash, including noncombustible fractions of waste, leaves the grate as slag or bottom ash through the ash chute.

Different grate systems can be distinguished by the way the waste is conveyed through the different zones in the combustion chamber. The type of grate system determines the efficacy of primary air feeding, conveying velocity and raking, as well as mixing of the waste.

Advantages of Grate Incinerators:

- There is no need for prior sorting or shredding.
- Technology is widely tested and meets the standards of technical performance.
- It accommodates large variations in waste composition and calorific value.
- It allows for an overall thermal efficiency of up to 85%.

Disadvantage of grate incinerators:

- Capital and maintenance costs are relatively high.

Grate incinerators are of two types:

- Moving grate furnace system: waste enters from one end while ash is discharged at other
- Fixed grates: series of steps with drying stage and initial combustion phase, complete combustion and final carbon burn-out

Reciprocating grates: Many modern MSWM incinerator facilities use reciprocating grates. The quality of burnout achieved is generally good. Reciprocating grates consist of sections that span the width of the furnace but are stacked above each other. Alternate grate sections slide back and forth, while the adjacent sections remain fixed. Waste tumbles off the fixed portion and is agitated and mixed as it moves along the grate.

There are essentially two main reciprocating grate variations:

1. **Reverse reciprocating grate:** The grate bars oscillate back and forth in the reverse direction to the flow of the waste. The grate is sloped from the feed end to the ash discharge end and is comprised of fixed and moving grate steps.
2. **Push forward grate:** The grate bars form a series of many steps that oscillate horizontally and push the waste in the direction of the ash discharge.

Other grate types that have been in use include rocking grates, travelling grates, roller grates, and cooled grates.



Timarpur Okhla Municipal Solid Waste Management Project is one of the few waste-to-energy (WTE) facility in India which is using a reciprocating forward moving grate incinerator for combustion of mixed solid waste of Delhi.



Other types of incinerators including the fluidised bed incinerator and rotary kiln incinerator are not suitable for mixed municipal solid waste (MSW) incineration. Rotary kiln incinerators are typically used for incineration of hazardous waste and biomedical waste.

3.3.3.7 INCINERATOR AIR FEEDING

The incineration air fulfills the following objectives:

- provision of oxidant
- cooling
- avoidance of slag formation in the furnace
- mixing of flue-gas

Air is added at various places in the combustion chamber; depending on the location, it is described as primary and secondary air. Tertiary air and re-circulated flue gases may also be used.

Primary air is generally taken from the waste bunker. This lowers the air pressure in the bunker hall and eliminates most odour emissions from the bunker area. This primary air is blown by fans into the areas below the grate, where its distribution can be closely controlled using multiple wind boxes and distribution valves. Primary air is forced through the grate into the fuel bed. It cools the grate bar to preserve structural integrity of the grate and carries oxygen into the incineration bed.

Secondary air is blown into the incineration chamber at high speed via, for example, injection lances or internal structures. This is carried out to secure complete incineration and is responsible for the intensive mixing of flue gases and prevention of the free passage of unburned gas streams.

3.3.3.8 FLUE GAS RECIRCULATION

Flue gas recirculation is an integral part of the furnace design. After passing through the dust filter, part of the flue gas is retained and recirculated through an insulated duct to the furnace. The recirculated flue gas is injected through separate nozzles in the furnace. The primary advantages of flue gas recirculation are the following:

- 10%–20% of secondary combustion air can be replaced with flue gas.
- Mono-nitrogen oxides (NO_x) reduction is achieved because the supplied re-circulated flue gases have lower oxygen concentration and, therefore, lower flue gas temperature, which leads to a decrease of the nitrogen oxide levels.



Flue gas recirculation has its operational, economic and environmental advantages

- It stabilises and improves the flow and turbulence conditions, particularly at partial load.

3.3.3.9 RESIDUAL HAULAGE AND DISPOSAL SYSTEM

During the incineration process, most of the waste is combusted and converted to gases such as carbon dioxide (CO_2), water vapor, and toxic gases, which are cleaned through a complex flue gas treatment system. However, part of the waste is incombustible and is removed from the incineration furnace as slag or bottom ash, a solid residue. The amount of slag generated depends on the composition of the waste and amounts to 20%–25% by weight of the waste combusted.

The flue gas cleaning process also produces residues, either directly (fly ash) or by the subsequent treatment of the spent scrubbing liquids, depending on the flue gas cleaning method applied. Fly ash from filter systems is highly contaminated and, hence, care must be taken to collect bottom ash and fly ash separately. Bottom ash can be treated for further use.

The slag from a well-operated waste incinerator will be well burned out, with only a minor content of organic material. Besides, the heavy metals in the slag, which are normally leachable, will, to some extent, become vitrified and thus insoluble.

Bottom ash may be treated either on-site or off-site by a dry system or wet system suitably combined with or without ageing. Dry bottom ash treatment installations combine the techniques of ferrous metals separation, size reduction and screening, nonferrous metals separation, and ageing of the treated bottom ash, usually for 6–20 weeks. The product is a dry aggregate which can be used as a secondary construction material.

Wet bottom ash treatment system in the ash quench tank allows the production of a material for recycling with minimal leachability of metals. The economy of the bottom ash treatment depends on the market price of the produced fractions. Revenue can be generated by the sale of nonferrous and ferrous metals fractions.

The fly ash generated in the boilers (approximately 1%–2% of input MSW quantity) and air pollution control equipment is highly contaminated and must be disposed appropriately. Since the salt and heavy metal content is very high in the ash, it cannot be used for construction purposes. Depending on the heavy metals constituents of fly ash, it should be appropriately mixed with binding agents like cement which would reduce the solubility of heavy metals, thus preventing their leaching and making the safe disposal of fly ash possible. If the treatment, storage, and disposal facility (TSDF) is not available, then

Fly ash should be transported in 'silos' and disposed in hazardous landfill

Residual wastes from incinerators like slag could be used as road construction material while fly ash from flue gas cleaning should be disposed in hazardous landfill



solidified and stabilised fly ash blocks should be disposed in an identified cell of municipal sanitary landfill.

3.3.3.10 CONSUMPTION OF RAW MATERIALS AND ENERGY BY INCINERATION PLANTS

Waste incineration plants (process dependent) may consume:

- electricity, for process plant operation;
- heat, for specific process needs;
- fuels, support fuels (e.g., gas, light oils, coal, char);
- water, for flue gas treatment, cooling, and boiler operation;
- flue gas treatment reagents, e.g., caustic soda, lime, sodium bicarbonate, sodium sulfite, hydrogen peroxide, activated carbon, ammonia, and urea;
- water treatment reagents, e.g., acids, alkalis, trimercapto triazine, sodium sulphite, etc.; and
- high pressure air, for compressors.

3.3.3.11 ENVIRONMENTAL CONSIDERATIONS

MSW incineration produces a range of volatile and gaseous emissions, which, if untreated and released to the atmosphere, can compromise environment quality. Fly ash and dust carry toxic contaminants. Ash leachate might contaminate soil and water.

The actual range of emissions depends on the specific characteristics of the waste stream and engineering design of the plant such as combustion temperature, combustion chamber design, and ancillary emission abatement technologies. Proper planning to minimise environmental damage as well as public education and involvement are essential to successful incineration programmes.

3.3.3.12 EMISSION REDUCTION IN INCINERATORS

Incineration of MSW generates large volumes of flue gases, which carry ash, heavy metals, and a wide range of organic and inorganic compounds. Major air emissions from MSW incinerators include hydrogen chloride, hydrogen fluoride, sulphur dioxide, NO_x , carbon monoxide, volatile organic compound, heavy metals, etc., which are hazardous to human health and environment. Dioxins and furans are especially potent and need to be controlled through appropriate operating conditions and flue gas treatment technology.

State of the art incinerator technology and flue gas treatment system coupled with strict monitoring would ensure environmentally safe incinerator facilities

MSW incinerators pose environmental risks through potential emission of contaminants and ash leachate that could contaminate soil and water

Primary control measures include initiatives that actually retard the formation of pollutants, especially NO_x and dioxins:

- efficient combustion process
 - with long flue gas retention duration at high temperature
 - appropriate oxygen content
 - intensive mixing
 - recirculation of flue gas
- precipitation of ashes in the boiler
- short flue gas retention time at intermediate temperature

Secondary measures include installation of air pollution control equipment which comprise of bag house filters, dry, acid gas removal systems, catalytic reduction systems etc. Table 3.10 briefly describes available emission control technologies for different constituents of flue gas.

Table 3.10: Air Emission Control Technologies³⁷

FLUE GAS CONSTITUENTS	TECHNOLOGY DESCRIPTION
Total dust	Effective maintenance of dust control systems is very important. Controlling dust levels generally reduces metal emissions too. Flue gas treatment (FGT) (pre-dust control before FGT): bag filters, ESPs, cyclones, and multi-cyclones Additional flue gas polishing system: bag filters, wet electrostatic precipitator (ESP), electro dynamic venture scrubbers, agglomeration modules, ionizing wet scrubber
Hydrogen chloride (HCl), hydrogen fluoride (HF), sulphur dioxide (SO_2)	Waste control: Blending and mixing can reduce fluctuations in raw gas concentrations that can lead to elevated short-term emissions. FGT: Wet flue gas treatment systems generally have the highest absorption capacity and deliver the lowest emission levels for these substances, but are more expensive and difficult to maintain.
Nitrogen monoxide (NO) and nitrogen dioxide (NO_2), expressed as NO_2 for installations using SCR	Waste and combustion control techniques coupled with selective catalytic reduction (SCR) generally result in operation within acceptable emission ranges. The use of SCR imposes an additional energy demand and costs. In general, at larger installations, the use of SCR results in less significant additional cost per ton of waste treated. Waste with high nitrogen content may result in increased raw gas NO_x concentrations.
Nitrogen monoxide (NO) and NO_2 , expressed as NO_2 for installations using SNCR	Waste and combustion control techniques with selective non-catalytic reduction (SNCR) generally result in operation within acceptable emission ranges.

³⁷ "Reference Document on the Best Available Techniques for Waste Incineration", European Commission (2006).
Available at: <http://eippcb.jrc.ec.europa.eu/reference/wi.html>

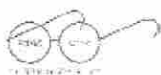


Table 3.10: Air Emission Control Technologies [contd.]

FLUE GAS CONSTITUENTS	TECHNOLOGY DESCRIPTION
Gaseous and vaporous organic substances, expressed as total organic carbon (TOC) or carbon monoxide (CO)	Techniques that improve combustion conditions reduce emissions of these substances. Carbon monoxide levels may be higher during start-up and shutdown, and with new boilers that have not yet established their normal operational fouling level.
Mercury (Hg) and its compounds	Adsorption using carbon based reagents is generally required to achieve these emission levels with many wastes- as metallic Hg is more difficult to control than ionic Hg. The precise abatement performance and technique required will depend on the levels and distribution of Hg in the waste. Some waste streams have very highly variable Hg concentrations; waste pre-treatment may be required in such cases to prevent peak overloading of flue gas circulation system capacity.
Cadmium (Cd) and thallium (Th)	Dust and other metal control methods are more effective at controlling these substances.
Other metals	Techniques that control dust levels generally also control these metals.
Polychlorinated dibenzodioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs), expressed as nanograms of dioxin toxic equivalent per normal cubic meter (ng TEQ/Nm ³)	Combustion techniques destroy PCDD and PCDF in the waste. Specific design and temperature controls reduce de novo synthesis. FGT: static activated carbon filters or activated carbon is injected into the gas flow. The carbon is filtered from the gas flow using bag filters. The activated carbon shows a high absorption efficiency for mercury as well as for PCDD and PCDF. Catalytic bag filters are also used to reduce concentrations of PCDD and PCDF.
Ammonia (NH ₃)	Effective control of NO _x abatement systems, including reagent dosing contributes to reducing ammonia emissions.
Benzo(a)pyrene, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs)	Techniques that control PCDD and PCDF also control Benzo(a)pyrene, PCBs, and PAHs.
Nitrous oxide (N ₂ O)	Effective oxidative combustion and control of NO _x abatement systems contribute to reducing nitrous oxide emissions.

3.3.3.13 MONITORING REQUIREMENTS

The SWM Rules, 2016 provide emission standards for incineration.

Schedule II (C): Standards for Incineration:

Emission standards.

The stack emission standards for Incinerator/Thermal technologies in solid waste treatment/disposal facility:-

Table 3.11: The Stack Emission Standards for Treatment and Utilisation of Municipal Solid Waste Using Incinerator or Thermal Technologies

PARAMETER	EMISSION STANDARD	
Particulates	50 mg/Nm ³	Standard refers to half hourly average value.
HCl	50 mg/Nm ³	Standard refers to half hourly average value.
SO ₂	200 mg/Nm ³	Standard refers to half hourly average value.
CO	100 mg/Nm ³	Standard refers to half hourly average value.
	50 mg/Nm ³	Standard refers to daily average value.
Total Organic Carbon (TOC)	20 mg/Nm ³	Standard refers to half hourly average value.
HF	4 mg/Nm ³	Standard refers to half hourly average value.
NO _x (NO and NO ₂ expressed as NO ₂)	400 mg/Nm ³	Standard refers to half hourly average value.
Total dioxins and furans	0.1 ng TEQ/Nm ³	Standard refers to 6–8 hours sampling. Please refer guidelines for 17 concerned congeners for toxic equivalence values to arrive at total toxic equivalence.
Cd + Th + their compounds	0.05 mg/Nm ³	Standard refers to sampling time anywhere between 30 minutes and 8 hours.
Hg and its compounds	0.05 mg/Nm ³	Standard refers to sampling time anywhere between 30 minutes and 8 hours.
Sb + As + Pb + Cr + Co + Cu + Mn + Ni + V + their compounds	0.5 mg/Nm ³	Standard refers to sampling time anywhere between 30 minutes and 8 hours.

Note:

- Suitably designed pollution control devices shall be installed or retrofitted with the incinerator to achieve the above emission limits.
- Waste to be incinerated shall not be chemically treated with any chlorinated disinfectants. (c) Incineration of chlorinated plastics shall be phased out within two years.
- if the concentration of toxic metals in incineration ash exceeds the limits specified in the Hazardous Waste (Management, Handling and Trans boundary Movement) Rules, 2008, as amended from time to time, the ash shall be sent to the hazardous waste treatment, storage and disposal facility.
- Only low sulphur fuel like LDO, LSHS, Diesel, bio-mass, coal, LNG, CNG, RDF and bio-gas shall be used as fuel in the incinerator.
- The CO₂ concentration in tail gas shall not be more than 7%.
- All the facilities in twin chamber incinerators shall be designed to achieve a minimum temperature of 950 °C in secondary combustion chamber and with a gas residence time in secondary combustion chamber not less than 2 (two) seconds.
- Incineration plants shall be operated (combustion chambers) with such temperature, retention time and turbulence, as to achieve total Organic Carbon (TOC) content in the slag and bottom ash less than 3%, or the loss on ignition is less than 5% of the dry weight.
- Odour from sites shall be managed as per guidelines of CPCB issued from time to time
- All values corrected to 11% oxygen on a dry basis.

The Central Pollution Control Board (CPCB) shall prescribe standards for maintenance of ambient air quality and permissible levels of dioxins and furans around the waste to energy (WtE) plants other than small facilities, treating less than 5 TPD waste, and circulate the same to all State Pollution Control Board (SPCB) and committees for uniform application.

The SPCB or committee shall prescribe standards for maintenance of ambient air quality and permissible levels of dioxins and furans around the waste to energy plants in consonance with the emission standards prescribed by the CPCB. If the proposal includes the technology other than the one for which standards have been prescribed by the CPCB, the SPCB or committee shall forward the proposal with its recommendations to CPCB or prescribing suitable standards.

As waste processing plants are often near a city or even within it, it is necessary to have stringent standards for emission control in order to safeguard public health and environment. It is desirable that for existing plants, a time frame of about 3 years may be set for conversion into the new norms.

International air emission (European Union) standards for MSW based incineration plants are more stringent as compared with those in the SWM Rules, 2016. Consolidated Emission norms from EU-Directive on the incineration of wastes (2000/76/EC) and its subsequent amendments.³⁸ As mentioned in Table 3.12.

Table 3.12: Emission Norms for Incineration of Municipal Solid Waste as per European Union Directive

(a) Daily average values:	
Total dust	10 mg/m ³
Gaseous and vaporous organic substances, expressed as total organic carbon (TOC)	10 mg/m ³
Hydrogen chloride (HCl)	10 mg/m ³
Hydrogen fluoride (HF)	1 mg/m ³
Sulphur dioxide (SO ₂)	50 mg/m ³
Nitrogen monoxide (NO) and nitrogen dioxide (NO ₂) expressed as nitrogen dioxide for existing incineration plants with a nominal capacity of 6 tonnes per hour or new incineration plants	200 mg/m ³
Nitrogen monoxide (NO) and nitrogen dioxide (NO ₂) expressed as nitrogen dioxide for existing incineration plants with a nominal capacity of 6 tonnes per hour or less	400 mg/m ³
(*) Until 1 January 2007 and without prejudice to relevant (Community) legislation the emission limit value for NOx does not apply to plants only incinerating hazardous waste.	
Exemptions for NOx may be authorised by the component authority for existing incineration plants.	

³⁸ Directive of the European Parliament and of the Council on the Incineration of Waste [2000]. Available at <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CONSLEG:2000L0076:20081211:EN:PDF>



Table 3.12: Emission Norms for Incineration of MSW as per EU Directive [contd.]

* with a nominal capacity of 6 tonnes per hour, provided that the permit foresees the daily average values do not exceed 500 mg/m ³ and this until 1 January 2008.		
* with a nominal capacity of >6 tonnes per hour but equal or less than 16 tonnes per hour, provided the permit foresees the daily average values do not exceed 400 mg/m ³ and this until 1 January 2010.		
* with a nominal capacity of >16 tonnes per hour but <25 tonnes per hour and which do not produce water discharges, provided that the permit foresees the daily average values do not exceed 400 mg/m ³ and this until 1 January 2008.		
* Until 1 January 2008, exemptions for dust may be authorised by the competent authority for existing incinerating plants, provided that the permit foresees the daily average values do not exceed 20 mg/m ³ .		
(b) Half-hourly average values:		
	(100%) A	(97 %) B
Total dust	30 mg/m ³	10 mg/m ³
Gaseous and vaporous organic substances, expressed as total organic carbon (TOC)	20 mg/m ³	10 mg/m ³
Hydrogen chloride (HCl)	60 mg/m ³	10 mg/m ³
Hydrogen fluoride (HF)	4 mg/m ³	2 mg/m ³
Sulphur dioxide (SO ₂)	200 mg/m ³	50 mg/m ³
Nitrogen monoxide (NO) and nitrogen dioxide (NO ₂), expressed as nitrogen dioxide for existing incineration plants with a nominal capacity exceeding 6 tonnes per hour or new incineration plants	400 mg/m ³ (*)	200 mg/m ³ (*)
(*) Until 1 January 2007 and without prejudice to relevant Community legislation the emission limit value for NO _x , does not apply to plants only incinerating hazardous waste.		
Until 1 January 2010, exemptions for NO _x may be authorised by the competent authority for existing incineration plants with a nominal capacity between 6 and 16 tonnes per hour, provided the half-hourly average value does not exceed 600 mg/m ³ for column A or 400 mg/m ³ for column B.		
(c) All average values over the sample period of a minimum of 30 minutes and a maximum of 8 hours:		
Cadmium and its compounds, expressed as cadmium (Cd)	Total 0.05 mg/m ³	Total 0.1 mg/m ³ (*)
Thallium and its compounds, expressed as thallium (Tl)		
Mercury and its compounds, expressed as mercury (Hg)	0.05 mg/m ³	0.1 mg/m ³
Antimony and its compounds, expressed as antimony (Sb)	total 0.5 mg/m ³	total 1 mg/m ³ (*)
Arsenic and its compounds, expressed as arsenic (As)		
Lead and its compounds, expressed as lead (Pb)		
Chromium and its compounds, expressed as chromium (Cr)		
Cobalt and its compounds, expressed as cobalt (Co)		
Copper and its compounds, expressed as copper (Cu)		
Manganese and its compounds, expressed as manganese (Mn)		
Nickel and its compounds, expressed as nickel (Ni)		
Vanadium and its compounds, expressed as vanadium (V)		
(*) Until 1 January 2007 average values for existing plants for which the permit to operate has been granted before 31 December 1996, and which incinerate hazardous waste only.		

Table 3.12: Emission Norms for Incineration of MSW as per EU Directive [contd.]

These average values cover also gaseous and the vapour forms of the relevant heavy metal emissions as well as their compounds.		
(d) Average values shall be measured over a sample period of a minimum of 6 hours and a maximum of 8 hours. The emission limit value refers to the total concentration of dioxins and furans calculated using the concept of toxic equivalence:		
Dioxins and furans	0.1 ng/m ³	
(e) The following emission limit value of carbon monoxide (CO) concentrations shall not be exceeded in the combustion gases (excluding the start-up and shut-down phase):		
50 milligrams/m ³ of combustion gas determined as daily average value.		
150 milligrams/m ³ of combustion gas of at least 95% of all measurement determined as 10-minute average values or 100 mg/m ³ of combustion gas of all measurements determined as half-hourly average values taken in any 24-hour period.		
Exemptions may be authorised by the competent authority for incineration plants using fluidised bed technology, provided that the permit foresees an emission limit value for carbon monoxide (CO) of not more than 100 mg/m ³ as an hourly average value.		

3.4 BIOMETHANATION

Biomethanation is the anaerobic (in the absence of free oxygen) fermentation of biodegradable matter in an enclosed space under controlled conditions of temperature, moisture, pH, etc. The waste mass undergoes decomposition due to microbial activity, thereby generating biogas comprising mainly of methane and carbon dioxide (CO₂), and also digested sludge, which is almost stabilised but may contain some pathogen. Due to the anaerobic environment, hydrogen sulfide (H₂S) is generated with varying percentage depending on the sulphur content in the system (in the form of protein, sulphate, etc.). Like composting, biomethanation is one of the most technically viable options for Indian municipal solid waste (MSW) due to the presence of high organic and moisture content.

Simple small to medium scale systems have been developed in India, especially for cattle manure; these plants are called Gobar Gas Plants. According to the Ministry of New and Renewable Energy (MNRE), 4.3 million family type biogas plants have been installed in India. Toilet linked biogas plants have been installed at family, community, and institutional levels. Application of biomethanation for MSW can be seen broadly in three categories: (i) small biogas plants for canteen waste; (ii) medium-sized digesters for market waste (flower, fruit, vegetable, slaughterhouse, etc.); (iii) and large-scale plants.



There are some well-known examples of installation of MSW based biogas plants: (i) 16 tonnes MSW plus 4 tonnes per day (TPD) slaughterhouse waste based facility in Vijayawada; (ii) 30 TPD flower-fruit market waste based biogas plant in Koyambedu, Chennai; and (iii) 500 TPD MSW based facility at Lucknow. So far, large biogas plants fed with MSW have not been successful in India although such plants have been successful in some other countries. The failure of MSW based biogas plants is not related to the basic technology; this is more due to lack of understanding of the process and planning capability and due to mismatch between the expectations of the concessionaire and the consignee with respect to quality and quantity of MSW supply. However, there are ongoing attempts by different urban local bodies (ULBs) to set up MSW based biogas plants. Medium to large digesters are appropriately designed and engineered for smooth operation. Different designs and models of biogas plants are discussed later.



Production of biogas under controlled condition is often termed as biomethanation, also known as anaerobic digestion

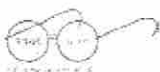
3.4.1 SOLID WASTE MANAGEMENT RULES, 2016: GUIDANCE ON BIOMETHANATION



As per SWM Rules, 2016:

Clause 15: Duties and responsibilities of local authorities:-

- (m) collect waste from vegetable, fruit, flower, meat, poultry and fish market on day to day basis and promote setting up of decentralised compost plant or biomethanation plant at suitable locations in the markets or in the vicinity of markets ensuring hygienic conditions;
- (t) involve communities in waste management and promotion of home composting, bio-gas generation, decentralised processing of waste at community level subject to control of odour and maintenance of hygienic conditions around the facility;
- (v) facilitate construction, operation and maintenance of solid waste processing facilities and associated infrastructure on their own or with private sector participation or through any agency for optimum utilisation of various components of solid waste adopting suitable technology including the following technologies and adhering to the guidelines issued by the Ministry of Urban Development from time to time and standards prescribed by the Central Pollution Control Board. Preference shall be given to decentralised processing to minimize transportation cost and environmental impacts such as-
 - a) biomethanation, microbial composting, vermi-composting, anaerobic digestion or any other appropriate processing for bio-stabilisation of biodegradable wastes;



Clause 4: Duties of waste generator:-

- (6) All resident welfare and market associations shall, within one year from the date of notification of these rules and in partnership with the local body ensure segregation of waste at source by the generators as prescribed in these rules, facilitate collection of segregated waste in separate streams, handover recyclable material to either the authorised waste pickers or the authorised recyclers. The bio-degradable waste shall be processed, treated and disposed off through composting or biomethanation within the premises as far as possible. The residual waste shall be given to the waste collectors or agency as directed by the local body.
- (7) All gated communities and institutions with more than 5,000 sqm area shall, within one year from the date of notification of these rules and in partnership with the local body, ensure segregation of waste at source by the generators as prescribed in these rules, facilitate collection of segregated waste in separate streams, handover recyclable material to either the authorised waste pickers or the authorised recyclers. The bio-degradable waste shall be processed, treated and disposed off through composting or biomethanation within the premises as far as possible. The residual waste shall be given to the waste collectors or agency as directed by the local body.
- (8) All hotels and restaurants shall, within one year from the date of notification of these rules and in partnership with the local body ensure segregation of waste at source as prescribed in these rules, facilitate collection of segregated waste in separate streams, handover recyclable material to either the authorised waste pickers or the authorised recyclers. The bio-degradable waste shall be processed, treated and disposed off through composting or biomethanation within the premises as far as possible. The residual waste shall be given to the waste collectors or agency as directed by the local body.

3.4.2 MERITS OF BIOMETHANATION PROCESS

- Energy generation, the produced biogas can be used for cooking or for the production of electricity and heat.
- Biogas may also be cleaned by removing CO_2 and H_2S . The resulting methane enriched biogas containing more than 90% methane (CH_4) is somewhat like compressed natural gas (CNG). However, for this gas to be used as automotive fuel, the percentage of CO_2 has to be less than 5%, which corresponds to methane percentage of 95% or more. H_2S has to be less than 10 parts per million (ppm) for use in automobiles. Use of this fuel is more benign for the environment than using petroleum-based automotive fuels. Like composting,



biomethanation also leads to reduced landfill requirement, thus extending the life of existing landfills.

- Biomethanation of biodegradable organic material would result in stabilised sludge which can be used as a soil conditioner and fertiliser. However, pathogen kill or inactivation may not be complete during anaerobic digestion with the relatively short hydraulic retention time (HRT) designed for optimisation of biogas production. Therefore, aerobic composting of the sludge is recommended to pass the material through temperature cycle of above 60°C–70°C for at least 2 days.
- Although the total system of biomethanation is more cost intensive than the total system of open aerobic composting, biomethanation has certain advantages with respect to much less odour and bird menace. The time frame (cycle time) is also less, so that less land is required for the same capacity. These two can be a big advantage where the only available sites are close to habitation. This way, biomethanation can be compared to in-vessel composting, which is again more expensive than open aerobic composting.

3.4.3 APPLICABILITY OF BIOMETHANATION

- Biomethanation is ideal for wet organic wastes, e.g., cooked food. Biomethanation plants require a consistent source of degradable organic matter, free from inert and toxic material. Slaughterhouse waste is eminently suitable for biomethanation.
- Odour problems are also considerably reduced by adopting biomethanation. If the proposed waste processing site is in close proximity to residential areas, biomethanation is a preferred treatment option, especially considering odour issues.
- Anaerobic digestion technology can be adopted in both
 - decentralised systems—up to 5 TPD (much smaller quantities can be processed where O&M is not outsourced); and
 - centralised systems—in modules of up to 50 TPD digesters (for higher capacity in one digester, the size may become unwieldy and difficult to maintain).
- The design of the plant has to be done according to the substrate (feed material) for smooth functioning. The next most important challenge is to make the digester leak-proof. Proper O&M is a critical factor for ensuring the success of the biogas plant which can be achieved through a well-defined standard operating procedure (SOP). Economic viability of the plants is ensured when there is a sustainable and viable market for the generated biogas in the vicinity of the plant and the sludge manure produced during the process.



3.4.4 GENERAL PROCESS INVOLVED IN BIOMETHANATION

Generally the overall process can be divided into four stages:

- pre-treatment
- anaerobic fermentation
- collection of biogas and its usage
- residue treatment

Pre-treatment: Most digestion systems require pre-treatment of waste to obtain a homogeneous feedstock. For anaerobic fermentation, pre-processing involves separation of non-digestible material either through source segregation (e.g., two-bin system; see Section 2.2 of Part II) or through mechanical sorting at the biogas plant facility. Source segregation results in less contaminated sludge compost. The separation ensures the removal of undesirable or recyclable material such as glass, metals, stones, etc. The waste is shredded before it is fed into the digester for better fermentation especially when the incoming material has large pieces or whole items.

Anaerobic Fermentation (Digestion): Anaerobic fermentation happens in three steps brought about by different groups of microbes: hydrolysis (hydrolytic bacteria), acidogenesis (acidogenic bacteria), and finally biomethanation (methanogenic bacteria). Normally the digesters (fermenters) are designed as single stage or single phase, where all the three processes take place in micro environments within the single vessel. Later, the concept of biphasic fermenters were developed where the process up to acidogenesis happens in the first phase in a slightly lower pH range and the methanogenesis happens in the second phase at near neutral pH range. This mode is supposed to be more efficient from the point of pH as well as time management because of the flexibility to optimise each of these reactions.

However, for MSW, the normal practice is to use suspended particulate fermenter configuration in one digester or two digesters in tandem. In the latter case, the efficiency as well as effluent quality improves. The size of the fermenter (digester) depends on the input volume of the substrate (feed material for microbial action) in suspension and the HRT. There are other digester configurations which have been discussed later in this chapter. Inside the digester, the feed is diluted to achieve the desired solids content and remains in the digester for a designated retention time. For dilution, a varying range of water sources can be used such as clean water, sewage, or re-circulated liquid from the digester effluent. Usually, the solids concentration is around 6%–10%, but some of the well-known systems have more than 20% total solids; such systems are called dry fermentation or digestion. In batch mode, solids concentration of even 40% can be used.



A heat exchanger can be fitted for better utilisation of heat in the whole system, especially for maintaining the desired temperature range in the digesting vessel.

Gas Recovery: The biogas obtained may be scrubbed to ensure automotive quality CNG-like gas (CO_2 less than 5% and H_2S less than 10 ppm). Biogas may also be used for generating electricity.

Residue Treatment: The digested sludge from the digester is dewatered and the liquid recycled for use in the dilution of incoming feed. The biosolids are dewatered to 50%–55% total solids with a screw press, filter press, or other types of dewatering systems and aerobically cured to obtain a compost product.

Segregated organic waste free from inert and toxic material is a pre-requisite for biomethanation

3.4.5 OPERATING PARAMETERS FOR BIOMETHANATION

Certain physical parameters should be controlled in the digester to enhance microbial activity and increase efficiency of the system. These parameters include the following:

- **Temperature:** Temperature affects bacterial growth and hence the amount of biogas produced. Treatment of waste in anaerobic reactors is normally carried out within two ranges: around 25°C – 40°C (ideally 35°C – 37°C) known as mesophilic range, and higher than 45°C (ideally 55°C – 60°C) known as thermophilic range.

At higher temperatures (thermophilic range)

- the rate of digestion is faster, and thus shorter retention times are required;
- smaller reactor volumes are required for treating the same amount of waste;
- there is higher rate and efficiency of hydrolysis of the suspended particulate matter; and
- destruction of pathogens is more efficient.
- **pH:** The anaerobic digestion process is limited to a relatively narrow pH band from 6.0 pH to 8.5 pH approximately, especially that the methanogenic bacteria are very sensitive to pH (close to neutral pH around 7.0).
- **Moisture:** The moisture content of waste is important as explained above.
- **Toxicity:** A number of compounds are toxic to anaerobic microorganisms. Methanogens are commonly considered to be the most sensitive to toxicity.

Biomethanation provides an example of an efficient technology where residue from waste treatment is also used e.g. bio-solids used as compost



Anaerobic digestion process can be:

- Single stage: all three stages of anaerobic process occur in one reactor
- Multi stage: acetogenesis and methanogenesis are separated

- **Carbon-to-nitrogen ratio:** Optimum carbon-to-nitrogen (C/N) ratio in anaerobic digesters is 20:30. A high C/N ratio is an indication of rapid consumption of nitrogen by methanogens and results in lower gas production. On the other hand, a lower C/N ratio causes ammonia accumulation and pH values exceeding 8.5, which is toxic to methanogenic bacteria. Optimum C/N ratios of the digester materials can be achieved by mixing material of high and low C/N ratios, such as organic solid waste (high in carbon) and sewage or animal manure (high in nitrogen).
- **Organic loading rate:** Organic loading rate is the frequency and speed at which the substrate is added to the digester. For each plant of a particular size, there is an optimal rate at which the substrate should be loaded. Beyond this optimal rate, further increases in the feeding rate will not lead to a higher rate of gas production. Agitation or consistent stirring of the contents in the digester also plays an important role in determining the amount of biogas produced.
- **Retention time:** The required retention time for completion of the reactions varies with differing technologies, process temperature, and waste composition. The retention time for waste treated in a mesophilic digester ranges from 20 to 30 days. Lower retention times are required in digesters operated in the thermophilic range. A high solids reactor operating in the thermophilic range has a retention time of about 14 days.

3.4.6 TYPES OF ANAEROBIC DIGESTERS IN USE

Different types of anaerobic digesters or biogas plants have been designed and used mainly depending upon the following factors:

- iii. monophasic or biphasic number of digesters in the monophasic system;
- iv. floating holder or fixed dome or combination of both;
- v. concentration of substrate (feed material);
- vi. operating temperature—mesophilic (near ambient) or thermophilic (heated digesters maintained around 55°C–60°C);
- vii. batch, semi-continuous or continuous; and
- viii. suspended particulate, upflow anaerobic filter (UAF), upflow anaerobic sludge blanket (UASB), or hybrid systems.

The various systems have their merits and constraints. For example, the fermentation is more efficient or more complete when the concentration of solids is relatively less but the volumetric efficiency of the digester is less.



This means that for unit quantity of substrate, total biogas production is more, but biogas produced per unit volume of the digester is less. On the other hand, when the concentration of the solids is more, gas production per unit volume of the digester is more, but gas production per unit weight of the substrate is less. While designing a digester, one tries to make a balance between these factors. For this reason, the single-stage high solids systems (22%–40% of total solids) are supposed to be more efficient than the single-stage low solids systems (less than 10% total solids).

The predominantly used single-stage low solids reactor is the continuously stirred tank reactor, where the digestate is continuously stirred and completely mixed. Feed is introduced in the reactor at a rate proportional to the rate of effluent removed. Generally, the retention time is 14–28 days depending on the kind of feed and operating temperature.

High solids systems require smaller reactor volumes per unit of biogas production, but high concentrations of solids will result in higher feed pumping costs. Some examples of patented single-stage high solids anaerobic digester systems for solid waste are dry anaerobic composting (DRANCO), Kompogas, and Valorga processes. The retention time in these systems varies from 14 to 20 days.

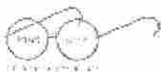
The DRANCO process is a dry thermophilic process for treatment of the organic fraction of MSW. This process requires high total solids content in the reactor to have optimal performance. After the waste is pre-treated and screened, it is mixed with recirculating material from the reactor. Mixing of the waste with digested material ensures inoculation of the incoming material. The reactor is a downward plug-flow type reactor where mixing is deliberately minimised. The Valorga process could be either a thermophilic or a mesophilic process, where the pre-treated waste is mixed with recycled process water. After mixing with process water, the influent is pumped into the reactor. The reactor is fully mixed reactor type where mixing takes place by pneumatic stirring, i.e., the produced biogas is compressed and sent through the contents of the reactor.

Batch reactors are less efficient and hence not popular for treatment of organic fraction of MSW. Upflow anaerobic sludge blanket (UASB) and upflow anaerobic filter process (UAFP) are typically used for treatment of high strength industrial or municipal waste waters.

Important
operating
parameters
controlling
biomethanation

- Temperature
- Ph
- Moisture
- Toxicity
- C/N ratio
- Organic loading rate
- Retention period

Organic loading
rate for a plant
of particular
size determines
the amount
substrate to
be added for
optimum biogas
production



Scum formed at the top and layer of heavier fractions at the bottom should be removed on a routine basis to keep biogas yield at optimum levels

Examples of single stage anaerobic digester include: DRANCO (thermophilic), Kompogas and Valorga (mesophilic)

TERI Enhanced Acidification and Methanation (TEAM) Bioreactor

The Energy and Resources Institute (TERI)'s enhanced acidification and methanation (TEAM) is a patented multi-stage high-rate digester for biomethanation of fibrous and semi-solid organic wastes.

The TEAM process is two-phase. The first phase, regarded as the acidification phase, consists of extracting a high organic strength (chemical oxygen demand of 15,000–20,000 mg/l) liquid called leachate from the solid waste in the acidification reactor. In the second phase, known as the methanation phase, biogas is generated by treating the leachate in an upflow anaerobic sludge blanket (UASB) reactor.

Before the process gets started, the organic solid waste is cut into small pieces and fed into the acidification reactor. The waste bed is kept submerged in water. Organic acids are formed as a result of bed degradation, leading to the formation of leachate. This leachate is periodically recirculated through the bed at a predetermined fixed rate to have uniform concentration of microorganisms and nutrients through the bed and to wash off organic acids formed as a result of further bed degradation.

Once a high chemical oxygen demand (COD) concentration is reached, the leachate is extracted in the leachate collection tank. The acidification phase has a retention time of 6 days; therefore, six such reactors are provided to ensure continuous operation. Anaerobic conditions prevail inside the reactor during the whole process. The phase separation provides suitable environment to the microorganisms in acidification and methanation stages, thus enhancing the activity. The residue inside the acidification reactor is dried in the sun and then used as manure. This system is a variant of the UASB technology for sludge and solid waste treatment.

A waste treatment plant with a capacity of about 50 kg green leafy vegetables per day was installed at TERI's Gual Pahari campus, Gurgaon. The plant has been generating good quality biogas and manure from the organic wastes for a few years. TEAM plant has also been installed in two more places in corporate units like National Thermal Power Corporation (NTPC) India (for household waste management) and Sona Koyo Steering, Haryana (for canteen waste management). This system has good scale-up potential.

Adoption of the Nisargruna Biogas Technology: An Approach toward Decentralised Waste Management Operated by Waste Pickers

Location: Mumbai

Year of start: 1998

Main Players: Municipal Corporation of Greater Mumbai (MCGM), Stree Mukti Sanghatana (SMS), Bhabha Atomic Research Centre (BARC), waste pickers cooperatives, institutions, Navi Mumbai Municipal Corporation (NMMC)

Approach: Mumbai, the capital city of Maharashtra, has witnessed rapid urbanisation, economic growth, and rising standard of living which has led to increase in the quantity of waste generated coupled with inefficient waste management and disposal practices.



The problems are multi-fold and cover issues that relate to the socio-political, economic, and environmental sustainability. Several initiatives have been taken to address these issues like adoption of technology, new management approaches, imposition of regulation, etc. However, all these initiatives remained largely unsatisfactory. In order to address the ever-increasing problems related to waste management, the Advanced Locality Management (ALM) scheme was started in 1997 by MCGM with the main objective of mobilising citizens in a participative approach to set up a system for solid waste management in an environmental friendly manner. Local non-government organisations (NGOs) along with the MCGM have taken up new initiatives through ALM scheme to improve on existing practices, striking the appropriate partnership between MCGM and SMS.

SMS is a woman's liberation organisation established in 1975. SMS has directed its efforts toward uplifting women, primarily by creating awareness in the society about women's issues with the help of songs and theatre, family counselling centres, day care centres, adolescent sensitisation programme, publication of books, etc. About 85% of the waste pickers are women. To uplift this sector, the Parisar Vikas Programme (PVP) was one of the initiatives implemented by SMS in 1998. SMS has imparted training on segregation, handling of waste, composting, and maintaining and operationalising the bio gas plant through interactive sessions with the women waste pickers, who are commonly addressed as "parisar bhaginis" (neighborhood sisters).

Institutional approach:

- SMS facilitated the formation of federation of self-help groups (SHGs) and cooperatives of several women waste pickers and guided them for signing a formal contract with municipality or individual apartments, institutions, and public and private sector companies.
- SMS trained the waste pickers on the principles of zero waste, segregation concept, pre-sorting and handling waste from multi-family dwellings, operationalising composting and biogas plants.
- A team structure was organised for waste pickers for operating the collection, segregation, and on-site processing unit: one supervisor at one site for every four bhaginis.
- Innovative, locally viable technology for generation of biogas at the site itself (Nisargruna biogas technology) was institutionalised and adopted; and the workers were trained about the operation and maintenance of the plant.
- New training centre for biogas, composting, rain water harvesting, and garbage gallery at Kopar Khairane, Navi Mumbai was developed.
- New training manual for composting and biogas maintenance was developed.

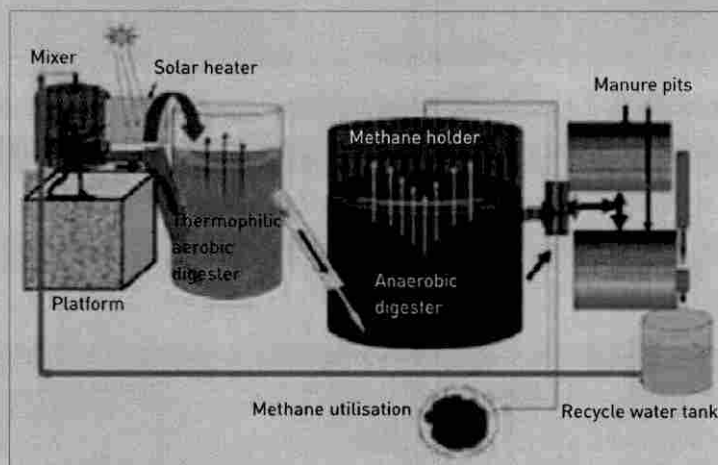
Technological approach:

- The Nisargruna technology developed by BARC was used to generate biogas and manure. The technology has basically three stages of operation.
- The system is based on a floating dome design, a proven technology for manure digestion in India and China. It is a two-stage continuous wet system. The waste gets hydrolyzed in first stage; and in second stage, methane is produced. The reactor is



constructed underground, reducing the building costs, and the reactor contents flow under gravity by volume displacement.

- **Mixing stage.** Proper segregation of waste must be done before entering the plant as some material may detrimentally affect the efficiency of the plant. On-site sorting is a prerequisite. Waste is mixed with equal amount of hot water to breakdown fibres, converting it into homogeneous slurry.
- **Pre-treatment stage.** Slurry is kept in a thermophilic aerobic pre-digester, converting it into organic acids (acetic acid, butyric acid). Every time the digester is fed, an equal amount of reactor content will leave the pre-digester and is fed to the methane reactor.
- **Anaerobic digestion stage.** Acidic slurry is transferred to an anaerobic tank (methane reactor) to produce methane. Prior digestion helps in improving the purity of methane gas up to 85%, thereby increasing the fuel efficiency.
- Slurry from the methane reactor is then sent to sand pits, and high quality manure is recovered and water is recycled in the plant again, resulting in a zero effluent system.
- Simplified plant operation process was designed to be used by non-skilled workers
- Training for operation and maintenance (O&M) on site was provided to the workers or bhaginis.



Nisargruna Biogas Plant

Outcome:

- 300 groups, with 10 Parisar Bhaginis each, have been established. 200 groups are working as saving groups and a federation of these groups has been registered as an independent organisation called Parisar Bhagini Vikas Sangha (PBVS) along with six working cooperatives.
- 100% segregation of waste was achieved at the plant to produce biogas.
- Recycling efficiency was improved through market exploration and tie-ups with recycling units by SMS.
- There was income from the sale of recyclables (Rs100–Rs150 per day) apart from the service fee for collecting, sorting, and managing biogas plant.
- Only 50 m² (less space) was required for a plant processing 100 kg per day.
- Utilisation of the end product as cooking gas fuel for both domestic or industrial purpose.

Success factors:

- Strategic partnership is required among SMS, BARC, MCGM, and waste pickers cooperative. Stakeholders should be motivated to take forward the decentralised waste management system.
- On behalf of cooperatives, SMS negotiates, markets, signs, and manages contracts with the apartments and institutions.
- The approach is modular and adaptable to the demands of customer and has simple components.

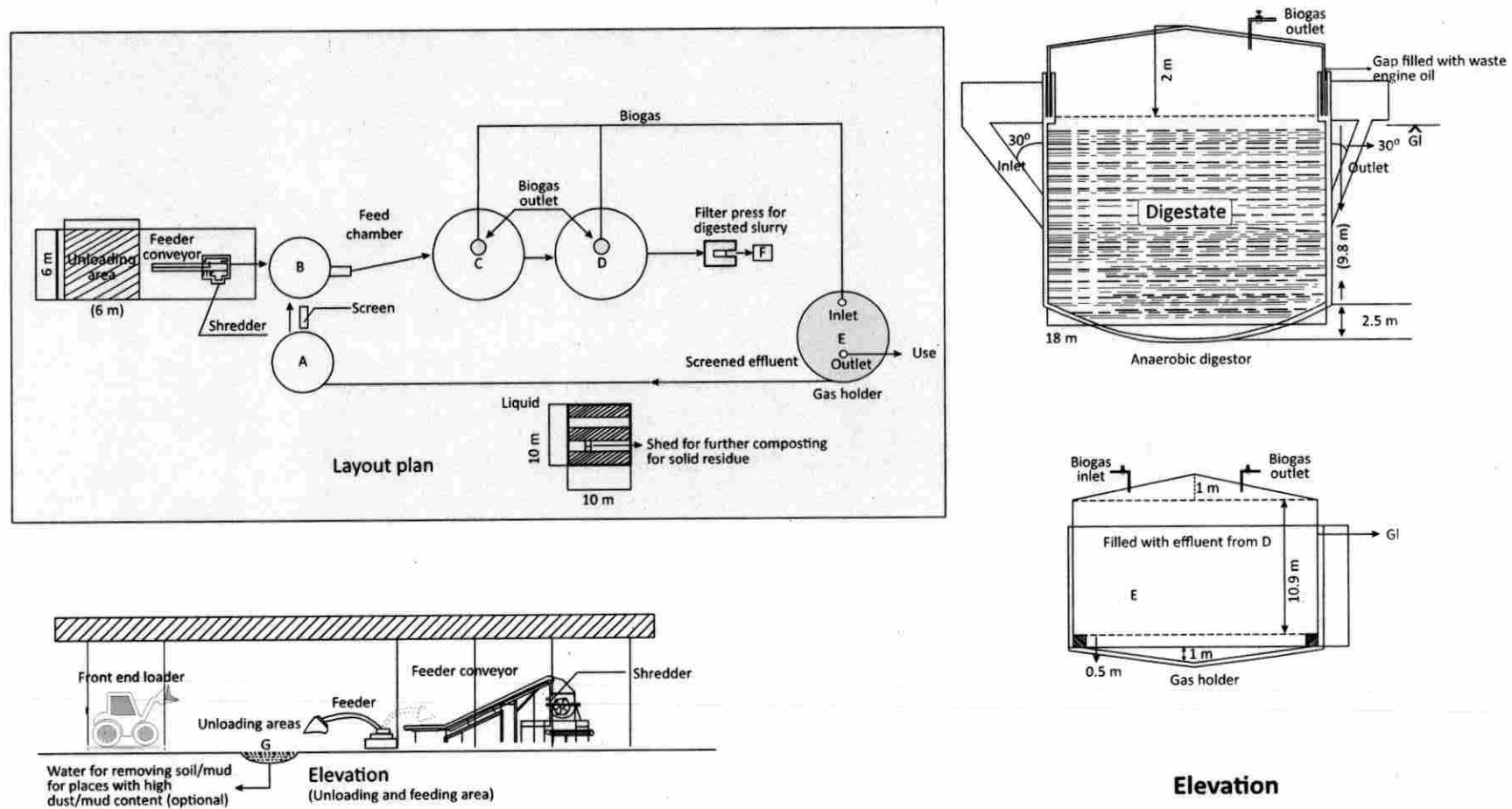
Overall sustainability:

The overall model should have collection, segregation, and on-site processing that is modular and opportunistic, providing services to complement its customers' needs. The simple components and integrated decentralised system has allowed Parisar Vikas to bid for a variety of contracts. The model is self-sustaining and has successfully demonstrated the viability of decentralised waste management as income is generated from the sale of recyclables and at many sites a service fee for collection and managing the biogas plants is charged. The initiative has helped to mainstream the marginalised population of waste pickers giving them a recognised role in the formal waste management system.

Source: SMS



Figure 3.25: Biomethanation Plant for 50 TPD feed (biodegradable MSW and cattle manure)



- A = Slurry preparation tank for cattle manure (Cattle Dung) dia = 4m, depth = 2 m, fitted with slurry pump for mixing
 B = Screened cattle manure slurry in which segregated, shredded MSW is fed dia = 4m, depth = 2m, Fitted with slurry pump for mixing
 C = Primary digester dia = 18 m, Ht. = 9.8 m, Effective Volume (Slurry) 2520m³ (Outlet from 'C' feeds into Inlet of 'D')
 D = Secondary Digester dia = 18 m, Ht. = 9.8 m, Effective Volume (Slurry) 2520m³ (Outlet from 'D' Feeds into Inlet of 'A')
 E = Gas Holder dia = 16m, Ht. = 10.9 m, Volume = 2200m³ (50% Gas Storage Capacity)
 F = Solid residue from filter press taken to F
 G = Dirty water to be periodically drained into 4m dia, 4m deep pit and supernatant pumped into A/B; bottom sludge to be pumped out and land filled
 H = Shed for Aerobic Windrow Composting / Vermi Composting

Note: In Case Cattle Mannure is not available 'A' and screen is not required

The plant shown in Figure 3.25 is for a capacity of 50 tonnes per day (TPD). For larger capacities, a series of such digesters (50 TPD capacity or less) can be constructed. In the urban areas, there is accumulation of large quantity of cattle manure in many cities because of the presence of dairy farms within or in periphery of the city. Therefore, two options of the drawings have been presented—one for 50 TPD MSW (biodegradable portion) and the other for combination of the biodegradable MSW and cattle manure (combined weight 50 TPD). In case source segregated waste is not available, pre-sorting or pre-treatment of the waste material will have to be done inside the plant and adequate provision must be planned.

3.4.7 UTILITY OF BIOGAS PRODUCED IN BIOMETHANATION PLANTS

The percentage of methane (CH_4) varies with the efficiency of the anaerobic digestion and the composition of the substrate. With cattle manure, about 55%–60% methane is obtained; whereas with water hyacinth and some food waste, 70% methane is obtained. Biogas is also water saturated (100% humidity). The calorific value of biogas is 5,000–6,000 kilocalories per cubic meter (kcal/m^3) depending on the methane percentage. The biogas, by virtue of its high calorific value, has tremendous potential to be used as fuel for power generation through either internal combustion engines or gas turbines.

Broadly, biogas can be used for the following purposes:

- cooking or heating fuel;
- motive power (e.g., biogas pump);
- electrical power; and
- gaseous automotive fuel—after stripping carbon dioxide (CO_2), hydrogen sulfide (H_2S), and moisture called compressed biogas (CBG).

Since the last couple of years, interest is rapidly growing in CBG.

3.4.7.1 LOCAL GAS USE

The simplest and most cost-effective option for use of biogas is local use with limited pipe length and without stripping CO_2 and H_2S . Moisture is removed by using a condenser. Typically, such applications are for cooking and mantle lamps. However, in urban areas, there is very limited scope of such application due to presence of liquefied petroleum gas (LPG) cylinders and piped natural gas (PNG). Another option is generation of electrical power, but this can happen only if the volume of gas is sufficient for conversion in a gas engine or a dual fuel engine.





Provision of pre-sorting should be planned at the plant, in case source segregated waste is not received

3.4.7.2 PIPELINE INJECTION

Purified and CBG can be injected into PNG line. Certain scale is required for this conversion, especially for the removal of CO_2 and compression to the desired pressure. Practically, this can be done for large biogas plants or battery of biogas plants where the biogas generation is at least 500 m^3 per hour ($12,000 \text{ m}^3$ per day).

3.4.7.3 ELECTRICITY GENERATION

Electricity can be generated from biogas for on-site processing or for distribution through the local electric power grid. Internal combustion engines and gas turbines are the most commonly used for biogas-to-power generation projects. Unlike automotive use, the CO_2 is not scrubbed, and H_2S has to be removed to the extent of 50 parts per million (ppm). Although this means lower efficiency, removal of CO_2 requires a certain minimum scale depending on the method of stripping. Their flexibility, especially for small generating capacities, makes them the only electricity generating option for smaller gas volumes.



Under a special purpose vehicle (SPV) - Solapur Bio-Energy Systems Pvt. Ltd (SBESPL), established India's first demonstration plant for MSW processing 400 TPD based on biomethanation (thermophilic anaerobic digester) at Solapur, Maharashtra. The plant is commissioned and in operation since 2013, generating power (4MW) from produced biogas. The electricity generated from the project is being wheeled to the grid for off take by MSEDCL since July 2013 onward.

3.4.7.4 PURIFICATION OF BIOGAS

Commercially biogas is purified according to the ultimate use (automotive, electrical power, etc.) by one of the following methods:

- i. cryogenic method;
- ii. high pressure water scrubbing method;
- iii. pressure swing adsorption (PSA) method;
- iv. amine scrubbing method;
- v. metal absorption for H_2S using iron or copper foil; and
- vi. biological oxidation (biological process for H_2S).

Each of these has been developed to a commercial level with substantial engineering inputs. However, high pressure water scrubbing, PSA, amine scrubbing, and biological oxidation are in greater use. For selecting the appropriate technology, one has to consider the ultimate use, scale, investment required, space needed, etc.



3.5 REFUSE DERIVED FUEL

The SWM Rules, 2016 defines refuse derived fuel (RDF) as fuel derived from combustible waste fraction of solid waste like plastic, wood, pulp or organic waste, other than chlorinated materials, in the form of pellets or fluff produced by drying, shredding, dehydrating and compacting of solid waste. It is used as a fuel for either steam or electricity generation or as alternate fuel in industrial furnaces or boilers (co-processing or co-incineration of waste in cement, lime, and steel industry and for power generation). The composition of RDF is a mixture that has higher concentrations of combustible materials than those in the parent mixed MSW.

3.5.1 LEGAL FRAMEWORK FOR REFUSE DERIVED FUEL PRODUCTION AND UTILISATION

As per SWM Rules, 2016:

Clause 15: Duties and responsibilities of local authorities:-

(v) facilitate construction, operation and maintenance of solid waste processing facilities and associated infrastructure on their own or with private sector participation or through any agency for optimum utilisation of various components of solid waste adopting suitable technology including the following technologies and adhering to the guidelines issued by the Ministry of Urban Development from time to time and standards prescribed by the Central Pollution Control Board. Preference shall be given to decentralised processing to minimize transportation cost and environmental impacts such as-

b) waste to energy processes including refused derived fuel for combustible fraction of waste or supply as feedstock to solid waste based power plants or cement kilns;

18. Duties of the industrial units located within one hundred km from the refused derived fuel and waste to energy plants based on solid waste- All industrial units using fuel and located within one hundred km from a solid waste based refused derived fuel plant shall make arrangements within six months from the date of notification of these rules to replace at least five percent of their fuel requirement by refused derived fuel so produced.

21. Criteria for waste to energy process.-

(1) Non recyclable waste having calorific value of 1500 K/cal/kg or more shall not be disposed of on landfills and shall only be utilised for generating energy either or through refuse derived fuel or by giving away as feed stock for preparing refuse derived fuel.

(2) High calorific wastes shall be used for co-processing in cement or thermal power plants.



- (3) The local body or an operator of facility or an agency designated by them proposing to set up waste to energy plant of more than five tones per day processing capacity shall submit an application in Form-I to the State Pollution Control Board or Pollution Control Committee, as the case may be, for authorisation.
- (4) The State Pollution Control Board or Pollution Control Committee, on receiving such application for setting up waste to energy facility, shall examine the same and grant permission within sixty days.

Also Schedule II A (d) states that pre-process and post-process rejects shall be removed from the processing facility on regular basis and shall not be allowed to pile at the site. Recyclables shall be routed through appropriate vendors. The non-recyclable high calorific fractions to be segregated and sent to waste to energy or for RDF production, co-processing in cement plants or to thermal power plants. Only rejects from all processes shall be sent for sanitary landfill site(s).

The SWM Rules, 2016 specifies that the “residual combustible wastes shall be utilised for supplying as a feedstock for preparing RDF or for generating energy or power from the waste by adopting proven waste to energy (WtE) technologies for which emission standards as well as standards for dioxins and furans have been prescribed by the Central Pollution Control Board (CPCB).” Currently, there are no binding legal definitions which specify the composition of RDF, conditions of use, or environmental monitoring requirements for RDF incineration.³⁹

To put in a nutshell:

- RDF based power projects come under the purview of the Electricity Act, 2003.
- RDF facilities are also governed by the Environment Protection Act. These facilities also have to obtain the consent for establishment and consent for operation licenses from the State Pollution Control Boards (SPCBs).
- Emission standards are specified by the SPCB in accordance with the National Ambient Air Quality Standards, 2009.
- All industrial units utilising RDF as fuel also have to adhere to applicable laws (air, water, and environment protection acts). Stack emissions have to be monitored once a year and submitted to the SPCB.
- Cement kilns using RDF also come under the purview of all the above acts.
- Emissions from industries like cement or power shall be governed by the industrial norms.

In Europe, there is a separate directive for RDF. The Annex IIB of EU Directive 75/442/EEC as amended, defines RDF as waste used “principally as a fuel or other means to generate energy.” This directive specifies the norms and standards for production, utilisation, and monitoring mechanisms to regulate RDF.

³⁹ GIZ. [n.d.]. Status Paper on Utilisation of Refuse Derived Fuel (RDF) in India. http://www.igep.in/live/hrdpmp/hrdpmaster/igep/content/e54413/e54441/e61172/e61173/20130425_RDFstatuspaper_final4.pdf



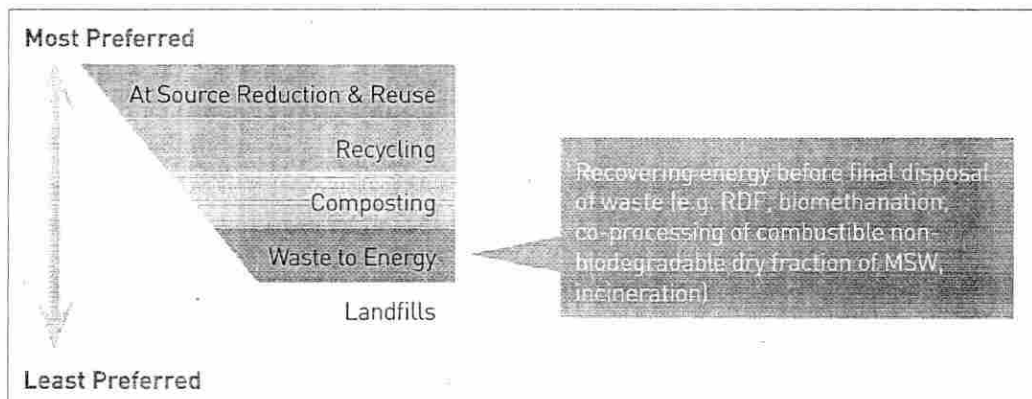
3.5.2 REFUSE DERIVED FUEL IN INTEGRATED SOLID WASTE MANAGEMENT HIERARCHY

While according to the integrated solid waste management (ISWM) hierarchy (Figure 3.26) source reduction, reuse, and recycling are the most sustainable solid waste management options, recovery of energy from MSW is the next desirable waste management strategy.

Production and combustion of RDF for energy recovery is not only an economically viable option for municipal solid waste management (MSWM), but it also greatly reduces the requirement for landfill space. The techno-economic feasibility of producing high calorific value RDF from mixed MSW has to be seen in the context of the concrete framework conditions of a particular urban local body (ULB).

The opportunity to produce high calorific value RDF from mixed waste rather than dumping waste makes RDF a more desirable option than landfilling

Figure 3.26: Refuse Derived Fuel in Integrated Solid Waste Management Hierarchy



3.5.3 GENERAL COMPOSITION OF REFUSE DERIVED FUEL IN INDIA

RDF typically consists of the residual dry combustible fraction of the MSW including paper, textile, rags, leather, rubber, non-recyclable plastic, jute, multilayered packaging and other compound packaging, cellophane, thermocol, melamine, coconut shells, and other high calorific fractions of MSW. However from the ISWM hierarchy perspective, the city should prioritise separately recycling relevant components (e.g., paper, plastics, jute, metal, glass, multilayered packaging used for liquid food items, etc.). The composition and resultant energy content of RDF varies according to the origin of waste material and the sorting, separation, and processing being adopted in the facility.

Typical desired ranges of these parameters observed in various studies are indicated in Table 3.13. Values given herein are specific to the considered waste mix and are only indicative in nature. Required quality of RDF is determined by the end use of the fuel.

RDF typically consists of high calorific fractions of MSW like paper, textile, jute etc.

Table 3.13: Indicative Net Calorific Value of Refuse Derived Fuel vs. Coal⁴⁰

ITEM	NET CALORIFIC VALUE (KCAL)
Indian coal	2500-5000
Mixed plastic	6000
Segregated municipal solid waste (plastic, cloth, jute, paper, multilayered polythene, multilayered packaging, thermocol, melamine, coconut shells)	2000-2500

The suitability of RDF for use as a fuel is dependent on certain critical parameters of the constituent waste:

- calorific value;
- water content;
- ash content;
- sulphur content; and
- chlorine content.

The required specific composition and characteristics of RDF for co-processing will be determined by the kind of furnace, temperatures achieved in the furnace, and the associated flue gas management systems.

3.5.4 REFUSE DERIVED FUEL POTENTIAL FROM MUNICIPAL SOLID WASTE

RDF quantity and composition is determined by the nature of the waste and extent of materials recovery or recycling processes implemented by the city. The quantity of RDF that can be produced per ton of MSW varies depending on the type of collection, pre-processing, and composition of waste source.

3.5.5 UTILISATION OF REFUSE DERIVED FUEL

RDF may be utilised in the following manner:

- co-processing in cement kilns;
- co-combustion in coal fired power plants (however, attempts to do so are under way and has not been proven effective yet in India); and
- on-site or off-site in an appropriately designed waste incinerator for thermal recovery or power generation.

RDF quantity and composition is determined by the nature of the waste and extent of material recovery or recycling processes implemented by the city

⁴⁰ Exploring co-processing as an option for disposal of certain fraction of MSW. GIZ [2010].

3.5.6 REFUSE DERIVED FUEL PRODUCTION PROCESS

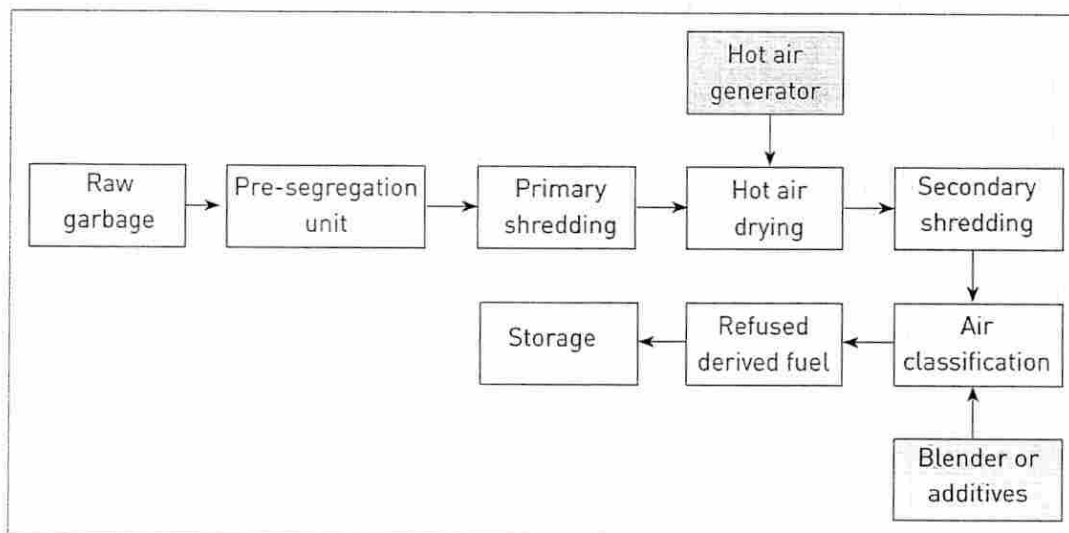
The RDF production line (Figure 3.27) consists of several unit operations in series to separate unwanted components and condition the combustible matter to obtain required RDF characteristics. In general, segregation and processing may include:

- sorting or mechanical separation (in case of effectively source segregated feed material, this process may not be required);
- size reduction (shredding, chipping, and milling);
- drying (where required);
- separation;
- screening;
- air density separation (for removing fine inert material);
- blending;
- packaging; and
- storage

The quality of RDF depends on the characteristics of incoming waste feed. Segregation of waste into combustibles and non-combustibles is a pre-requisite

The type and configuration of unit operations selected depend on the type of secondary material that will be recovered and on the desired quality of the recovered fuel fraction. The end use of the RDF determines the necessary characteristics of RDF (size, moisture, ash content, calorific value, chloride, heavy metals, etc.).

Figure 3.27: Refuse Derived Fuel Production Line (Pelletization)⁴¹

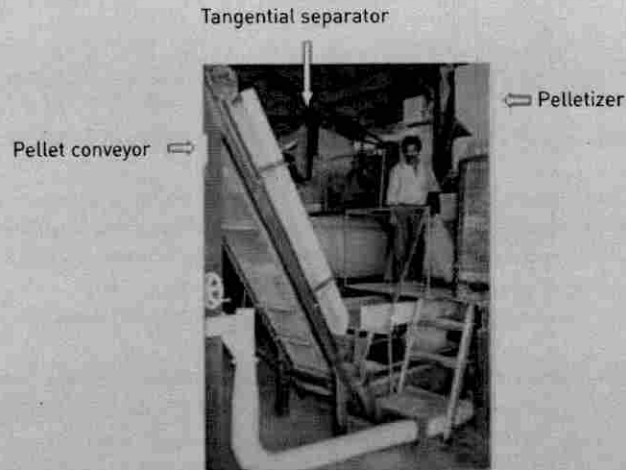


41 International Council for Local Environmental Initiatives South Asia.



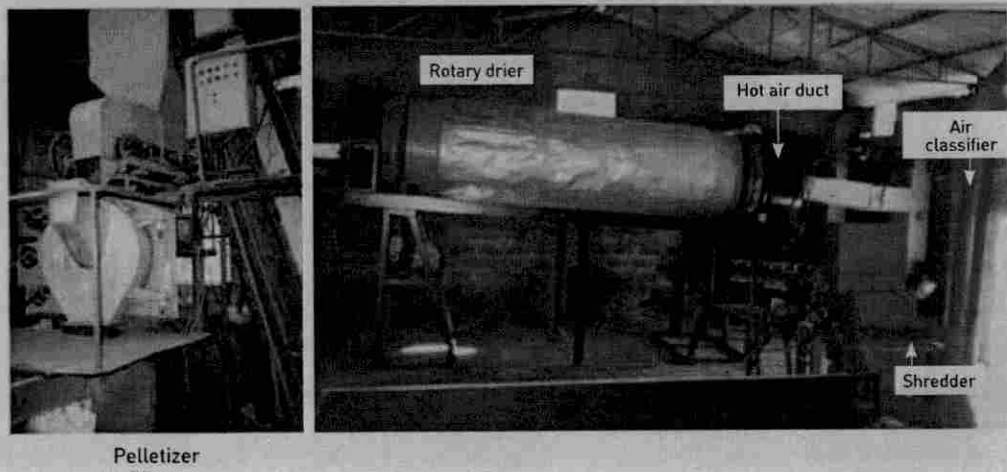
Historical Evolution of RDF Pilot Plants

Bengaluru, 1998



Pelletization: In the early days of refuse derived fuel (RDF) production, pelletization of RDF was favoured. The current trend is to use RDF fluff (shredded un-consolidated RDF).

RDF Pellets: Light combustibles were ground to 10–15 mm particle size. The binder or additives were mixed with ground garbage in a mixer or conditioner before pelletizing. The pellets coming out of the pelletizer were cooled and stored in the pellet storage yard for dispatch.



Only those plastics that cannot be techno-economically recycled or reused may be considered for co-processing as RDF

3.5.7 POTENTIAL USE OF REFUSE DERIVED FUEL IN INDUSTRY

In keeping with the present state of technology, RDF is fired in a moving grate furnace or a boiler equipped with some form of grate. RDF can also serve as a feedstock for other types of thermal systems, e.g., pyrolysis and fluidised bed systems. The relative uniformity of properties and higher quality of RDF as compared with mixed MSW has led, in the past, to a preference for RDF in some applications.

3.5.7.1 CO-PROCESSING IN CEMENT KILNS OR COAL BASED POWER PLANTS

RDF can be used in cement plants as a partial substitute for fossil fuels. Any RDF produced in a municipal waste management plant should be used for co-processing only in processes equipped with suitable air pollution abatement technology. Emission standards are to be prescribed by CPCB or relevant SPCB. In India, currently, the only proven sustainable use of RDF is for co-processing in cement plants. Depending on the characteristics of the RDF and the plant design, this RDF can be fed into the kiln or the pre-calciner. It needs to be noted that certain constituents of the RDF, such as chlorine, need to be controlled to avoid adverse impacts on the production processes and end product quality.

The suitability of RDF for use in a cement kiln as a fuel is contingent on the material having the appropriate consistency, heat value, and composition as per the requirements of the specific cement plant.

3.5.7.1.1 Technical Specification of Boilers

Boiler design dictates the final shape and size of RDF. Most boilers designed to burn RDF use spreader stokers and fire fluff RDF in a semi-suspension mode.

It is proven that RDF co-processing in cement kilns has several advantages. The cement kiln process has wide ranging temperature zones with different residence times which provide opportunities to fine tune waste management systems appropriately. Different wastes can be co-processed at different points within the kiln system depending on their physical and chemical characteristics. The temperature in the cement kiln process varies from about 850°C to 1,800°C. Excess level of oxygen and counter flow operation with flue gases moving in a direction opposite to the materials lends a high degree of turbulence to the process. The presence of an alkaline reducing environment (lime) and the pre-heating of the raw materials by a pre-heater tower (>100 m tall) acts as an ideal scrubber for hot flue gases before they are emitted into the atmosphere. The long residence time, temperature, and turbulence in cement kilns provides extremely high destruction removal efficiency for all waste types (>99.99%). Co-processing leaves no residue as the incombustible, inorganic content of the waste materials are incorporated in the clinker matrix.



Long residence time, high temperature and turbulence in cement kilns ensures minimal production of dioxins and furans

Desirable Refuse Derived Fuel Characteristics for Co-processing in Cement Plants (Pre-calcliner/Kiln)⁴⁹

- Moisture, preferably < 20%
- Size, 2D < 120 mm, 3D < 70 mm subject to process limitation of specific cement plant
- Chlorine, preferably < 0.7% depending on particular raw mix and fuel mix
- Calorific value, preferably > 3,000 kcal/kg
- Sulfur, < 2% depending on particular raw mix and fuel mix
- Free of restricted items (polyvinyl chloride, explosives, batteries, aerosol containers, biomedical waste)

Advantages of co-processing RDF in cement kilns:

- High kiln temperature (1,800°C at main burner and 1,000°C at pre-calcliner) ensures destruction of organic pollutants.
- Long residence time (5–6 seconds at 1,800°C and 2–6 seconds at > 800°C) yields complete combustion.
- Self-cleaning process of acid gas is done by lime.
- Ash is incorporated into the clinker matrix

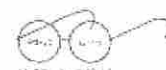
Limitations of co-processing RDF in cement kilns:

- More often than not, cement industry enterprises are reluctant to use RDF because of lack of established practice and requirements of retro-fitting of the existing feeder mechanisms.
- Regular supply of adequate quantity and quality of RDF is not available.
- Economics of producing and marketing RDF are largely contingent on the distance to which the finished RDF needs to be hauled by the ULB. Economic viability of the RDF system can be ensured by supplying appropriate quality of RDF to cement plants within a 200 km radius from the RDF production plant.

In order to overcome some of these shortcomings, the RDF processing facility may produce crude RDF. This RDF from multiple locations can be transported to the cement plant by either the ULB or operator or cement plant. Further refinement of the RDF may be accomplished at the cement plant through installation of secondary shredders, hot air generators, and air density separator, based on the specific requirements.

Siting of RDF plant plays an important role in ensuring viability of RDF usage in cement plants. Ideally, distance between RDF and cement plants should be within 200 km radius

⁴⁹ Cement Manufacturer, India



Benefits of Refuse Derived Fuel Based Plants Vs. Mass Burn Plants

- Refuse-derived fuel (RDF) is a buffer against fluctuating quality of incoming waste, since the waste is segregated and processed to ensure that the RDF comprises only desired waste fractions.
- All boilers (incinerators), including those using RDF as fuel, require an annual shutdown for 4–6 weeks for mandatory maintenance. During such time, the produced RDF may be sent for co-processing in cement plants or power plants. However, in mass burn plants, during periods of shutdown, the mixed waste will need to be diverted.

Co-processing of Segregated Plastic Waste: An Initiative of Jabalpur Municipal Corporation and ACC–Holcim

Location: Jabalpur, ACC–Kymore Cement Works

Main Players: Jabalpur Municipal Corporation (JMC), ACC–Kymore Cement Works, Central Pollution Control Board (CPCB), Madhya Pradesh Pollution Control Board (MPPCB), waste pickers

Year of start: 2008

Approach: A committee was constituted by the High Court of Delhi under the chairmanship of Justice R. C. Chopra to study the issue of environmental hazards, including health hazards from the use of plastic bags and waste generation. One of the recommendations submitted by the committee was to use plastic waste as a partial fuel in the cement kilns. The matter was further discussed in 54th Conference of Chairman and Member Secretaries of State Pollution Control Board (SPCBs). These discussions in the APEX conference prompted MPPCB to identify rotary cement kilns for co-processing of non-recyclable plastic waste and to tie up with municipal corporations. Kymore Cement Works of ACC Limited⁴³ pioneered the initiative, and the trial of segregated plastic waste was conducted successfully. The approach adopted includes:

1. planning and formulation of the strategy for the disposal of plastic waste by identifying different stakeholders and linkages in the process;
2. assessment of plastic waste generation in the municipal corporation;
3. coordination with cement industries by MPPCB for conducting trial runs for co-processing of plastic waste;
4. establishment of the system managed solely by waste pickers, sub-vendors, and kabadi system;
5. ensuring the arrangements for the transportation of the plastic waste to the cement plant;
6. development of appropriate storage and handling facility at ACC–Kymore; and
7. regular skill development and awareness programmes for the waste pickers.

⁴³ ACC is a 77-year-old cement company in India. It is now under Holcim, a Swiss-based global cement company which is a pioneering cement company providing cement kiln co-processing solutions for management of wastes.



Outcome

1. Out of 340 tonnes of MSW generated in Jabalpur Municipal limits, 5% was plastic and other combustible fractions (approximately 15–20 tonnes of waste per day), which was sent to the cement plant.
2. JMC introduced door-to-door waste collection service from households in 6–7 colonies as a pilot service wherein waste pickers collect the waste.
3. Self-help groups (SHGs) of over 200 waste pickers were formed for collection and segregation of waste.
4. JMC initiated a process of issuing identification numbers followed by issuing identification cards to the waste collectors or waste pickers to formally integrate them into the system.
5. Non-recyclable fractions of waste—e.g., double coated plastic, torn paper, jute, tetrapaks, thermocol, waste tyres, etc.—were segregated and transported to cement plants.
6. Until 2013, ACC–Kymore Cement Works had successfully co-processed 1,622 tonnes of segregated waste, and the initiative is being replicated in other locations as well.

Success Factor

- Proactive role of CPCB, MPPCB, and JMC
- Regular capacity building of workers
- Readiness of the cement plants to modify the equipment according to the feedstock

Overall sustainability

To demonstrate the co-processing methodology, ACC had conducted co-processing trial of plastic waste at Kymore Cement Works plant, with support from CPCB and MPPCB. The results of the trial run demonstrated that there are no negative influences of the stack emissions on product quality. The presence of high temperature and long residence time of the kiln ensures complete destruction, thus making co-processing in cement kiln a safer and greener way of management of segregated plastic waste. The pilot was replicated in Bhopal and Indore in Madhya Pradesh and gradually spread in many states, e.g., Tamil Nadu, Orissa, etc., wherever the SPCB and cement industry took an active role in the subject.

Considering the importance and benefits of the co-processing technology and based on the experience of various successful trial runs for hazardous and non-hazardous waste across the country, CPCB formulated the "Guidelines on Co-processing in Cement or Power or Steel Industry." In these guidelines, CPCB has included plastic as a non-hazardous fraction that can be co-processed.

However, co-processing of plastic fraction as a substitute to coal is still in its nascent stage, and the business model is yet to be fully developed.

Source: ACC-Holcim



3.5.8 MONITORING REQUIREMENTS FOR FACILITIES UTILISING REFUSE DERIVED FUEL

The SWM Rules, 2016 is the only legal document stipulating standards for flue gas emissions from incineration. However, standards for emissions from boilers using RDF are not specifically stated. Therefore, until such standards are specified, stack emission standards for treatment or utilisation of MSW using incinerators and thermal technologies, as provided in Clause C of SWM Rules, 2016, should be adhered to.

3.5.9 GREENHOUSE GAS MITIGATION POTENTIAL FROM REFUSE DERIVED FUEL UTILISATION

Waste management practices can influence greenhouse gas (GHG) emissions by affecting energy consumption, methane generation, carbon sequestration, and non-energy-related manufacturing emissions.

There are a number of climate-related advantages of converting MSW into fuel for power generation. These include reducing the methane emission from landfills that would have been generated from anaerobic degradation of the organic components. The production and subsequent utilisation of the RDF as fuel for energy recovery processes is a better option than mass burn. Uncontrolled combustion of materials such as plastic waste increase the atmospheric concentration of GHGs. RDF also reduces the consumption of depleting resources such as fossil fuels.

SPCB or CPCB set environmental standards for emissions from RDF combustion

3.6 TECHNOLOGIES UNDER DEVELOPMENT

Prevalent MSW treatment and processing technologies are based on long-lasting experiences in many countries. However, there are upcoming technologies which have been successfully tested in laboratories and in pilot facilities, but remain to be validated commercially. With respect to the applicability of upcoming technologies, some of these are being tested with support from the Government of India. The results of these tests should be awaited.

As indicated in the Report of the Task Force on Waste to Energy by the Planning Commission, pyrolysis and gasification are some of the technologies that could be explored by ULBs beside incineration, biomethanation, and RDF. However, the economics of these technologies is sensitive to waste characteristics and quantities. Until these technologies are well established commercially, these should be regarded as experimental technologies and should be handled as a research and development (R&D) project or specially designed concession agreements through public-private partnership (PPP) mode in case of large plants. Five years of successful commercial operation of new technologies may be regarded as a safe bet. Pilot projects based

Recent technologies that are at their nascent stage:

- Pyrolysis
- Plasma pyrolysis vitrification
- Gasification
- Bioreactor landfill



on new technologies could be encouraged through private funding or a combination of government and private funding. However, replication of technologies in other cities should be allowed only after successful implementation of the pilot project or when 100% capital cost is borne by private entrepreneur and government provides generation based support.

Factors for consideration while adopting Alternative Technologies for Municipal Solid Waste Processing

- Established technologies for defined and clean substances don't work automatically for heterogeneous wastes.
- Alternative technologies have to cope with:
 - existing stringent emission standards;
 - reliable continuous operation;
 - verification of a complete analysis of inputs and outputs; and
 - proof of reliable costs (investment, operation, maintenance).
- Decisions to rely on alternative technologies need backup by other possibilities to dispose waste in case the new technology system fails.
- If a solution for managing the arising waste is needed urgently, proven technologies are recommended.

This section details a few selected technologies, namely, pyrolysis and gasification.

3.6.1 PYROLYSIS

Pyrolysis involves an irreversible chemical change brought about by the action of heat in an atmosphere devoid of oxygen. Synonymous terms are thermal decomposition, destructive distillation, and carbonisation. Pyrolysis, unlike incineration, is an endothermic reaction and heat must be applied to waste to distil volatile components. Process of converting plastic to fuels through pyrolysis is possible, but it is yet to be proven to be a commercially viable venture.

Pyrolysis is carried out at 500°C–1,000°C and produces three component streams:

1. **Gas:** It is a mixture of combustible gases such as hydrogen, carbon monoxide, methane, carbon dioxide, and some hydrocarbons.
2. **Liquid:** It consists of tar, pitch, light oil, and low boiling organic chemicals like acetic acid, acetone, methanol, etc.
3. **Char:** It consists of elemental carbon along with the inert material in the waste feed.

Gas, liquid, char are useful because of their high calorific value. Part of the heat obtained by combustion of either char or gas is often used as

Pyrolysis is the conversion of waste and biomass into liquid and gaseous fuel as well as solid residues and char at 500°C–1000°C in absence of air



process heat for the endothermic pyrolysis reaction. It has been observed that even after utilising the heat necessary for pyrolysis, extra heat still remains which can be commercially exploited.

Although a number of laboratory and pilot investigations have been made, only a few have led to full scale plants. German experience also indicates that while several small scale pyrolysis and gasification plants for MSW were set up a few decades ago, almost all have been shut down due to operational and commercial issues.⁴⁴

3.6.1.1 FEED STOCK FOR PYROLYSIS

Feedstock for pyrolysis should have high calorific value with very less moisture content and should be homogenous in nature. Many plastics, particularly the polyolefins, which have high calorific values and simple chemical constitutions of primarily carbon and hydrogen, are usually used as a feedstock in pyrolysis. More recently, pyrolysis plants are being tested to degrade carbon-rich organic material such as MSW. For mixed MSW pre-processing is necessary to bring homogeneity to increase efficiency.

Ideal feedstock for pyrolysis should have high calorific value with very less moisture content and should be homogenous in nature

3.6.1.2 MUNICIPAL SOLID WASTE PYROLYSIS

Sorted and pre-treated feedstock is supplied to pyrolysis reactor—rotary kilns, rotary hearth furnaces, and fluidised bed furnaces are commonly used as MSW pyrolysis reactors—where partial combustion of material occurs at 500°C–800°C.

As a result of combustion of organic matter in an oxygen-deficient environment, various products such as char (ash), pyrolysis oil, and syngas are produced. Production of these is dependent on the organic component of MSW, temperature, pressure, and time of retention in the reactor. Char or solid residue is a combination of non-combustible material and carbon. Figure 3.28 shows an overview of the pyrolysis process.

The syngas is a mixture of gases (combustible constituents include carbon monoxide, hydrogen, methane, and a broad range of other volatile organic compounds). Syngas is further refined to remove particulates, hydrocarbons, and soluble matter, and is then combusted to generate electricity. The syngas typically has a net calorific value (NCV) of 2,800–4,800 kilocalorie per normal cubic meter (kcal/Nm³) or 10–20 megajoule per normal cubic meter (MJ/Nm³). If required, the condensable fraction can be collected by cooling the syngas, potentially for use as a liquid fuel (oils, waxes, and tars).

Syngas has a net calorific value of 2,800–4,800 kcal/Nm³ (10–20 MJ/Nm³) and can be further refined and combusted to generate electricity

44 Evolution of Waste Incineration and Co-Processing - In Germany and Europe - Dr.-Ing. Helmut Schnurer Deputy Director General (retired) - Federal Ministry for the Environment Bonn and Berlin, Germany. Presented at the 2nd Expert Committee Meeting for the Revision of the CPHEEO Municipal Solid Waste Management Manual

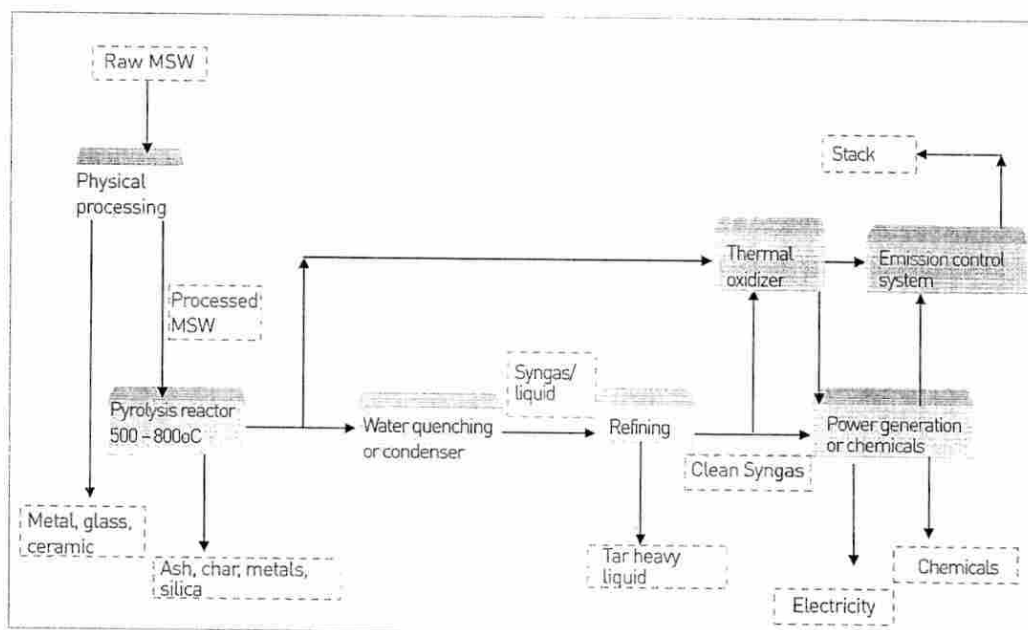


One key issue for use of syngas in energy recovery is tarring. The deposition of tars can cause blockages and other operational challenges and has been associated with plant failures and inefficiencies at some pilot and commercial scale facilities. Tarring issues may be overcome by higher temperature secondary processing.

In order to recover the energy content of syngas, it should be further processed in the following ways:

1. Syngas can be burned in a boiler to generate steam, which may be used for power generation or industrial heating;
2. Syngas can be used as a fuel in a dedicated gas engine;
3. Syngas, after reforming, may be suitable for use in a gas turbine;
4. Syngas can also be used as a chemical feedstock.

Figure 3.28: Municipal Solid Waste Pyrolysis ⁴⁵



For plasma pyrolysis of MSW, it should be noted that—along with pre-sorted MSW as feedstock—additional inputs, such as flux material and carbonaceous material (e.g., coke) are required.

The first pyrolysis plant that uses MSW exclusively as feedstock is under construction in Tees Valley in the United Kingdom. The plant is to process 950 tonnes per day (TPD) of household waste and converts it into 50 megawatts (MW) of electricity.

For hazardous waste, a plasma pyrolysis facility has been set up in Talaja, near Mumbai.

⁴⁵ Developed by the Expert Committee for revision of MSWM manual (2013-15).



3.6.1.3 PLASMA PYROLYSIS VITRIFICATION

This is a modified pyrolysis technology aiming at energy or resource recovery from organic waste. The system uses a plasma reactor, which generates, by application of high voltage between two electrodes, an extremely high temperature ($5,000^{\circ}\text{C}$ – $14,000^{\circ}\text{C}$). This hot plasma zone dissociates the molecules in any organic material into the individual elemental atoms, while all the inorganic material are simultaneously melted into a molten lava. This process is still far away from any proven practical and sustainable application in MSWM.

Plasma pyrolysis vitrification is a modified pyrolysis technology which employs application of high voltage to decompose inorganic matter in waste stream

3.6.2 GASIFICATION

Gasification is a partial combustion of organic or fossil based carbonaceous material, plastics, etc. into carbon monoxide, hydrogen, carbon dioxide, and methane. This is achieved at high temperature (650°C and above), with a controlled amount of air, oxygen, or steam. The process is largely exothermic, but some heat may be required to initialise and sustain the gasification process. The main product is syngas, which contains carbon monoxide, hydrogen, and methane. Typically, the gas generated from gasification will have an NCV of $4\text{--}10 \text{ MJ/Nm}^3$. The other main product produced by gasification is a solid residue of non-combustible material (ash), which contains a relatively low level of carbon.

Gasification is a process of converting carbonaceous material in MSW into CO_2 and syngas (CO , H_2 and CH_4) at high temperatures in the presence of controlled air or steam

3.6.2.1 GASIFICATION OF MUNICIPAL SOLID WASTE⁴⁶

Feedstock Preparation: MSW should be pre-processed before it can be used as feedstock for the gasification process. The pre-processing comprises of manual and mechanical sorting, grinding, blending with other material, drying, and pelletization. The purpose of pre-processing is to produce a feed material with consistent physical characteristics and chemical properties. Carbonaceous material of municipal waste stream is most important feedstock for gasification.

Gasification of MSW in the waste gasification plant as shown in Figure 3.29 is accomplished in two chambers: (i) the primary chamber is operated below the stoichiometric air requirement and (ii) the secondary chamber is operated under excess air conditions. The waste is fed into the primary chamber and semi-pyrolyzed, releasing moisture and volatile components. The heat is provided by the controlled combustion of fixed carbon within the waste. The syngas that is driven off contains a high calorific value and can act as a feedstock for the secondary chamber. Combustion air is then added to the syngas, making it highly combustible and prone to self-ignition. The secondary chamber is equipped with

Gasification takes place in two chambers:

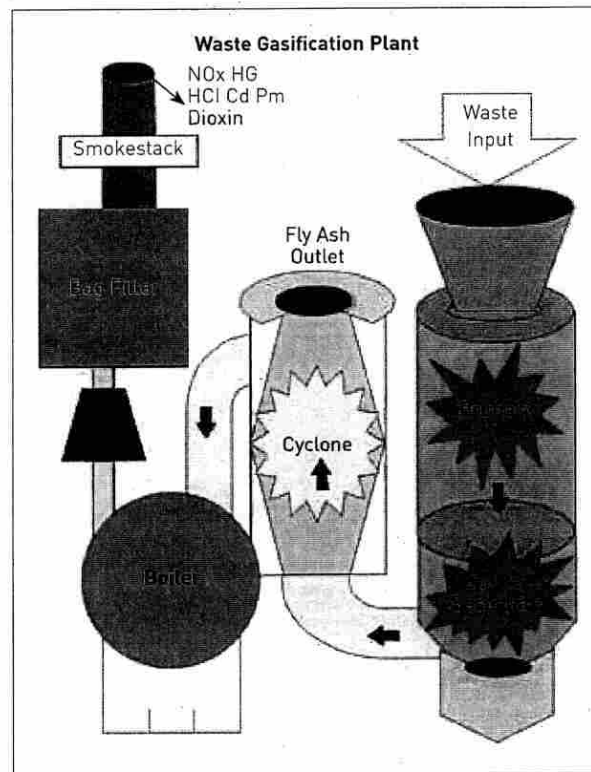
- Primary chamber: operated below stoichiometric air requirement
- Second chamber: under excess air conditions

46 "Gasification of Municipal Solid Waste". Zafar, S. (2009). Altenergymag. http://www.altenergymag.com/content.php?issue_number=09.06.01&article=zafar



a conventional burner to maintain operating temperature at all times. The combined gases are combusted in the secondary chamber.

Figure 3.29: Waste gasification plant⁴⁷



3.6.2.2 TYPES OF GASIFIERS FOR MUNICIPAL SOLID WASTE TREATMENT

Gasification technology is selected on the basis of available fuel quality, capacity range, and gas quality conditions. The main reactors used for gasification of MSW are fixed beds and fluidised beds. Larger capacity gasifiers are preferable for treatment of MSW because they allow for variable fuel feed, uniform process temperatures due to highly turbulent flow through the bed, good interaction between gases and solids, and high levels of carbon conversion.

(1) Fixed Beds

Fixed bed gasifiers typically have a grate to support the feed material and maintain a stationary reaction zone. They are relatively easy to design and operate, and are therefore useful for small and medium scale power and thermal energy uses. The two primary types of fixed bed gasifiers are updraft and downdraft.

Two main reactors used for gasification are: fixed bed and fluidised bed. Technology selection depends upon available fuel quality, capacity and gas quality

Fixed bed gasifiers are relatively easier to design and operate and more useful for small and medium scale power and thermal energy uses

47 Ibid.

In an updraft gasifier, the fuel is also fed at the top of the gasifier but the airflow is in the upward direction. As the fuel flows downward through the vessel, it dries, pyrolyzes, gasifies, and combusts. The main use of updraft gasifiers has been with direct use of the gas in a closely coupled boiler or furnace. Because the gas leaves this gasifier at relatively low temperatures, the process has a high thermal efficiency and, as a result, wet MSW containing 50% moisture can be gasified without any pre-drying of the waste.

In a downdraft gasifier, air is introduced into a downward flowing packed bed or solid fuel stream and gas is drawn off at the bottom. The air or oxygen and fuel enter the reaction zone from the top, decomposing the combustion gases and burning most of the tars. Downdraft gasifiers are not ideal for waste treatment because they typically require a low ash fuel such as wood to avoid clogging.

(2) Fluidised Beds

Fluidised beds are an attractive proposition for the gasification of MSW.⁴⁸ In a fluidised bed boiler, a stream of gas (typically air or steam) is passed upward through a bed of solid fuel and material (such as coarse sand or limestone). The gas acts as the fluidising medium and also provides the oxidant for combustion and tar cracking. Waste is introduced either on top of the bed through a feed chute or into the bed through an auger. Fluidised beds have the advantage of extremely good mixing and high heat transfer, resulting in very uniform bed conditions and efficient reactions. Fluidised bed technology is more suitable for generators with capacities greater than 10 MW because it can be used with different fuels, requires relatively compact combustion chambers, and allows for good operational control. The two main types of fluidised beds for power generation are bubbling and circulating fluidised beds.

In a bubbling fluidised bed (BFB), the gas velocity must be high enough so that the solid particles, comprising the bed material, are lifted, thus expanding the bed and causing it to bubble like liquid. A bubbling fluidised bed reactor typically has a cylindrical or rectangular chamber designed so that contact between the gas and solids facilitates drying and size reduction (attrition). As waste is introduced into the bed, most of the organics vaporise pyrolytically and are partially combusted in the bed. Typical desired operating temperatures range from 900°C to 1,000°C.

A circulating fluidised bed (CFB) is differentiated from a bubbling fluid bed in that there is no distinct separation between the dense solids zone and the dilute solids zone. The capacity to process different feedstock

Fixed bed gasifiers are of two types:

- Updraft: highly efficient, wet waste with 50% moisture can be gasified
- Downdraft: not preferred for MSW treatment

Fluidised bed are preferred for gasification of MSW as it can be used with multiple fuels, offers relatively compact combustion chambers and good operational control

Two types of fluidised bed are:

- Bubbling fluidised bed
- Circulating fluidised bed

48 "Gasification of Municipal Solid Waste". Zafar, S (2009). *Alternenergymag*.
http://www.alternenergymag.com/content.php?issue_number=09.06.01&article=zafar



with varying compositions and moisture contents is a major advantage in such systems.

Table 3.14: Thermal Capacity of Different Gasifier Design⁴⁹

GASIFIER DESIGN	FUEL CAPACITY
Down draft	1kW – 1MW
Updraft	1.1 MW – 12 MW
Bubbling fluidised bed	1 MW – 50 MW
Circulating fluidised bed	10 MW – 200 MW

3.6.2.3 EMERGING TRENDS IN GASIFICATION

(a) Plasma Gasification

Plasma gasification or plasma discharge uses extremely high temperatures in an oxygen-starved environment to completely decompose input waste material into very simple molecules in a process similar to pyrolysis. The heat source is a plasma discharge torch, a device that produces a very high temperature plasma gas. Plasma gasification has two variants, depending on whether the plasma torch is within the main waste conversion reactor or external to it. It is carried out under oxygen-starved conditions and the main products are vitrified slag, syngas, and molten metal. Vitrified slag may be used as an aggregate in construction; the syngas may be used in energy recovery systems or as a chemical feedstock; and the molten metal may have a commercial value depending on quality and market availability.⁵⁰

Technical and Commercial Challenges of Plasma Gasification Technology for Municipal Solid Waste: A Case of the Eco-Valley Facility in Japan

The first waste-to-energy (WTE) facilities in the world to utilise plasma gasification technology on a commercial basis is the Eco-Valley facility in Japan which was set up in April 2003. The facility processes up to 220 tonnes per day (TPD) of municipal solid waste (MSW) or up to 165 TPD of a 50/50 mixture of MSW and automotive shredder residue (ASR). The Eco-Valley facility faced several operational issues during the initial 7 years, which were later resolved. Due to poor commercial performance, the plant was closed. Being a first of its kind, Eco-Valley facility had to overcome several operational challenges during and after commissioning:

- 1) The internal diameter of the bottom of the gasifier was initially too large. Cold spots formed which rendered the gasifier inoperable.
- 2) The refractory that was initially specified for the gasifier did not achieve an acceptable lifespan.

⁴⁹ Ibid.

⁵⁰ Ibid.



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⁴⁹ Ibid.

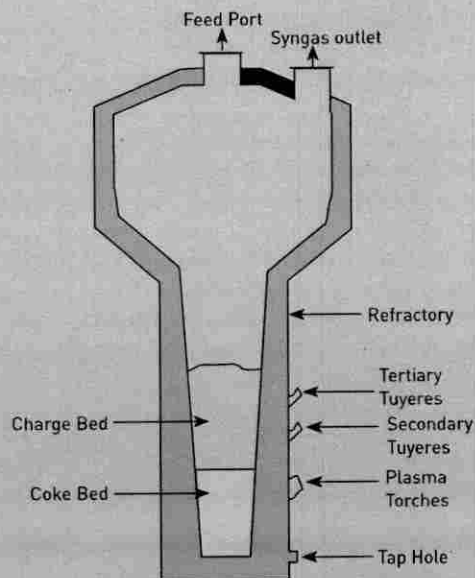
⁵⁰ Ibid.



- [3] Fine particulate entrained in the syngas that exits the gasifier attacked the refractory in the afterburner and accumulated on the walls of the afterburner.

The plant produced electricity through steam (Rankine cycle). The process employed includes the following:

- 1) **Waste Pit:** MSW and ASR are deposited in the waste pit. An overhead crane grabs waste and drops it into a shredder to reduce the size of the feedstock to 2.5 inches. The shredded material is returned to the waste pit where it is mixed with ASR, which arrives in shredded form.
- 2) **Gasifier:** Waste material is conveyed to the gasifier and enters at the top of the vessel. Organic material in the waste was converted into synthesis gas, i.e., syngas, which consists primarily of carbon monoxide, hydrogen, methane combustible gases as well as carbon dioxide and nitrogen non-combustible gases. The syngas exits at the top of the gasifier. Inorganic material were melted and exits the gasifier at the bottom of the gasifier as a molten slag, which forms vitreous granules as it is water quenched.
- 3) The syngas travels to the afterburner, a refractory lined cylindrical vessel, in which it is immediately combusted.
- 4) The hot gas leaves the afterburner and travels to the heat recovery steam boiler where it was cooled to produce steam.
- 5) The steam was used to drive a steam turbine generator.
- 6) The flue gas exits the heat recovery steam boiler and was cleaned in a bag house system before being vented to the atmosphere.



Schematic Plasma Gasification Reactor used in the Eco valley plant

Such systems are not only very expensive but require a high level of understanding of the nature of the feedstock, may require feedstock other than MSW for commercial viability, and require experienced and advanced technical capacity to ensure smooth and continuous operation. As such, this and similar technologies are not yet proven in the Indian context.

3.6.2.4 INTEGRATED GASIFICATION WITH POWER GENERATING EQUIPMENT

MSW gasification can be integrated with power turbines, steam cycle, and other power generating equipment to provide thermal energy. Combination of MSW gasification with power turbines and fuel cells increases overall efficiency of the system. Development is happening on the following lines:

1. Integrated gasification combined cycle (IGCC) is based on the concept of integrating MSW gasification with gas turbines and steam cycle.
2. Fuel cells are integrated with MSW gasifier. Tubular solid oxide fuel cells have been found to be most effective for these applications.

3.6.2.5 CHALLENGES OF OPERATING GASIFICATION PLANTS

Gasification takes place in low oxygen environment that limits the emission of pollutants. It also generates fuel gas that can be further used in a number of ways, as suggested in the section on pyrolysis. During gasification, tars, heavy metals, halogens, and alkaline compounds are released within the product gas and can cause environmental and operational problems. Tars are high molecular weight organic gases that ruin reforming catalysts, sulfur removal systems, and ceramic filters and increase the occurrence of slagging in boilers, on other metal and refractory surfaces. Alkalis can increase agglomeration in fluidised beds that are used in some gasification systems and can also ruin gas turbines during combustion. Heavy metals are toxic and accumulate, if released into the environment. Halogens are corrosive and a cause of acid rain, if emitted to the environment. The key to achieving cost efficient, clean energy recovery from MSW gasification will be overcoming problems associated with the release and formation of these contaminants.

3.6.2.6 CHALLENGES OF UTILISING PYROLYSIS AND GASIFICATION IN THE INDIAN CONTEXT

- High calorific value waste, which may otherwise be processed in more sustainable processes, is required as feedstock. Organics can be converted into compost in a much more cost-effective and environmentally safe process, as against using them as feedstock for these processes.
- Pyrolysis and gasification processes require specific feedstock quality, which has a direct impact on the efficiency and commercial viability of the product. Pre-treatment of waste is a must. Specific size and consistency of solid waste should be achieved before MSW can be used as feed.



3.7 CONSTRUCTION AND DEMOLITION WASTE (C&D WASTE)

With the growing importance of construction and demolition waste, the Government of India has deemed it appropriate to formulate a separate regulation for construction and demolition waste namely Construction and Demolition Waste Rules, 2016 describing the roles and responsibilities of the different stakeholders as well as the compliance criteria for the management of the construction and demolition waste.

According to the rules, construction and demolition waste “means the waste comprising of building materials, debris and rubble resulting from construction, remodeling, repair and demolition of any civil structure.

C&D waste includes bricks, tiles, stone, soil, rubble, plaster, drywall or gypsum board, wood, plumbing fixtures, non-hazardous insulating material, plastics, wall paper, glass, metal (e.g., steel, aluminium), asphalt, etc. However, C&D waste does not include any hazardous waste as defined under the Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016.

3.7.1 SOLID WASTE MANAGEMENT RULES, 2016 – REQUIREMENTS ON CONSTRUCTION AND DEMOLITION WASTE



Clause 4: Duties of waste generators:-

- (c) store separately construction and demolition waste, as and when generated, in his own premises and shall dispose off as per the Construction and Demolition Waste Management Rules, 2016;

Clause 15: Duties and responsibilities of local authorities:-

- (s) transport construction and demolition waste as per the provisions of the Construction and Demolition Waste management Rules, 2016;

3.7.2 CONSTRUCTION AND DEMOLITION WASTE RULES

Since construction and demolition waste was not given its due importance, there were very little efforts to keep records of its generation, composition, etc. However, it is estimated that 25–30 million tonne of C&D waste is generated annually in India. It has been further estimated that 40–60 kilogram per cubic meter (kg/m^3) of C&D waste is generated during construction and minor repair or renovation. During demolition of proper concrete and masonry buildings (locally called pucca building), about 500 kg/m^3 of C&D waste is generated whereas 300 kg/m^3 is generated for structures with partial concreting and masonry. Presence of excavated soil and silt may change this



composition. Even in metro cities like Delhi and Mumbai, where C&D waste is collected separately, waste is mixed containing about 50% of soil and silt. Natural calamities like earthquakes, landslides, etc. result in generation of large quantities of C&D waste.

Construction and demolition waste does not include any waste which may have any chance of getting contaminated with nuclear waste or exposed to nuclear radiation. Special care shall be taken before demolition of any nuclear establishment.

Material generated from de-silting activity is also excluded from construction and demolition waste category as it contains decomposed organic material and may also contain heavy metals and other toxic materials. However, de-silted materials from natural drains and storm water drains, not contaminated with organic material, may be accepted as construction and demolition waste.



Composition of Construction and Demolition Waste

Construction and demolition (C&D) waste is complex due to the different types of building materials being used. In general, C&D waste may comprise the following materials:

Major components. Cement and concrete; bricks; cement plaster; steel (from reinforced concrete, door or window frames, roofing support, railings of staircase, etc.); rubble; stone (marble, granite, sand stone); timber or wood (especially demolition of old buildings)

Minor components. Conduits (iron, plastic); pipes (GI, iron, plastic); electrical fixtures (copper or aluminum wiring, wooden baton, Bakelite or plastic switches, wire insulation); panels (wooden, laminated); glazed tiles; glass panes; etc.

C&D wastes are heavy (due to high density), often bulky, and occupy considerable storage space. C&D wastes stored outside construction sites and along road sides are a cause of both traffic congestion and mishaps. These wastes are quite often given away for filling in low lying areas or plots to private agencies, or disposed at open spaces or on the road side illegally. Waste from small generators quite often finds its way into the nearest municipal bin, vat, waste storage depots, making the municipal waste heavy and degrading its quality for further treatment like composting or energy recovery. C&D waste is also often dumped in surface drains obstructing the flow of waste water leading to urban flooding.

The C&D Waste Rules have introduced the concept of "Deconstruction," which means that a planned selective demolition in which salvage, reuse, and recycling of the demolished structure is maximized. This is made possible by a planned regime of construction



so that demolition is facilitated when desired. In a way, de-construction is “construction in reverse.” De-construction leads to less wastage and higher environmental sustainability.

3.7.3 RESPONSIBILITIES OF VARIOUS STAKEHOLDERS FOR CONSTRUCTION AND DEMOLITION WASTE MANAGEMENT

The waste generator, service provider, urban local body (ULB), and State Pollution Control Board (SPCB) and Pollution Control Committee (PCC) are the most important stakeholders for appropriate management of C&D waste. Construction and demolition waste rules, 2016 details out the duties of waste generator, service provider, ULBs, etc., and Schedule I explicitly describes the management of C&D waste.

Clause (4) Duties of the waste generator:-

- (1) Every waste generator shall prima-facie be responsible for collection, segregation of concrete, soil and others and storage of construction and demolition waste generated, as directed or notified by the concerned local authority in consonance with these rules.
- (2) The generator shall ensure that other waste (such as solid waste) does not get mixed with this waste and is stored and disposed separately.
- (3) Waste generators who generate more than 20 tonnes or more in one day or 300 tonnes per project in a month shall segregate the waste into four streams such as concrete, soil, steel, wood and plastics, bricks and mortar and shall submit waste management plan and get appropriate approvals from the local authority before starting construction or demolition or remodeling work and keep the concerned authorities informed regarding the relevant activities from the planning stage to the implementation stage and this should be on project to project basis.
- (4) Every waste generator shall keep the construction and demolition waste within the premise or get the waste deposited at collection centre so made by the local body or handover it to the authorised processing facilities of construction and demolition waste; and ensure that there is no littering or deposition of construction and demolition waste so as to prevent obstruction to the traffic or the public or drains.
- (5) Every waste generator shall pay relevant charges for collection, transportation, processing and disposal as notified by the concerned authorities; Waste generators who generate more than 20 tonnes or more in one day or 300 tonnes per project in a month shall have to pay for the processing and disposal of construction and demolition waste generated by them, apart from the payment for

storage, collection and transportation. The rate shall be fixed by the concerned local authority or any other authority designated by the State Government.

Clause (5) Duties of service provider and their contractors:-

- (1) The service providers shall prepare within six months from the date of notification of these rules, a comprehensive waste management plan covering segregation, storage, collection, reuse, recycling, transportation and disposal of construction and demolition waste generated within their jurisdiction.
- (2) The service providers shall remove all construction and demolition waste and clean the area every day, if possible, or depending upon the duration of the work, the quantity and type of waste generated, appropriate storage and collection, a reasonable timeframe shall be worked out in consultation with the concerned local authority.
- (3) In case of the service providers have no logistics support to carry out the work specified in sub- rules (1) and (2) , they shall tie up with the authorised agencies for removal of construction and demolition waste and pay the relevant charges as notified by the local authority.

Clause (6) Duties of local authority-The local authority shall:-

- (1) issue detailed directions with regard to proper management of construction and demolition waste within its jurisdiction in accordance with the provisions of these rules and the local authority shall seek detailed plan or undertaking as applicable, from generator of construction and demolition waste;
- (2) chalk out stages, methodology and equipment, material involved in the overall activity and final clean up after completion of the construction and demolition ;
- (3c) seek assistance from concerned authorities for safe disposal of construction and demolition waste contaminated with industrial hazardous or toxic material or nuclear waste if any;
- (4) shall make arrangements and place appropriate containers for collection of waste and shall remove at regular intervals or when they are filled, either through own resources or by appointing private operators;
- (5) shall get the collected waste transported to appropriate sites for processing and disposal either through own resources or by appointing private operators;
- (6) shall give appropriate incentives to generator for salvaging, processing and or recycling preferably in-situ;



- (7) shall examine and sanction the waste management plan of the generators within a period of one month or from the date of approval of building plan, whichever is earlier from the date of its submission;
- (8) shall keep track of the generation of construction and demolition waste within its jurisdiction and establish a data base and update once in a year;
- (9) shall device appropriate measures in consultation with expert institutions for management of construction and demolition waste generated including processing facility and for using the recycled products in the best possible manner;
- (10) shall create a sustained system of information, education and communication for construction and demolition waste through collaboration with expert institutions and civil societies and also disseminate through their own website;
- (11) shall make provision for giving incentives for use of material made out of construction and demolition waste in the construction activity including in non-structural concrete, paving blocks, lower layers of road pavements, colony and rural roads.



Clause (8) Duties of State Pollution Control Board or Pollution Control Committee:-

- (1) State Pollution Control Board or Pollution Control Committee shall monitor the implementation of these rules by the concerned local bodies and the competent authorities and the annual report shall be sent to the Central Pollution Control Board and the State Government or Union Territory or any other State level nodal agency identified by the State Government or Union Territory administration for generating State level comprehensive data. Such reports shall also contain the comments and suggestions of the State Pollution Control Board or Pollution Control Committee with respect to any comments or changes required;
- (2) State Pollution Control Board or Pollution Control Committee shall grant authorization to construction and demolition waste processing facility in Form-III as specified under these rules after examining the application received in Form I;
- (3) State Pollution Control Board or Pollution Control Committee shall prepare annual report in Form IV with special emphasis on the implementation status of compliance of these rules and forward report to Central Pollution Control Board before the 31st July for each financial year.



Smaller ULBs should designate specific locations in each zone for separate collection of small and large quantities of C&D waste. Small quantities of C&D waste should be periodically transported to bulk storage areas

(10) Duties of the Central Pollution Control Board - (1) The Central Pollution Control Board shall,-

- (a) prepare operational guidelines related to environmental management of construction and demolition waste management;
- (b) analyze and collate the data received from the State Pollution Control Boards or Pollution Control Committee to review these rules from time to time;
- (c) coordinate with all the State Pollution Control Board and Pollution Control Committees for any matter related to development of environmental standards;
- (d) forward annual compliance report to Central Government before the 30th August for each financial year based on reports given by State Pollution Control Boards or Pollution Control Committees.

(11) Duties of Bureau of Indian Standards and Indian Roads Congress - The Bureau of Indian Standards and Indian Roads Congress shall be responsible for preparation of code of practices and standards for use of recycled materials and products of construction and demolition waste in respect of construction activities and the role of Indian Road Congress shall be specific to the standards and practices pertaining to construction of roads.

3.7.4 MANAGEMENT OF CONSTRUCTION AND DEMOLITION WASTE

Schedule I of the construction and demolition waste management rules, specifies the management of construction and demolition waste. It details out guidance on storage, collection, transportation, processing, and disposal and also the use of the recycled products. Reuse, processing, and recycling have been emphasized. Large generators have to be incentivized for setting up in-situ processing facility. For large facilities, say for million plus cities, processing should be done through appropriate technology which minimizes process residues for landfilling, e.g., "wet" process, which can retrieve sand grade material (4.75 mm to 75 μ) from soil and other fine inert material.

Schedule II provides for further use of processed C&D products in operation of sanitary landfill. It must be clarified that while processed C&D waste shall be utilized in sanitary landfill for MSW of the city or region, residues from C&D waste processing or recycling industries shall be landfilled in the sanitary landfill for MSW.



3.7.5 STORAGE COLLECTION TRANSPORTATION AND DISPOSAL OF CONSTRUCTION AND DEMOLITION WASTE

3.7.5.1 SITE SELECTION FOR STORAGE, COLLECTION, PROCESSING AND RECYCLING OR PROCESSING FACILITIES FOR CONSTRUCTION AND DEMOLITION WASTE

Schedule I details out the compliance criteria for storage and processing or recycling facilities for C&D waste:-

- (1) The concerned department in the State Government dealing with land shall be responsible for providing suitable sites for setting up of the storage, processing and recycling facilities for construction and demolition and hand over the sites to the concerned local authority for development, operation and maintenance, which shall ultimately be given to the operators by Competent Authority and wherever above Authority is not available, shall lie with the concerned local authority.
- (2) The Local authority shall co-ordinate (in consultation with Department of Urban Development of the State or the Union territory) with the concerned organizations for giving necessary approvals and clearances to the operators.
- (3) Construction and demolition waste shall be utilized in sanitary landfill for municipal solid waste of the city or region as mentioned at Schedule I of this rule. Residues from construction and demolition waste processing or recycling industries shall be land filled in the sanitary landfill for solid waste.
- (4) The processing or recycling shall be large enough to last for 20-25 years (project based on-site recycling facilities).
- (5) The processing or recycling site shall be away from habitation clusters, forest areas, water bodies, monuments, National Parks, Wetlands and places of important cultural, historical or religious interest.
- (6) A buffer zone of no development shall be maintained around solid waste processing and disposal facility, exceeding five Tonnes per day of installed capacity. This will be maintained within the total area of the solid waste processing and disposal facility. The buffer zone shall be prescribed on case to case basis by the local authority in consultation with concerned State Pollution Control Board.
- (7) Processing or recycling site shall be fenced or hedged and provided with proper gate to monitor incoming vehicles or other modes of transportation.



- (8) The approach and or internal roads shall be concreted or paved so as to avoid generation of dust particles due to vehicular movement and shall be so designed to ensure free movement of vehicles and other machinery.
- (9) Provisions of weigh bridge to measure quantity of waste brought at landfill site, fire protection equipment and other facilities as may be required shall be provided.
- (10) Utilities such as drinking water and sanitary facilities (preferably washing/bathing facilities for workers) and lighting arrangements for easy landfill operations during night hours shall be provided and Safety provisions including health inspections of workers at landfill sites shall be carried out made.
- (11) In order to prevent pollution from processing or recycling operations, the following provisions shall be made, namely:
 - (a) Provision of storm water drains to prevent stagnation of surface water;
 - (b) Provision of paved or concreted surface in selected areas in the processing or recycling facility for minimizing dust and damage to the site.
 - (c) Prevention of noise pollution from processing and recycling plant:
 - (d) provision for treatment of effluent if any, to meet the discharge norms as per Environment (Protection) Rules, 1986.
- (12) Work Zone air quality at the Processing or Recycling site and ambient air quality at the vicinity shall be monitored.
- (13) The measurement of ambient noise shall be done at the interface of the facility with the surrounding area, i.e., at plant boundary.
- (14) The following projects shall be exempted from the norms of pollution from dust and noise as mentioned above: For construction work, where at least 80 percent construction and demolition waste is recycled or reused in-situ and sufficient buffer area is available to protect the surrounding habitation from any adverse impact.
- (15) A vegetative boundary shall be made around Processing or Recycling plant or site to strengthen the buffer zone.

ULBs should make bye-laws as well as special arrangements for storage, transportation, processing and disposal of Construction and Demolition waste.

Small municipalities under 1 Lakh population should make simple arrangements as under:

- Notify locations, preferably in each zone (North, South, East, West) and centre of the city, where waste generators having small quantities of C&D waste under 1 MT load should be allowed to deposit their waste. Construct an enclosure at each notified location for storage of small quantities of waste or place tractor trolley at each such location for storage of C&D waste.
- Arrange for transportation of C&D waste deposited at collection centres through covered tractor trolleys or trucks to the area designated for bulk storage.
- Citizens to avail of the facility at designated locations and refrain from disposal of C&D waste at any other location or in MSW bins.
- Plan for reuse and recycling of such waste with private sector participation or use the same for land reclamation by filling in low lying areas or for carrying out bio engineering works to prevent mosquito breeding, by using C&D waste to fill in areas where stagnant water is repeatedly observed.

In cities above 1 Lakh population, the municipality should make elaborate arrangements as under:

- Notify suitable locations in different parts of the city where waste generators having small quantities of C&D waste under 1MT load can deposit their waste conveniently.
- Create a system of renting skips or containers for storage of C&D waste at source departmentally or through an authorised private operator, where the generation of such waste is greater than 1 MT.
- Prescribed rates for collection and transportation of C&D waste to be published or notified.
- Citizens to avail the facility and refrain from disposal of small quantities of C&D waste anywhere else.
- Arrange for transportation of C&D waste through skip lifting system departmentally or through designated contractor. Normally 4.5 cu.m open skips and 10 cu.m roll on and roll of open containers (to be hauled by hook loaders are suitable for C&D waste).
- Plan for reuse and recycling of such waste with private sector participation. The rejects from these plants (soft fines) are used for filling in low lying areas.
- While depositing waste in the bins, care should be taken by the small generators to see that waste material is not dumped outside the bin or skip. These bins or skips should be periodically inspected by the municipal authority to ensure that they are cleared before they over flow. Littering should be strictly prohibited, particularly C&D waste should never be allowed to be deposited in open or covered drains.
- Large generators who are provided with open skips or tractor trolleys on rent by the local body or its authorised private operators, should inform the municipal authority or concerned agency when the containers are likely to be full in order to replace the filled skip or trolley with an empty one and transport the waste at



a designated site. In case of very large generators responsible for demolition, renovation, construction of infrastructure projects like bridges, fly-over, roads, large commercial or housing complex or demolition of unauthorised structures by municipality etc., the area should be screened and cordoned off and the material should be stacked systematically without obstructing traffic or causing any hindrance to the neighbourhood. Different waste components may be segregated and stored separately. Segregated material should be loaded into tipper lorries or tractors with the help of front end loaders or back hoes and transported to designated sites for further processing or other use. Private sector may be encouraged to facilitate reuse and recycling of C&D waste.

- The ULB should fix and notify charges for door step collection and transportation of C&D waste, based on the volume generated.
- Placement of Skips on Public Roads: Normally for bulk generators dedicated hook loader bins or skips may be provided at a cost wherever required and should be kept within the construction sites. The ULB should notify byelaws with regard to management of C&D waste and safety requirements of such containers on public roads.

3.7.5.2 BENEFITS OF PROCESSING CONSTRUCTION AND DEMOLITION WASTE

- C&D waste can be put to a profitable use, given the scarcity of sand and stone for construction, thereby saving natural resources.
- It prevents public nuisance and traffic congestion issues arising from indiscriminate dumping of C&D waste.
- It saves valuable space at landfill sites.
- It reduces cost of bulk transportation if recycled close to source of generation.





Experiences of first pilot project of Construction and Demolition waste Management in India

In 2009, the Municipal Corporation of Delhi (MCD) and IL&FS Environmental Infrastructure and Services Ltd. (IEISL) took an initiative of setting up a pilot project to process 500 tonnes per day (TPD) of construction and demolition (C&D) waste at Burari, Jahangirpuri, Delhi, which is a first of its kind plant in the country. A concession agreement for 10 years had been signed on public-private partnership (PPP) model, and 7 acres of land was provided by MCD for setting up the processing unit. Presently the project is in the jurisdiction of the North Delhi Municipal Corporation.

The project is based on an integrated approach covering collection and transportation of C&D waste from designated points by using skips and bins of different sizes (hailed by dumper placers or hook loaders) or tipping trucks with front-end loaders followed by transportation to the processing facility in vehicles fitted with GPS.

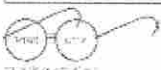
Process flow

- Incoming waste is subjected to weighment at the site.
- Undesirable items like rags, plastics, metal, fibre reinforced plastic (FRP) sheets, etc. are segregated through mechanical and manual means.
- Remaining waste is segregated into three parts:
 - whole bricks (kept for internal use and sale),
 - large concrete, and
 - mixed C&D waste.
- Depending on the waste inflow and its quality, the waste is processed.

Process Technology

Initially, the dry process was developed, in which loose soil was removed and the C&D waste was crushed and screened in stages to get the desired range of product sizes. However, in mixed C&D waste, considerable quantity of loose soil and grit is present which cannot be converted into useful products. To overcome this problem, the "wet" process was developed. In this process, the size grade of sand—4.75 mm to 75 μ (0.075 mm)—was extracted in the form of "manufactured sand." The remaining fraction <75 μ was silt, which was removed. In this process, residue was drastically reduced.

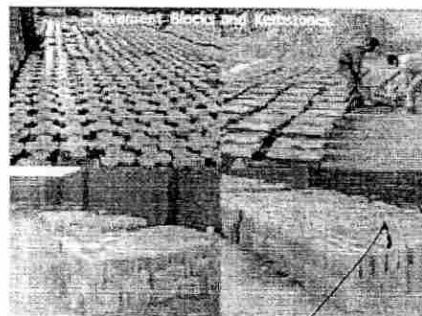
- Collected C&D waste is first screened through the grizzly to remove loose soil and grit.
- Oversized screened materials are collected in the hand sorting section where bricks and concrete are separated.
- Segregated bigger concrete boulders as well as mixed concrete are broken using rock breakers. Thereafter crushing is done by jaw or impact (horizontal or vertical shaft) crusher, depending on the material, size of operation, and targeted end use.
- Multilayered vibro-screens with suitably sized interchangeable screens have been used for size grading the crushed material. This is the "dry" process. The different sizes of aggregates are used to make value-added products as mentioned below.
- In the wet process for extracting manufactured sand, C&D waste is crushed and then passed through a washing and screening train comprising log washer, vibro-screens (3-deck pro-grade screen), evo-wash, evo-screen, thickener and filter press to remove the silt material and recycle the water. Only about 15% make up water is needed to run the wet process.



- The wet processing technology is effective in controlling dust and noise, which is also important for compliance with the new rule.

Final Products

The processed waste is being used for making road sub-base—granular sub-base (GSB)—and making pavement blocks and pre-cast products like curbstones, paver blocks, and square tiles. The loose soil separated by the grizzly is sold. The manufactured sand is used for making ready-mix concrete for nonstructural application and lean concrete.



In order to test the application of the recovered GSB from the plant, the roads within the plant as well as the access road to the plant (about 150 meter in length) were made with the recycled C&D aggregates.

Source: IEISL

3.7.5.3 REUSE AND RECYCLING POTENTIAL

Use of recycled C&D waste products (such as in non-structural concrete, manufactured sand, paving blocks, lower layers of road pavements, colony and rural roads etc.) shall be incentivised in places where there is an operational facility for recycling C&D waste. Such applications shall be subject to quality requirements for the specific application.

ii) Procurement of such materials shall be made mandatory (10-20%) in municipal and government contracts subject to strict quality control.

Many components of the C&D material have a high potential of reuse and recycling, as detailed in Table 3.15, provided they are properly segregated. Construction material such as aggregate, bricks, paving blocks etc. can also be made out of this waste.



Use of Construction and Demolition Waste for Road Works and Construction

- Experiments by Central Road Research Institute (CRRI) have shown that it is possible to use construction and demolition (C&D) waste for road and embankment construction such as embankment and sub-grade, sub-base, stabilised base course, rigid pavement, etc.
- The Government of National Capital Territory (Delhi) has accorded exemption of VAT for tiles and curbstones made from C&D waste or "malba".⁵¹

⁵¹ Construction, demolition debris chokes Delhi. Hindustan Times. 1 April. Singh, D. 2013. <http://www.hindustantimes.com/india-news/newdelhi/construction-demolition-debris-chokes-delhi/article1-1035318.aspx>



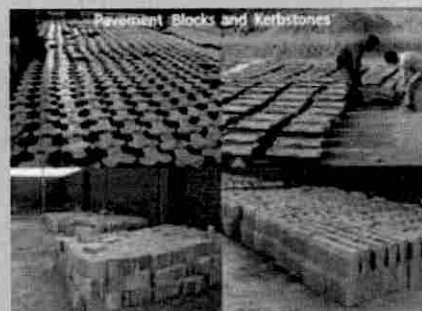
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The following table indicates some use potential of different components of recycled C&D waste material. However, care has to be taken in keeping durability and structural considerations in mind while planning such use.

Table 3.15: C&D Wastes and Their Reuse Potential ⁵²

MATERIAL	PROCESS	END USE
Demolition waste	Crushed and sorted	Recycled aggregate
Construction waste	Washed to remove cement and recover aggregate	Recycled aggregate
Reinforced concrete	Crushed, sorted and steel bars removed Steel recycled	Recycled concrete aggregate For recycling
Clay bricks and roof tiles	Cleaned Crushed and sorted Pulverised	Reused for masonry Aggregate Mixed with lime to produce mortar
Calcium silicate bricks	Cleaned Crushed Pulverised	Reused for masonry Aggregate Recycled into new calcium silicate bricks
Natural stone masonry	Cleaned Crushed	Reused for masonry Aggregate
Natural stone slabs	Cleaned Crushed	Flooring, cladding Aggregate
Ceramic tiles	Cleaned Crushed	Flooring, cladding Aggregate
Asphalt paving	Crushed and cold mixed Crushed and hot mixed	Road construction excluding wearing course
Mixed demolition waste (ABC i.e. asphalt, bricks, concrete)	Crushed	Fill material
Steel	Cleaned Recycled	Reused steel components New steel components
Aluminium	Cleaned Recycled	Aluminium recycling streams
Timber beams, doors etc.	Cleaned	Reused as beams, doors etc. (if free of hazardous preservatives).
Timber boards	Cleaned	Reused as shuttering and other products Feedstock for engineered woods
Plastics	Recycled	Plastic recycling streams
Gypsum plasterboard	Cleaned Crushed Recycled	Reuse as boards Soil conditioner New gypsum products
Glass	Cleaned Crushed Recycled	Glass recycling streams

⁵² "Reuse and Recycling of Construction and Demolition Waste". Holcim & GIZ, (2007).



3.7.5.4 PROPOSED USE FOR PROCESSED CONSTRUCTION AND DEMOLITION WASTE

The use of the processed construction and demolition waste has been described below, primarily mixed aggregates or recycled aggregates (RA) as well as recycled concrete aggregates (RCA).

- (i) Recycled aggregate (RA) may be used in making concrete for non-structural purposes. The extent of use would be limited to non-load bearing structures only, provided the conditions mentioned below at point no. 2 is complied with. Examples of use – wall between two RCC load bearing members, filling walls between RCC frame, non-industrial flooring, etc.
- (ii) The RA shall be free from deleterious material, such as, organic content, vegetable matter, coal, clay lumps, external substances such as, soft fragments like pieces of plastics, paper etc. RA shall also be free from chemicals, known to be detrimental for the strength or durability of concrete or steel reinforcement, such as, chlorides, etc. beyond the threshold value.
- (iii) Percentage of replacement of natural aggregates by RA can be up to 20% for any type of plain concrete work. The percentage can be increased up to 30% for road sub-base / base / other road related applications except wearing course. However, this shall be backed up by laboratory test reports.
- (iv) RA of appropriate quality (as mentioned above) can be used for various purposes, such as, in making kerb stones, paving blocks, concrete blocks and bricks, road sub-base, pathways for pedestrian use, rural roads (used for walking and bicycles) etc. However, it has to be ensured that the existing norms for strength (such as, M20, M25 etc.) are complied with for desired application.
- (v) Recycled concrete aggregate (RCA) can be used in all grades of PCC (non-structural and structural).
- (vi) Recycled concrete aggregates have to be pre-wetted near to SSD (saturated surface dry) conditions before use to avoid rapid slump loss due to its high water absorption rate. Admixtures with better slump retention effect would be useful.
- (vii) Fine washed aggregates in the range of 4.75 mm to 0.075 mm (75 μ) separated from C&D waste using 'wet' process may be used as 'manufactured sand' for non-load bearing structures.



3.7.6 SITING AND MANAGING CONSTRUCTION AND DEMOLITION RECYCLING PLANTS

3.7.6.1 IDENTIFICATION OF APPROPRIATE LAND FOR CONSTRUCTION AND DEMOLITION PROCESSING FACILITIES

The Town and Country Planning Department or Urban Development Department of the State or other Competent Authority should identify suitable site(s) for setting up processing facilities for construction and demolition waste according to the parameters necessary for such projects. The identified land should be incorporated in the approved land use plan so that there is no disturbance to the processing facility on a long term basis. 'No Development Zone' should be notified around the site to safeguard the facility.

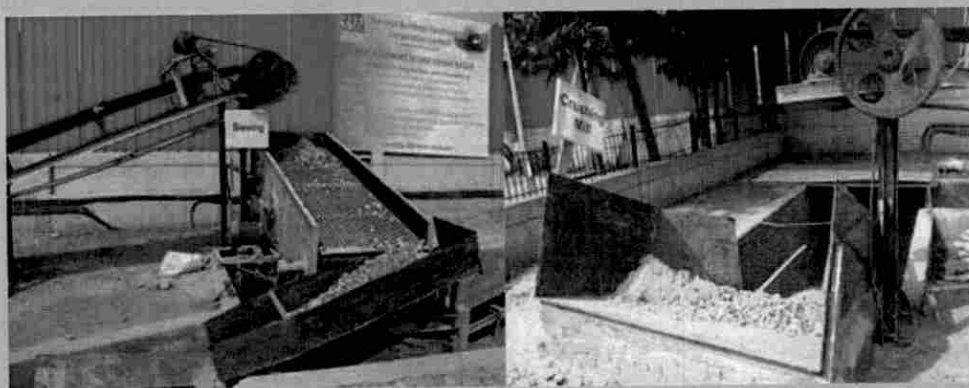
3.7.6.2 SITING CRITERIA FOR STORAGE AND PROCESSING FACILITIES

Consideration of environmental issues and suitability as well as adequacy of the chosen sites are the main criteria. A 'buffer zone of no development' shall be maintained—20 m for handling less than 500 tonnes per day (TPD) of C&D waste and 30 m for 500 TPD or more—around processing or recycling site and shall be incorporated in the land use plans of the concerned authority. In the case of successful implementation of 'no development zone,' the buffer zone inside the facility boundary should be limited to 6 m (for less than 500 TPD of C&D waste) and 10 m (for 500 or more TPD of C&D waste). Thus, land required for the facility would reduce.

In case the urban local body (ULB) or development authority is unable to procure a site where it is not feasible to provide any 'no development zone,' the ULB would constitute a committee comprising representation from the State Urban Development Department, State Pollution Control Board (SPCB) and Pollution Control Committee, and at least one expert institution to deliberate on the long-term impact and then give recommendations to the ULB. In case they recommend any specific technology or modification in design of the facility, the same should be incorporated in the bid. This way the project would be secure from objections from the neighbourhood for siting of the plant or facility. C&D recycling plants should ideally be installed in an industrial area or zone or adjacent to an existing or future landfill site.

In-situ Recycling of C&D Waste at Redevelopment Site by National Buildings Construction Corporation (NBCC): A New Example for India

An old government colony of about 2,500 dwelling units is being redeveloped at East Kidwai Nagar in New Delhi. The huge quantity of construction and demolition (C&D) waste generated at the site is being recycled at a facility set up within the site. The process involves crushing of the C&D waste material in a crusher housed underground followed by further grinding in an overground milling machine. The fine material is mixed with a patented catalyst in a pan mixer and the mixture is passed through a brick making machine. The green bricks are sun dried or cured in the sun for 4 weeks. The bricks are of standard size and would be used in the buildings coming up at the site. This in-situ recycling of C&D waste has avoided the need of transportation of C&D waste, resulting in substantial saving in transportation cost, and has minimised environmental degradation. The initiative will also save scarce land resource which is also increasingly getting difficult to procure.



Note: This being a new experiment in India, strength and durability of the bricks need to be monitored on a long-term basis.

C&D waste processing or recycling facilities should be located at least 500m away from the boundary of residential areas, preferably in industrial zones or adjacent to landfill sites

3.7.7 ENVIRONMENTAL CONSIDERATIONS

Dust and noise are usually the main issues with processing facilities for C&D waste. Table 3.16 provides a summary of environmental issues which need to be addressed during installation and operation of C&D plants.

Table 3.16: Potential Environmental Issues with Siting and Managing a Construction and Demolition Recycling Facility⁵³

ACTIVITY	POTENTIAL ISSUE	IMPACTS
Site clearing	Dust and noise Loss of biodiversity	Health Air pollution Ambience or visual impact Flora and fauna habitat
Site operations or contouring that permits water to pond on-site	Odour	Health Ambience or visual impact
Uncontrolled or poorly managed site run-off	Surface water run-off resulting in transportation of sediments (i.e. erosion)	Water pollution Soil erosion
Transporting materials to or from site or stockpiling of wastes or recycled products on site. Crushing, grinding or screening operations	Dust Noise	Health Air pollution Ambience
Asbestos contamination in waste loads	Asbestos pieces pass through crushing operations Asbestos from stockpiled material remains in soil	Health Air pollution Land contamination
Sorting of C&D waste	Hazardous waste components of C&D waste	Health Air pollution Land contamination
Litter	Litter from operations or during transportation to or from site	Littering, choking of drains

For prevention of pollution from processing or recycling operations, certain provisions have been mandated such as storm water drain and paving or concreting of selected areas in the processing or recycling facility.

⁵³ Source: Environment Guideline for C&D waste recycling Facilities, Department of Environment and Conservation, The Government of Western Australia



Table 3.17: Ambient Air Quality at the Processing or Recycling Site and in the Vicinity⁵⁴

SL. NO.	PARAMETERS	ACCEPTABLE LEVEL
(i)	Suspended Particulate Matter	500 µg/m ³ (24 hours)
(ii)	Respirable Suspended Particulate Matter (RSPM) or Particulate Matter [PM ₁₀] 10 Micron	100 µg/m ³ (24 hourly) 60 µg/m ³ (annual)
(iii)	Particulate Matter ≥ size (PM _{2.5})	60 µg/m ³ (24 Hourly) 40 µg/m ³ (Annual)

The ambient air quality monitoring (Table 3.17) shall be carried out at processing or recycling sites by the concerned authority as per the following schedule:

- a. six times a year for cities having a population of more than 5 million;
- b. four times a year for cities having a population between 1 million and 5 million;
- c. two times a year for town or cities having a population between 100,000 and 1 million; or
- d. once a year for all towns (including census towns) having a population below 100,000.

For noise levels, the noise standards recommended by Central Pollution Control Board (CPCB) and notified in the Environment (Protection) Rules, 1986 for industrial area shall be applicable (daytime 75 dB ALeq and night time 70 dB ALeq). The measurement would be done at the interface of the facility with the surrounding area, i.e., at plant boundary.

However, exemption from dust and noise provisions has been granted for the following projects:

1. for redevelopment of colonies and markets, where in-situ recycling is carried out, provided (a) the project is completed within 5 years, (b) minimum 80% of the C&D waste generated at the site is recycled or reused within the same site, and (c) sufficient buffer area is available to protect the surrounding habitation from any adverse impact; and
2. in-situ recycling at large construction sites (minimum 1 hectare so that some buffer area is available), provided (a) the project is completed within 3 years, and (b) minimum 50% of the C&D waste generated at the site is reused or recycled within the same site.

⁵⁴ Revised National Ambient Air Quality Standards [NAAQS], Ministry of Environment Forest and Climate Change, 2009.
<http://www.moef.nic.in/sites/default/files/notification/Recved%20national.pdf>



3.8 ACTION POINTS FOR AWARENESS GENERATION THROUGH INFORMATION, EDUCATION, AND COMMUNICATION ACTIVITIES FOR TECHNICAL ASPECTS OF PROCESSING AND TREATMENT OF MUNICIPAL SOLID WASTE

- Ensure active participation of the community for recycling waste at household level. Recycling reduces the overall quantities of waste to be treated.
- Success of any recycling programme depends on community cooperation.
 - Sensitise community toward waste pickers.
 - Conduct recycling programmes at ward level and schools to generate public awareness.
- Generate public awareness to segregate dry and wet waste at source. The success of any waste treatment technology will depend on raw materials received, which eventually depends on segregation of waste.
- Ensure community participation toward successful implementation of decentralised waste management system like composting and vermicomposting.
- Involve community while planning and designing any waste management system to avoid disagreement at later stages, especially during siting of plant.
- Inform community about various existing and new waste treatment technologies and requirements.
- Encourage the utilisation of compost for farming and gardening. Increasing public awareness and knowledge about compost use and benefits will subsequently lead to increased market demand of compost.
- Involve agricultural department officers in generating awareness on compost usage.
- Public support for adopting decentralised waste treatment technologies (e.g., vermicomposting and biomethanation) ensures success of treatment technologies and minimises financial implications for ULBs.
- Generate community awareness to avoid “not in my backyard” (NIMBY) syndrome, so that land can be earmarked for a decentralised waste treatment facility.



4

Technical Aspects: Municipal Sanitary Landfills

IN THIS SECTION

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4. TECHNICAL ASPECTS: MUNICIPAL SANITARY LANDFILLS

4.1 SOLID WASTE MANAGEMENT RULES, 2016 - ON LANDFILLS

As per SWM Rules, 2016:

Clause 15: Duties and responsibilities of local authorities:-

- (zh) stop land filling or dumping of mixed waste soon after the timeline as specified in rule 23 for setting up and operationalisation of sanitary landfill is over;
- (zi) allow only the non-usable, non-recyclable, non-biodegradable, non-combustible and non-reactive inert waste and pre-processing rejects and residues from waste processing facilities to go to sanitary landfill and the sanitary landfill sites shall meet the specifications as given in Schedule-I, however, every effort shall be made to recycle or reuse the rejects to achieve the desired objective of zero waste going to landfill;
- (zj) investigate and analyse all old open dumpsites and existing operational dumpsites for their potential of bio- mining and bio-remediation and wheresoever feasible, take necessary actions to bio-mine or bio-remediate the sites;
- (zk) in absence of the potential of bio-mining and bio-remediation of dumpsite, it shall be scientifically capped as per landfill capping norms to prevent further damage to the environment.

Clause 20: Criteria and actions to be taken for solid waste management in hilly areas:

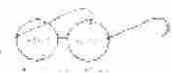
- (a) Construction of landfill on the hill shall be avoided. A transfer station at a suitable enclosed location shall be setup to collect residual waste from the processing facility and inert waste. A suitable land shall be identified in the plain areas down the hill within 25 kilometers for setting up sanitary landfill. The residual waste from the transfer station shall be disposed of at this sanitary landfill.
- (b) In case of non-availability of such land, efforts shall be made to set up regional sanitary landfill for the inert and residual waste.

SCHEDULE I: SPECIFICATIONS FOR LANDFILLS SITES

(A) Criteria for site selection:-

Specifications for Sanitary Landfills

- (i) The department in the business allocation of land assignment shall provide suitable site for setting up of the solid waste processing and treatment facilities and notify such sites.
- (ii) The sanitary landfill site shall be planned, designed and developed with proper documentation of construction plan as well as a closure plan in a phased manner. In case a new landfill facility is being established adjoining an existing landfill site, the closure plan of existing landfill should form a part of the proposal of such new landfill.
- (iii) The landfill sites shall be selected to make use of nearby wastes processing facilities. Otherwise, wastes processing facility shall be planned as an integral part of the landfill site.
- (iv) Landfill sites shall be set up as per the guidelines of the Ministry of Urban Development, Government of India and Central Pollution Control Board.
- (v) The existing landfill sites which are in use for more than five years shall be improved in accordance with the specifications given in this Schedule.
- (vi) The landfill site shall be large enough to last for at least 20-25 years and shall develop 'landfill cells' in a phased manner to avoid water logging and misuse.
- (vii) The landfill site shall be 100 meter away from river, 200 meter from a pond, 200 meter from Highways, Habitations, Public Parks and water supply wells and 20 km away from Airports or Airbase. However in a special case, landfill site may be set up within a distance of 10 and 20 km away from the Airport/Airbase after obtaining no objection certificate from the civil aviation authority/ Air force as the case may be. The Landfill site shall not be permitted within the flood plains as recorded for the last 100 years, zone of coastal regulation, wetland, Critical habitat areas, sensitive eco-fragile areas..
- (viii) The sites for landfill and processing and disposal of solid waste shall be incorporated in the Town Planning Department's land-use plans.
- (ix) A buffer zone of no development shall be maintained around solid waste processing and disposal facility, exceeding five Tonnes per day of installed capacity. This will be maintained within the total

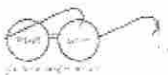


area of the solid waste processing and disposal facility. The buffer zone shall be prescribed on case to case basis by the local body in consultation with concerned State Pollution Control Board.

- (x) The biomedical waste shall be disposed of in accordance with the Bio-medical Waste Management Rules, 2016, as amended from time to time. The hazardous waste shall be managed in accordance with the Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016, as amended from time to time. The E-waste shall be managed in accordance with the e-waste (Management) Rules, 2016 as amended from time to time.
- (xi) Temporary storage facility for solid waste shall be established in each landfill site to accommodate the waste in case of non- operation of waste processing and during emergency or natural calamities.

(B) Criteria for development of facilities at the sanitary landfills:-

- (i) Landfill site shall be fenced or hedged and provided with proper gate to monitor incoming vehicles, to prevent entry of unauthorised persons and stray animals
- (ii) The approach and / internal roads shall be concreted or paved so as to avoid generation of dust particles due to vehicular movement and shall be so designed to ensure free movement of vehicles and other machinery.
- (iii) The landfill site shall have waste inspection facility to monitor waste brought in for landfilling h, office facility for record keeping and shelter for keeping equipment and machinery including pollution monitoring equipment. The operator of the facility shall maintain record of waste received, processed and disposed.
- (iv) Provisions like weigh bridge to measure quantity of waste brought at landfill site, fire protection equipment and other facilities as may be required shall be provided.
- (v) Utilities such as drinking water and sanitary facilities (preferably washing/bathing facilities for workers) and lighting arrangements for easy landfill operations during night hours shall be provided.
- (vi) Safety provisions including health inspections of workers at landfill sites shall be carried out made.
- (vii) Provisions for parking, cleaning, washing of transport vehicles carrying solid waste shall be provided. The wastewater so generated shall be treated to meet the prescribed standards.





(C) Criteria for specifications for land filling operations and closure on completion of land filling:-

- (i) Waste for land filling shall be compacted in thin layers using heavy compactors to achieve high density of the waste. In high rainfall areas where heavy compactors cannot be used, alternative measures shall be adopted.
- (ii) Till the time waste processing facilities for composting or recycling or energy recovery are set up, the waste shall be sent to the sanitary landfill. The landfill cell shall be covered at the end of each working day with minimum 10 cm of soil, inert debris or construction material.
- (iii) Prior to the commencement of monsoon season, an intermediate cover of 40-65 cm thickness of soil shall be placed on the landfill with proper compaction and grading to prevent infiltration during monsoon. Proper drainage shall be constructed to divert run-off away from the active cell of the landfill.
- (iv) After completion of landfill, a final cover shall be designed to minimise infiltration and erosion. The final cover shall meet the following specifications, namely :--
 - a) The final cover shall have a barrier soil layer comprising of 60 cm of clay or amended soil with permeability coefficient less than 1×10^{-7} cm/sec.
 - b) On top of the barrier soil layer, there shall be a drainage layer of 15 cm.
 - c) On top of the drainage layer, there shall be a vegetative layer of 45 cm to support natural plant growth and to minimise erosion.



(D) Criteria for pollution prevention.-In order to prevent pollution from landfill operations, the following provisions shall be made, namely:-

- (i) The storm water drain shall be designed and constructed in such a way that the surface runoff water is diverted from the landfilling site and leachates from solid waste locations do not get mixed with the surface runoff water. Provisions for diversion of storm water discharge drains shall be made to minimise leachate generation and prevent pollution of surface water and also for avoiding flooding and creation of marshy conditions.
- (ii) Non-permeable lining system at the base and walls of waste disposal area. For landfill receiving residues of waste processing facilities or mixed waste or waste having contamination of hazardous materials (such as aerosols, bleaches, polishes, batteries, waste oils, paint products and pesticides) shall have liner of composite barrier of 1.5 mm thick high density polyethylene (HDPE) geo-membrane or geo-synthetic liners, or equivalent, overlying 90 cm of soil (clay or amended



soil) having permeability coefficient not greater than 1×10^{-7} cm/sec. The highest level of water table shall be at least two meter below the base of clay or amended soil barrier layer provided at the bottom of landfills.

- (iii) Provisions for management of leachates including its collection and treatment shall be made. The treated leachate shall be recycled or utilized as permitted, otherwise shall be released into the sewerage line, after meeting the standards specified in Schedule- II.. In no case, leachate shall be released into open environment.
- (iv) Arrangement shall be made to prevent leachate runoff from landfill area entering any drain, stream, river, lake or pond. In case of mixing of runoff water with leachate or solid waste, the entire mixed water shall be treated by the concern authority.

(E) Criteria for water quality monitoring:-

- (i) Before establishing any landfill site, baseline data of ground water quality in the area shall be collected and kept in record for future reference. The ground water quality within 50 meter of the periphery of landfill site shall be periodically monitored covering different seasons in a year that is, summer, monsoon and post-monsoon period to ensure that the ground water is not contaminated.
- (ii) Usage of groundwater in and around landfill sites for any purpose (including drinking and irrigation) shall be considered only after ensuring its quality. The following specifications for drinking water quality shall apply for monitoring purpose, namely :-

S. NO.	PARAMETERS	IS 10500:2012, EDITION 2.2(2003-09) DESIRABLE LIMIT (MG/L EXCEPT FOR PH)
1	Arsenic	0.01
2	Cadmium	0.01
3	Chromium (as Cr ⁶⁺)	0.05
4	Copper	0.05
5	Cyanide	0.05
6	Lead	0.05
7	Mercury	0.001
8	Nickel	-
9	Nitrate as NO ₃	45.0
10	pH	6.5-8.5
11	Iron	0.3
12	Total hardness (as CaCO ₃)	300.0
13	Chlorides	250
14	Dissolved solids	500
15	Phenolic compounds as (C ₆ H ₅ OH)	0.001
16	Zinc	5.0
17	Sulphate (as SO ₄)	200



(F) Criteria for ambient air quality monitoring:-

- (i) Landfill gas control system including gas collection system shall be installed at landfill site to minimize odour, prevent off-site migration of gases, to protect vegetation planted on the rehabilitated landfill surface. For enhancing landfill gas recovery, use of geomembranes in cover systems along with gas collection wells should be considered.
- (ii) The concentration of methane gas generated at landfill site shall not exceed 25 per cent of the lower explosive limit (LEL).
- (iii) The landfill gas from the collection facility at a landfill site shall be utilized for either direct thermal applications or power generation, as per viability. Otherwise, landfill gas shall be burnt (flared) and shall not be allowed to escape directly to the atmosphere or for illegal tapping. Passive venting shall be allowed in case if its utilisation or flaring is not possible.
- (iv) Ambient air quality at the landfill site and at the vicinity shall be regularly monitored. Ambient air quality shall meet the standards prescribed by the Central Pollution Control Board for Industrial area.

G. Criteria for plantation at landfill site:- A vegetative cover shall be provided over the completed site in accordance with the following specifications, namely:-

- (a) Locally adopted non-edible perennial plants that are resistant to drought and extreme temperatures shall be planted;
- (b) The selection of plants should be of such variety that their roots do not penetrate more than 30 cms. This condition shall apply till the landfill is stabilized;
- (c) Selected plants shall have ability to thrive on low-nutrient soil with minimum nutrient addition; (d) Plantation to be made in sufficient density to minimise soil erosion.
- (e) Green belts shall be developed all around the boundary of the landfill in consultation with State Pollution Control Boards or Pollution Control Committees.

H. Criteria for post-care of landfill site:-

- (1) The post-closure care of landfill site shall be conducted for at least fifteen years and long term monitoring or care plan shall consist of the following, namely :-⁴
 - (a) Maintaining the integrity and effectiveness of final cover, making repairs and preventing run-on and run-off from eroding or otherwise damaging the final cover;

As per Municipal Solid Waste Management Rules 2000, to monitor the ambient air quality at the landfill site, the following specified standards should be met:

Standards for Ambient Air Quality around Landfill Sites

S. NO.	PARAMETERS	ACCEPTABLE LEVELS
(i)	Sulphur dioxide	50 µg/m ³ (Annual*) 80 µg/m ³ (24 hours**)
(ii)	Nitrogen dioxide	40 µg/m ³ (Annual*) 80 µg/m ³ (24 hours**)
(iii)	Particulate matter (size less than 10µ) or PM ₁₀	60 µg/m ³ (Annual*) 100 µg/m ³ (24 hours**)
(iv)	Particulate matter (size less than 2.5 µ) or PM _{2.5}	40 µg/m ³ (Annual*) 60 µg/m ³ (24 hours**)
(v)	Carbon monoxide	1 hour **: 04 mg/m ³ 8 hours **: 02 mg/m ³
(vi)	Ammonia (NH ₃) µg/m ³	100 µg/m ³ (Annual*) 400 µg/m ³ (24 hours**)
(vii)	Benzo (a) pyrene (BaP)- particulate phase only, ng/m ³	01 ng/m ³ (Annual*)

Notes:

* Annual arithmetic mean of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at uniform intervals.

** 24 hourly or 08 hourly or 01 hourly monitored values, as applicable, shall be complied with 98% of the time in a year, 2% of the time, they may exceed the limits but not on two consecutive days of monitoring.

- The ambient air quality monitoring shall be carried out by the concerned authority as per the following schedule, namely:-
 - (a) Six times in a year for cities having population of more than fifty lakhs;
 - (b) Four times in a year for cities having population between ten and fifty lakhs;
 - (c) Two times in a year for town or cities having population between one and ten lakhs.

- (b) Monitoring leachate collection system in accordance with the requirement;
- (c) Monitoring of ground water in and around landfill;
- (d) Maintaining and operating the landfill gas collection system to meet the standards.

(2) Use of closed landfill sites after fifteen years of post-closure monitoring can be considered for human settlement or otherwise only after ensuring that gaseous emission and leachate quality analysis complies with the specified standards and the soil stability is ensured.



I. Criteria for special provisions for hilly areas:-

Cities and towns located on hills shall have location-specific methods evolved for final disposal of solid waste by the local body with the approval of the concerned State Pollution Control Board or the Pollution Control Committee. The local body shall set up processing facilities for utilisation of biodegradable organic waste. The non-biodegradable recyclable materials shall be stored and sent for recycling periodically. The inert and non-biodegradable waste shall be used for building roads or filling-up of appropriate areas on hills. In case of constraints in finding adequate land in hilly areas, waste not suitable for road-laying or filling up shall be disposed of in regional landfills in plain areas.

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 bio mining 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 / utilisation 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.

4.2 ENVIRONMENTAL IMPACTS AND ITS MINIMISATION

In line with the Solid Waste Management (SWM) Rules, 2016 as documented in Section 4.1, sanitary landfills minimise the harmful impact of solid waste on the environment through the use of the following mechanisms:

- a) reduction of groundwater contamination through leachate collection and treatment;
- b) control of surface water contamination through runoff;
- c) reduction of air contamination due to gases, litter, dust, or bad odour;
- d) control of other problems due to rodents, pests, fire, bird menace, slope failure, erosion, etc.

4.3 TYPES OF MUNICIPAL SOLID WASTE TO BE ACCEPTED AT LANDFILLS

Waste categories suitable for sanitary landfills are the following:

- i) non-biodegradable and inert waste by nature or through pre-treatment;
- ii. commingled waste (mixed waste) not found suitable for waste processing;
- iii. pre-processing and post-processing rejects from waste processing sites; and
- iv. non-hazardous waste not being processed or recycled.

Sanitary landfilling is not mandated or required for the following waste streams in the municipal solid waste (MSW):

- (i) biodegradable waste or garden waste,
- (ii) dry recyclables, and
- (iii) hazardous waste or industrial waste (to be disposed in hazardous waste sites with special containment).

Hazardous wastes have to be disposed of in special facilities—e.g., treatment, storage, and disposal facilities (TSDF)—that are designed for the respective types of waste. MSW having limited contamination of hazardous materials—e.g., aerosols, household chemicals, used batteries, contaminated containers like paint, etc. can be disposed of in a sanitary landfill with adequate liner systems (see requirements in SWM Rules, 2016). However, in line with this manual, such wastes should be segregated at source and managed appropriately, minimising their disposal in sanitary landfills.

C&D waste should be landfilled separately so that it could be mined in the future, if required

Landfilling of construction and demolition (C&D) waste, where processing options are not available, will be done in a separate landfill or cell where the waste can be stored and mined for future use in earthwork or road projects. C&D waste can be used as a daily cover or for road construction at the MSW sanitary landfill.

4.4 ESSENTIAL COMPONENTS OF MUNICIPAL SANITARY LANDFILLS

The term sanitary landfill is used herein to describe a unit operation for final disposal of 'Municipal Solid Waste' on land, designed and constructed with the objective of minimising impact to the environment and according to the SWM Rules.

Figure 4.1: Section of Typical Sanitary Landfill¹

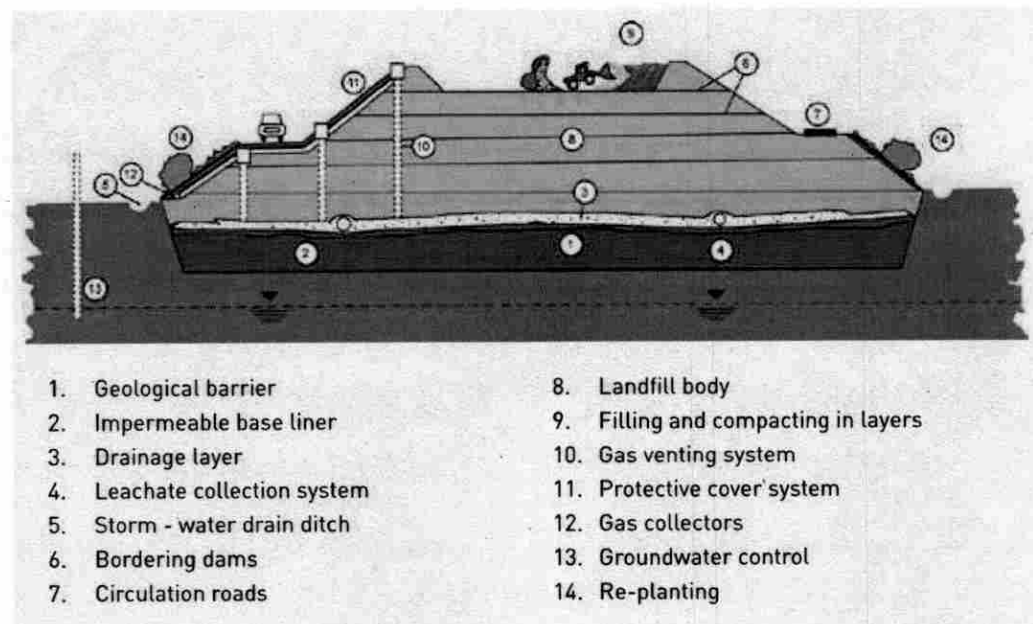


Figure 4.1 illustrates the essential components of a MSW sanitary landfill which include:

- a liner system at the base and sides of the sanitary landfill which prevents migration of leachate or gas to the surrounding soil;
- a leachate collection and control facility which collects and extracts leachate from within and from the base of the sanitary landfill and then treats the leachate;
- a gas collection and control facility (optional for small sanitary landfills) which collects and extracts gas from within and from the top of the sanitary landfill and then treats it or uses it for energy recovery;

¹ Developed by the Expert Committee for revision of MSWM manual (2013-15)

- a final cover system at the top of the sanitary landfill which enhances surface drainage, prevents infiltrating water, and supports surface vegetation;
- a surface water drainage system which collects and removes all surface runoff from the sanitary landfill site;
- an environmental monitoring system which periodically collects and analyses air, surface water, soil, gas, and groundwater samples around the sanitary landfill site; and
- a closure and post-closure plan which lists the steps that must be taken to close and secure a sanitary landfill site once the filling operation has been completed and the activities for long-term monitoring and operation and maintenance (O&M) of the completed sanitary landfill are functional.

4.5 PLANNING AND DESIGN OF A LANDFILL

Steps for designing, implementation and operation of a Sanitary Landfill are:

1. site selection,
2. sanitary landfill design,
3. construction of a sanitary landfill,
4. sanitary landfill operation, and
5. closure and post-closure plan.

4.5.1 SITE SELECTION

Selection of a sanitary landfill site shall be governed by the strategy identified in the state policy and SWM strategy and the municipal solid waste management (MSWM) plan of the urban local body (ULB). Decisions on constructing local landfills in relation to utilising regional landfills are based on these strategies or planning documents.

Site selection usually includes the following steps, which are described in the section below:

- location criteria,
- search area,
- development of a list of potential sites,
- data collection for potential sites,
- field visit for local verification and identification of potential sites,
- selection of best-ranked sites,
- preliminary environmental impact investigation, and
- final site selection.



4.5.1.1 LOCATION CRITERIA

The SWM Rules, 2016 provide the criteria for the location of a sanitary landfill (Section 4.1 of Part II). It should be verified if further criteria are specified by a regional regulatory agency (e.g., SPCB and PCC). “Guidelines for the Selection of Site for Landfilling” from the Central Pollution Control Board (CPCB) (Annexure 6) should also be referred. It also includes guidance for developing a site sensitivity index potential sites.

Pursuant to guidance in the SWM Rules, 2016 and based on good practices, the following criteria in Table 4.2 are suggested. Construction of sanitary landfills for municipal waste within restricted zones should be avoided at all costs.

Table 4.1: Criteria for Identifying Suitable Land for Sanitary Landfill Sites

S.NO	PLACE	MINIMUM SITING DISTANCE
1	Coastal regulation, wetland, critical habitat areas, sensitive eco-fragile areas, and flood plains as recorded for the last 100 years	Sanitary landfill site not permitted within these identified areas
2	Rivers	100 metres (m) away from the flood plain
3	Pond, lakes, water bodies	200 m
3	Non-meandering water channel (canal, drainage, etc.)	30 m
4	Highway or railway line, water supply wells	500 m from center line
5	Habitation	All landfill facilities: 500 m
6	Earthquake zone	500 m from fault line fracture*
7	Flood prone area	Sanitary landfill site not permitted
8	Water table (highest level)	The bottom liner of the landfill should be above 2 m from the highest water table
9	Airport	20 km**
* The urban local bodies (ULBs) located in seismic zone 4 and zone 5 should consult the seismic fault map before finalising the site for the sanitary landfill. They should also ensure that when the sanitary landfill is designed, the seismic factors are taken into consideration in determining the stability of the landfill structure.		
** In a special case, a landfill site may be set up within 10-20 km away from the airport or airbase if there is no objection certificate from the civil aviation authority or air force as the case may be.		

4.5.1.2 SEARCH AREA

In an event where potential sites for MSW landfill facilities are not demarcated by the Town Planning Department, the ULB should delineate an appropriate search area, which should ideally be located within the municipal boundary. The extent of the search area is usually governed by the economics of waste transportation (Section 2.3.12 of Part II). The Town Planning Department and other concerned authorities should be consulted while demarcating the search area.

Search areas help in identifying potential sites for sanitary landfill by delineating waste generating unit as a centre

4.5.1.3 DEVELOPMENT OF A LIST OF POTENTIAL SITES

After demarcating the search area and considering the various locational criteria, areas having potential for site development should be identified while mapping. A road map may be used to show the potential sites that satisfy the locational criteria.

In areas where land is scarce, degraded sites such as abandoned quarry sites or old waste dumpsites can be considered. Special design measures are required for such sites.

The values in Table 4.3 can be used as rough guidance or estimation for the required sanitary landfill area including the related infrastructure.

Table 4.2: Rough Guidance for Sanitary Landfill Sizes²

WASTE QUANTITY (TONNES PER DESIGN LIFE OF LANDFILL)		REQUIRED SITE AREA (HA)
in million	in lakhs	
< 1.0	< 10	15-20
1.0 - 2.0	10 - 20	20-30
2.0 - 3.0	20 - 30	30-40
> 3.0	> 30	> 40

4.5.1.4 DATA COLLECTION FOR POTENTIAL SITES

In order to identify the suitability of potential landfill sites in the search area, a map screening will be conducted by applying more detailed selection criteria and analysing site specific data. The objective is to exclude unsuitable areas which do not meet specified criteria. Maps and other available sources of information as tabulated in Table 4.4 may be used to support this secondary selection process:

Table 4.3: Data Collection and Sources³

S. NO.	DATA	INFORMATION	SOURCES
1	Topographic maps	The topography indicates low and high areas, natural surface water drainage patterns, streams, and rivers as well as roads, railways, and location of airports.	Survey of India
2	Soil maps	These maps, primarily meant for agricultural use, show the types of soil near the surface.	Indian Agricultural Research Institute (IARI)
3	Land use plans	These plans are useful in delineating areas with definite zoning restrictions. There may be restrictions on the use of agricultural land or forest land for sanitary landfill purposes.	Town planning authority or municipality.

² Developed by the Expert Committee for revision of MSWM manual (2013-15)

³ Ibid.

Potential sites for sanitary landfill development should also conform to the long-term land use goals

Map screening results in generating plans that indicate areas to be considered and areas that do not meet site selection criteria. Considered areas will require further investigations before they are finalised



Table 4.4: Data Collection and Sources [contd.]

S. NO.	DATA	INFORMATION	SOURCES
4	Water use plans	The plans indicating the following items: • private and public drinking water wells, • drinking water supply line(s), • wells located on surface water bodies and open wells, and • protection areas for drinking water.	
5	Flood plain maps	These maps are used to delineate areas that are within a 100 year flood plain.	Irrigation Department
6	Geologic maps	These maps indicate geologic features and bedrock levels. They may be used to identify predominantly sandy or clayey areas.	Geological Survey of India (GSI)
7	Aerial photographs, satellite imagery, Google maps	These can identify surface features such as small lakes, intermittent stream beds, and current land use, which may not have been identified in earlier map searches.	
8	Groundwater maps	These maps indicate the depth to groundwater as well as regional groundwater flow patterns.	Ground water boards or minor irrigation tube well corporations.
9	Rainfall data	Precipitation data are used for designing the amount of possible leachate in cities.	Indian Meteorological Department (IMD)
10	Wind rose maps	Wind rose maps indicate the predominant wind direction in the area, based on which the location and orientation of the landfill footprint has to be decided.	Indian Meteorological Department (IMD)
11	Seismic data	The seismic activity of a region has to be considered in the design of sanitary landfills; landfills should ideally not be located in zone 5 seismic zone. However, in case of siting in zone 5, complete structural analysis should be carried out for designing the landfill and the design should include appropriate structural controls.	GSI or National Geophysical Research Institute (NGRI)
12	Road maps	Road maps indicate accessibility of the potential site.	

Authorities and other relevant stakeholders may be asked to provide further information. The map screening excludes large unfavourable zones from further consideration and focuses on promising zones (e.g., areas away from settlements, hydro-geologically favourable etc.). All areas that do not meet specified criteria will be indicated in a constraint map.



The result of the map screening will be a plan (or plans) showing exclusionary (negative) areas as well as areas where further investigation (positive zones) is meaningful.

4.5.1.5 FIELD VISIT FOR LOCAL VERIFICATION AND IDENTIFICATION OF POTENTIAL SITES

A site reconnaissance will be conducted by a site visit as part of the preliminary data collection and map screening. All features observed in various maps will be confirmed.

The possible sites should be evaluated on the basis of the topographical conditions and the suitability of the landfill site, namely:

- a) sufficient land size;
- b) flat area with low inclination;
- c) connection to highways and conditions of the access roads;
- d) flooding during monsoons;
- e) land use and soil type;
- f) depth to groundwater table (as observed in open wells or bore wells)
- g) information on the sub-ground from clay, stone, or sand pits;
- h) crossing of electrical lines; and
- i) actual settlement patterns (eventual new or informal settlements).

4.5.1.6 SELECTION OF BEST RANKED SITES

CPCB, in 2003, developed the guidelines for selection of site for landfilling. These guidelines helped in the selection of most appropriate sites based on a Site Sensitivity Index. Once these sites are identified, they can be ranked on the basis of a defined criteria for the preliminary environmental impact investigation and final site selection as detailed in the following sections (Annexure 6).

4.5.1.7 PRELIMINARY ENVIRONMENTAL IMPACT INVESTIGATION

On the basis of the ranking scores of various sites, two or three sites may be chosen for a preliminary environmental impact investigation.

The impact of the sanitary landfill will be assessed and potentially quantified according to the national rules and the local conditions.

The preliminary environmental investigation should conclude in a rough comparison of assessed alternative sites among themselves as well as with the null alternative (i.e., if the project was not carried out) and suitability of the sites.



4.5.1.8 FINAL SITE SELECTION

The final selection of the site from amongst the best-ranked alternatives should be done by comparing:

- a) environmental impact,
- b) social acceptance,
- c) land availability,
- d) transportation costs, and
- e) sanitary landfilling costs (site specific costs are to be considered).

Transportation costs may be compared on the basis of average hauling distance from the centre of the waste generating area.

In general, the material costs for liner system, leachate collection system, daily covers, final cover system, and all facilities are similar for all sites, considering normal site conditions (this shall change in areas of high water table, in hilly areas, and other peculiar issues). The main differences include:

- distance of the access road to regional road system;
- sub-ground conditions for earthworks to prepare the base of filling area; and
- distance to waste generators and waste processing facilities.

In-depth information on site parameters beyond those of the site selection process is necessary for the adequate design of the sanitary landfill.

4.5.1.9 SITE INVESTIGATION AND SITE CHARACTERISATION

In-depth information on site parameters beyond those of the site selection process is necessary for the adequate design of the sanitary landfill at the selected site. A proper site investigation programme comprises:

- subsoil investigation,
- groundwater or hydrogeological investigation,
- surface water investigation,
- topographical investigation,
- environmental investigation, and
- traffic investigation.

Landfill design is dependent on all the above features. Hydrogeological and surface water investigations are critical for determining the detailed design of the landfill, and groundwater and surface water quality are

Transportation costs of waste to landfill plays a critical role in the selection of landfill site



to be monitored regularly during the active life and post-closure of the landfill to ensure fail-safe performance of the landfill.

Hydrogeological assessment:

An assessment of the hydrogeological settings of a landfilling site is necessary to ensure that the site is conducive to the proposed design of the landfill, which should be in line with the specifications of the SWM Rules, 2016. Such an assessment should also be used to develop effective groundwater and leachate monitoring plans.

The hydrogeological assessment should include the following:

- obtaining samples to characterise soil or bedrock conditions,
- mapping groundwater depth and pressure within the site, and
- assessing baseline groundwater quality.

The identification of unsuitable soils that would not support the overburden of the proposed fill height is possible through such an analysis. An analysis of the groundwater flow and pressure should result in the determination of groundwater flow paths and inform leachate control mechanisms and contingency plans for failure of the leachate liner. Future monitoring of groundwater quality should be against a reference of baseline conditions.

Within the site, the location of the boreholes should be along the groundwater flow path, both hydraulically upgrade and downgrade to the footprint of the landfill, at least 5 meters away from the footprint of the landfill. In addition, groundwater monitoring as per specifications in the SWM Rules, 2016 is mandated. The design of the landfill should consider this hydrogeological information to prevent failure of containment.



The objectives of a hydrogeological assessment are to:

- (i) determine the physical, hydraulic, and chemical properties of the surface material and bedrock where appropriate;
- (ii) define groundwater flow characteristics and potential contaminant migration pathways;
- (iii) determine the structural integrity of the subgrade to support the landfill including its construction and any overlying facilities;
- (iv) determine the availability and suitability of the soil for cover and liner uses;
- (v) establish a groundwater monitoring network; and
- (vi) determine the feasibility of the contingency plans for contaminant control.

The hydrogeological investigation report for a site should include:

- i. ground surface contour plan showing surface watercourses and surface water bodies;
- ii. a contour plan of the water table, showing expected directions of groundwater movement;
- iii. piezometric contour plans for each aquifer, showing expected directions of groundwater movement;
- iv. a description of any aquifers and their interconnection, with generalised estimates of groundwater flow, and the potential flow paths and contaminant attenuation capabilities in the event leachate leaves the waste fill area in planned or unplanned quantities;
- v. a description of the background quality of the groundwater, and the existing and potential uses of the groundwater;
- vi. site plans and cross sections of the hydrogeological conditions;
- vii. the identification of any unstable soils or unstable bedrock; and
- viii. a water balance analysis considering precipitation, surface water drainage, infiltration, groundwater flow, exfiltration, and evapotranspiration.

Surface Water Assessment:

An assessment of the surface water conditions on the proposed landfill site and in the vicinity of the site (500 m) is required to ensure a stable landfill that is not impacted by or impacts surface water.



The design of the site should include a plan to control runoff from the site and to prevent erosion and sedimentation downstream due to on-site activities. A surface water monitoring plan should be established for identifying surface water quality impacts, both on-site and off-site. Contingency plans should be prepared to control surface water impacts resulting from the production of leachate in a quantity greater than expected or with a quality worse than expected.

The surface water assessment report should include:

- a general description of the surface water features of the area (watershed) in which the site is located and the surface water features in the vicinity of the site (flood plains, natural watercourses and water bodies, municipal drains, drainage paths, and boundaries); and
- a detailed surface water investigation to assess water quality, quantity, and habitat conditions (e.g., benthic community inventory) of the surface water features identified on the site, any surface water features flowing through the site, and any surface water features receiving discharge from the site, including:



- a. an interpretation of the results of the detailed surface water investigation including:
 - (i) plans showing all existing surface water features; and
 - (ii) a description of current surface water quality, and the existing and proposed surface water uses.
- b. a site drainage plan showing the drainage of surface water at the site before the site is established, during operation of the site, and following site closure;
- c. plans, specifications and descriptions of the design features, control facilities and operational procedures to isolate, contain, convey, control or treat the surface water, on and off site, prior to its discharge to the receiving watercourse(s). The plans, specifications and descriptions should consider both clean surface water, sources (off-site and on-site flows separated from landfill operations through control mechanisms like berms and ditches) and potentially contaminated storm water (on-site flows originating from landfill areas);
- d. the design and location of any surface water control facilities, such as berms, swales, ditches, control ponds or other facilities for the control of the quality and quantity of surface water from the site. The design should be sufficient to convey peak flow volumes from a 25 year design storm. However external storm water conveyance mechanisms should be able to transport peak flows from a 100 year design storm.



Life of a sanitary landfill comprises the following:

- Active period: 20–25 years
- Closure and post-closure period: 15 years more after active period

4.5.2 SANITARY LANDFILL DESIGN

4.5.2.1 DESIGN LIFE

The life of a sanitary landfill comprises of an active period and a closure and post-closure period. The active period may typically range from 20 to 25 years depending on the availability of land area. The closure and post-closure period, for which a sanitary landfill will be monitored and maintained, will be 15 years and more after the active period is completed.

4.5.2.2 SPECIFIC WASTE VOLUME: SANITARY LANDFILL CAPACITY AND AREA

A rough capacity needs assessment was already conducted as the first step of the site selection process. An in-depth capacity calculation will be the first step in the design process, taking into account the municipal solid waste management (MSWM) plan and computed waste amounts for the active period of the sanitary landfill.



Landfill volume estimates are necessary for planning and determining the dimensions of the new landfill



Density of waste material in landfill will depend on refuse compaction, moisture content, and the degree of compaction



Amount of soil necessary for daily and final cover must be added to the refuse volume amount to obtain final landfill space projection



Planners and operators must carefully plan new facilities and optimise the design criteria that adhere to technical and environmental considerations

Based on the MSWM plan, the volume of waste in a sanitary landfill should be roughly calculated under the following assumptions:

- 1 tonne of waste is equivalent to 1 cubic metre (m^3) of sanitary landfill volume. (In reality, the specific weight of waste in a sanitary landfill is 0.8 t/m^3 during the first years and will increase after settlement over the time to 1.2 t/m^3 .)
- Covering of waste will use about 10% more volume.

The total sanitary landfill area (for details, see next section) would be larger than the area required for the filling area to accommodate all infrastructure and support facilities as well as to allow the formation of a green belt around the sanitary landfill.

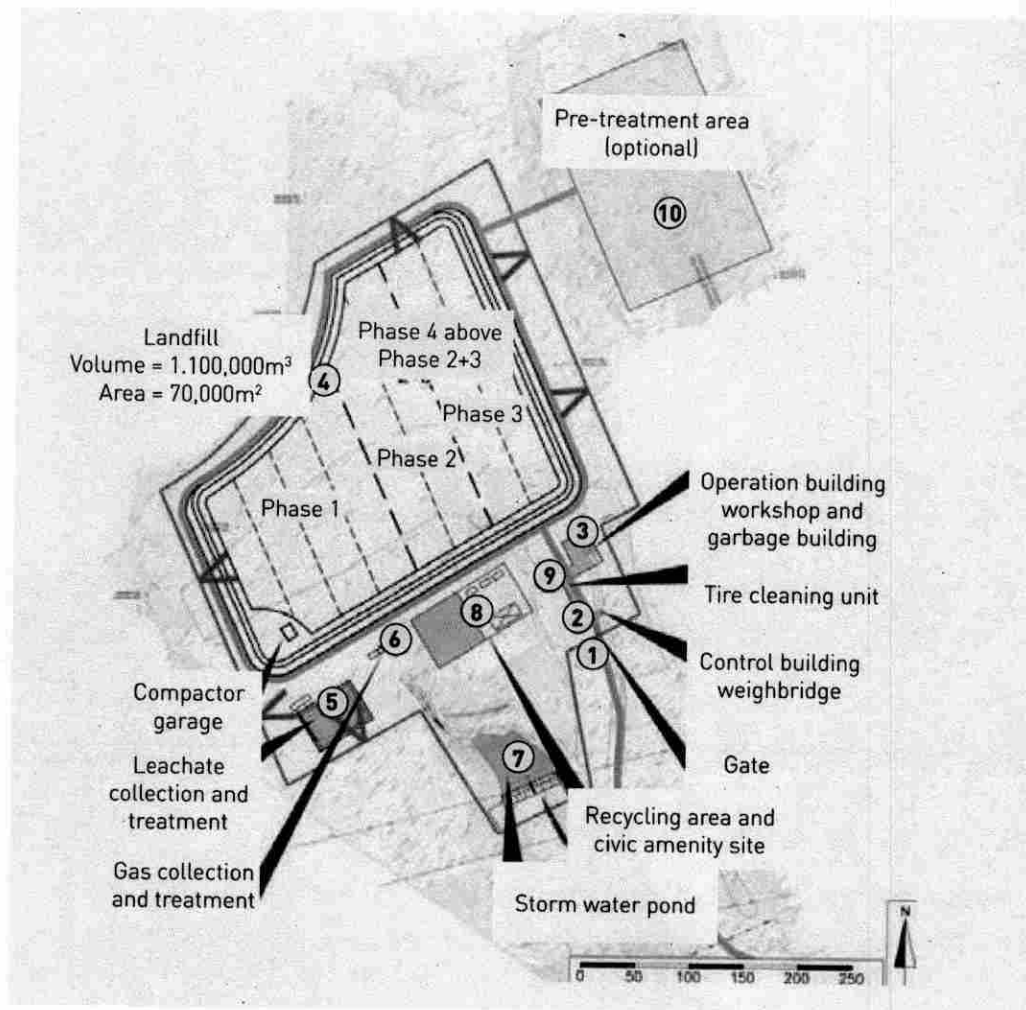
From an economical viewpoint, a small base area with a high sanitary landfill is preferable, because it reduces considerably the cost for the sealing systems, leachate collection system, and operational roads. The generation of leachate and the related costs will also decrease.

From a technical viewpoint, it is important to guarantee the runoff of rainwater. Therefore, minimum inclinations have to be maintained at the slopes. Every footprint of the disposal area of a landfill will have to maintain a certain minimum height to meet these inclination requirements. The height of the sanitary landfill is also constrained by the overburden pressure on the soil; it should be within acceptable limits.

From an environmental viewpoint, sanitary landfills with considerable heights can interfere with the landscape and cause visual disturbance. However, restricting the height would result in larger landfill footprints, requiring larger tracts of land. The larger the base of the landfill, the higher is the risk of leachate contamination of groundwater.

4.5.2.3 SANITARY LANDFILL LAYOUT

As mentioned above, a sanitary landfill site comprises an area in which the waste will be filled and an additional area for support facilities. Within the area to be filled, usually only a part is under active disposal in a specific phase of operation. Figure 4.2 depicts a typical layout of a sanitary landfill.

Figure 4.2: Typical Sanitary Landfill Layout with Facilities⁴

The following facilities must be located in the layout:

- access roads,
- equipment shelters,
- weighing scales,
- office space,
- location of waste inspection and transfer station (if used),
- temporary waste storage or disposal sites for special waste including domestic hazardous waste,
- areas to be used for waste processing (e.g., shredding),
- demarcation of the sanitary landfill areas and areas for stockpiling cover material and liner material,
- drainage facilities,
- location of sanitary landfill gas management facilities,

⁴ Internal GIZ document for preparation of MSWM manual, GIZ-IGEP (2014).

- location of leachate treatment facilities,
- location of monitoring wells, and
- tyre cleaning unit.

For each sanitary landfill site, a layout has to be designed incorporating all these facilities. The layout will be governed by the shape of the sanitary landfill area.

The technical design specifications of sanitary landfill focus on efficient leachate management

4.5.2.4 TECHNICAL DESIGN REQUIREMENTS

The design of the sanitary landfill focuses on optimised leachate management, as leachate is a main source of potential environmental pollution. It is important to minimise leachate generation and to avoid leachate being retained for a long time in the landfill body.

A landfill can be both above ground or partially below ground, based on the local hydro-geological situation and the availability of land. Where abandoned quarries are to be used as potential sanitary landfill sites, the landfill could be below ground, depending on the site situation.

Above ground landfills have the advantage that leachate flows by gravity according to the natural surface slope; leachate is collected in the main leachate pipe (header pipe), which is laid to extend beyond the footprint of the landfill. Leachate is pumped only from outside the footprint of the landfill.

If water table is not close to the ground surface, landfill base can be at a level below the ground, by excavation, to accommodate more waste per unit area of land.

However, below ground landfills are to be engineered and constructed appropriately to address the following issues:

- additional costs for excavation;
- the need to pump leachate during and beyond the active life of the landfill;
- environmental risks caused by nonfunctional pumps;
- potential for retention of leachate in the waste body;
- no possibility of pipe cleansing and controlling; and
- pumping cost for the leachate during the lifetime and the aftercare phase of the landfill.

Landfill constructed above ground faces minimal environmental impacts as leachate could be easily drained and collected for further treatment

Sanitary Landfills in Hilly Regions

In hilly regions, it is usually not possible to find flat ground for sanitary landfills. Slope sanitary landfills and valley sanitary landfills have to adapt to the topographical conditions. In a slope sanitary landfill, waste is placed along the sides of existing hill slope. Control of inflowing water from hillside slopes is a critical factor in design of such sanitary landfills.

The design of these landfills needs additional site investigations and calculations. Furthermore, the sealing system has to adapt to the regional conditions. If adequate quantity of clay or fine soil is not available and the soil has permeability in excess of 1×10^{-7} cm/sec, use of additional layers of geosynthetics, geocomposites, or geosynthetic clay liners can be considered along with the locally available low permeability soil. The requirement of 90 cm clay (of best available quality locally) should be complied with, and the overall equivalence of such design of soil and additional layers will be checked and certified by geotechnical experts. Where required, soils amended with bentonite may be used to meet design specifications.

Sanitary Landfills in Marshy Regions

Sanitary landfills should not be constructed in marshy areas; the local authority should access a regional landfill facility outside the marshy area.

4.5.2.5 BASE SEALING SYSTEM

The shape of the site should be adapted to the existing conditions with a minimum of fills and cuts. However, the mass which will be replaced by the sealing system has to be excavated.

For construction of the landfill geometry and the planned landfill embankments, soil material is required, which can be taken from the excavation part for the base sealing system. The remaining excavated soil should be stored for covering of waste during landfill operation.

The natural soil should be levelled and compacted to achieve 90% maximum dry density as obtained from Proctor compaction tests. This is sufficient to compact the overlying clay liner.

The base area has to have a sufficient slope to guarantee draining of leachate and storm water. Minimum inclinations are indicated in Table 4.5.

Excavated soil could be used as a potential base sealing system and can also be compacted to be used as overlying clay liner

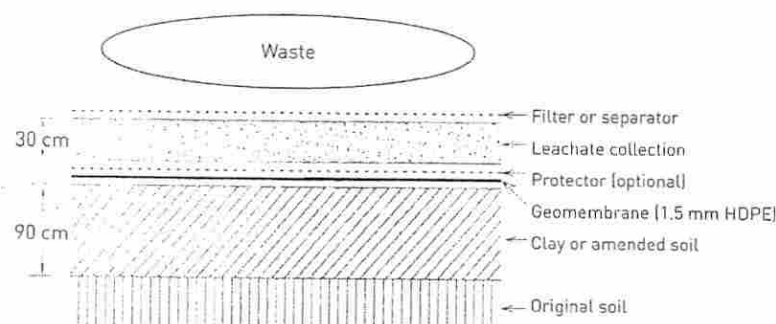


Table 4.4: Minimum Slopes Inside the Sanitary Landfill⁵

AREA	MINIMUM INCLINATION
Base sealing	3 % for leachate pipes, roof profile
Main leachate pipe	1.0 %
Secondary leachate pipe	3.0 %
Final slopes	Not steeper than 1V: 4H and not flatter than 1V: 20H

The composition of the base sealing system has to be in compliance with SWM Rules, 2016 and should consist of the following:

- **Mineral sealing liner:** It comprises three layers of clay or equivalent amended soil, at least 30 centimetres (cm) thickness each. In case adequate clay is not found in the vicinity, amended soil mixed with bentonite can be used. The permeability of the mineral sealing must be less than $k_f \leq 1 \times 10^{-7}$ cm per second (cm/s).
- **Geosynthetic clay liner:** In hilly regions, the mineral part of the sealing system can be reinforced by a geosynthetic clay liner (see box below), if clay or natural soil for bentonite mixture is not available in sufficient quantity at an acceptable transportation distance.
- **High-density polyethylene geomembrane:** The high-density polyethylene (HDPE) geomembrane should have a standardised thickness of 1.5 millimeter (mm). Only HDPE geomembranes that comply with the requirements of American Society for Testing and Materials (ASTM) or corresponding standards should be used.
- **Protection layer:** A protection layer (of silty soil) should be 20–30 cm thick or, alternatively, a protection layer (geotextile) should be 400 grams per square meter (g/m^2) for bottom liner and 200 g/m^2 for top cover, depending on the landfill height. If the planned height (height + depth) of the landfill is more than 20 m, geotextile should be 800 g/m^2 .
- **Leachate drainage layer:** A leachate drainage layer should be 30 cm thick made of filter gravel, ensuring a permeability greater than 10-2 cm/sec.

Figure 4.3: Base Liner⁶

⁵ Developed by the Expert Committee for revision of MSWM manual (2013-15)

⁶ Guidelines and Check-list for evaluation of MSW Landfills proposals with Information on existing landfills, CPCB (2008). Available at: http://cpcb.nic.in/upload/NewItems/NewItem_133_MSWM-REPORT.pdf

Use of Geosynthetic Clay Liner for Municipal Solid Waste Landfill

Geosynthetic clay liner (GCL) is engineered to provide an impermeable barrier and can supplement the usage of a 90 cm thick mineral layer (clay) in the landfill base and cover. It consists of bentonite clay bonded to a layer or layers of geosynthetics.



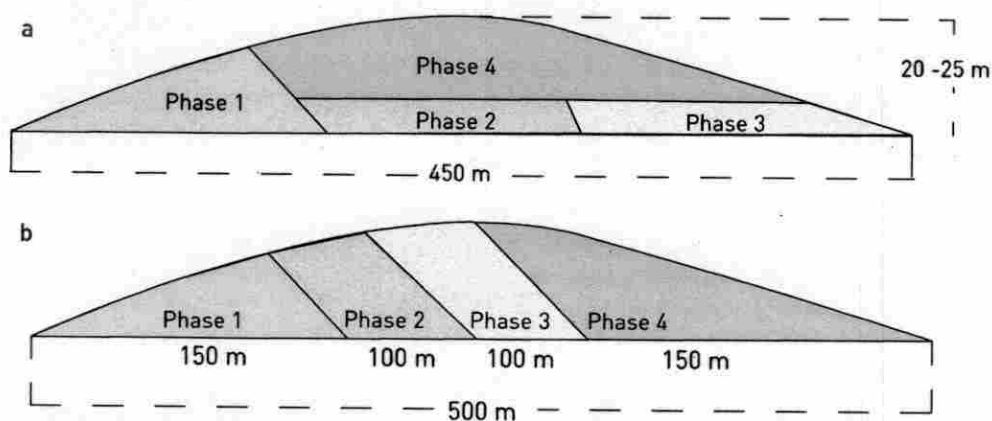
Bentonite (sodium montmorillonite) is volcanic clay used in a number of applications including GCL. In India, calcium bentonite, which has attributes similar to sodium bentonite, is commonly used.

GCL is typically bentonite sandwiched between geotextiles. It may be further reinforced by an additional layer of high-density polyethylene (HDPE) liner.

4.5.2.6 LANDFILL PHASING

The excavation of the landfill base should be phased in accordance with a predetermined phasing plan. To minimise damage to the landfill base layers, ensure continued integrity of base layers over the lifetime of the landfill, and minimise potential rainfall infiltration. The extent of each phase is designed so that the proposed waste fill volume (based on extent of base and waste fill contours) should be large enough for at least 1 year. Figure 4.4 shows indicative phasing schemes; depending on site conditions, either of the approaches may be followed. Phasing the landfill should be a site-specific decision, the below schemes are only indicative in nature.

Figure 4.4: a and b: Longitudinal Section Profile of Landfill Phasing (Not to Scale)⁷



It should be noted that phase base for phase 2 shall be excavated and prepared 6 months before the final contours of phase 1 are reached. Typically, at least 6 months is required for base preparation for each phase. In year 1, phase 1 is considered the active phase and phase 2

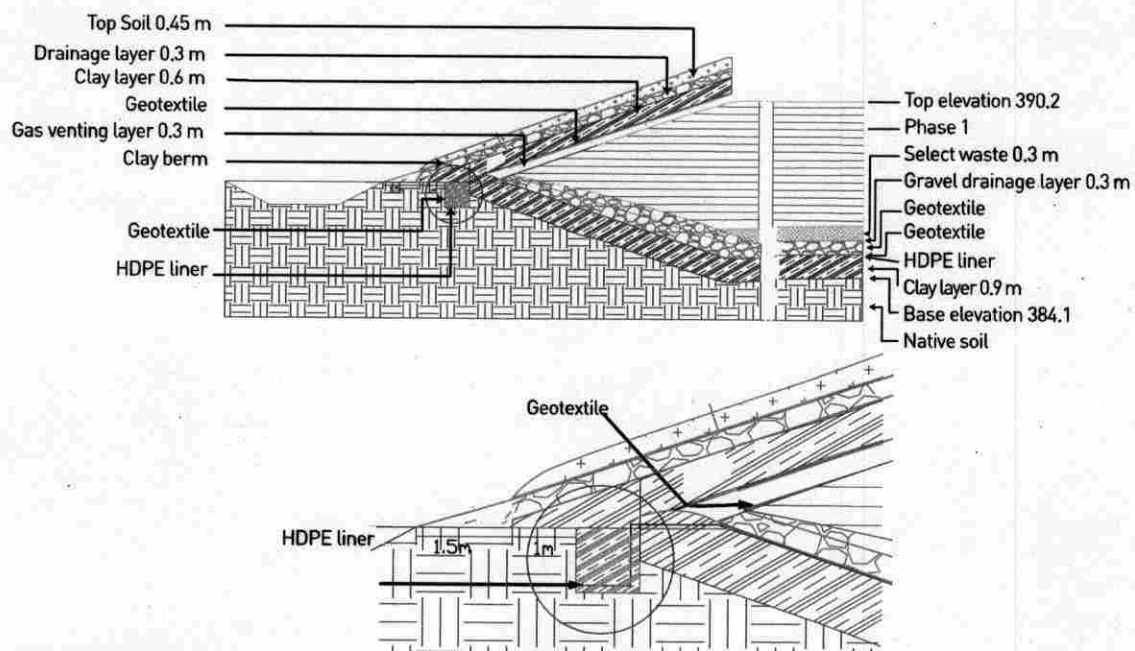
7 Developed by the Expert Committee for revision of MSWM manual (2013-15)

as the phase under preparation. Phase 3 is to be excavated and base prepared only when 6 months of landfill capacity is left for phase 2.

The phases of the landfill, which include the edge of the landfill, have certain specific construction needs:

- (i) The base clay liner should be integrated with the clay barrier layer on the top cover.
- (ii) A granular blanket layer, which is an extension to the drainage layer of the leachate collection system (LCS) along the side slopes of the base, should be prepared. This granular blanket layer is required to prevent the entry of any rainfall runoff into the waste layers from the periphery of the landfill.
- (iii) The geotextile and HDPE liner should be tucked into the trench along the periphery of the landfill until the top cover is built to maintain stability and integrity of the liner as illustrated in Figure 4.5. Once the top cover is placed, the HDPE liner will remain in the trench, but the geotextile will be turned in and taken below the gravel layer of the gas venting layer.

Figure 4.5: Liner Placement at the Edges of the Landfill⁸



At the end of each phase, until the edge of the fill is reached, the HDPE and the geotextile of the liner are tucked into a trench, a temporary road ramp into the landfill is prepared beyond the trench, and a clay berm is constructed beyond this road to prevent runoff entering into the active phase or cell area.

⁸ Developed by the Expert Committee for revision of MSWM manual (2013-15)

The first layers of waste above the liner layers are always made up of select waste (30 cm). Select waste is defined as waste which has no sharp objects and hard debris in it and has a size range not exceeding 2 cm. The side slopes of the base have an extra layer of granular soil to prevent infiltration of any water into the waste. This layer acts as a granular drainage blanket and drains any water into the leachate collection layer.

Once the top fill contours are reached during any phase, corresponding portion of the top cover layers is also laid.

4.5.2.7 LEACHATE MANAGEMENT

One of the most important objectives of a successful landfill management system is to avoid leachate generation as far as possible and to efficiently drain the leachate contained in the waste body and from other contaminated areas. As per the SWM Rules, organic and hazardous wastes should be diverted away from the landfill.

4.5.2.7.1 Leachate Generation

The principal sources of leachate include:

- (i) moisture content of waste entering the landfill,
- (ii) infiltration from direct precipitation on the waste surface,
- (iii) sealed areas of landfill which are only partially covered with waste, and
- (iv) surface water flow onto the active face of the landfill.

To minimize the generation of leachate, the system should be designed in a way that only filled areas and currently operated areas are connected to the leachate collection system. The other sections should be connected to storm water ditches by using a storm water bypass system. Therefore, the sealed landfill area should be divided into strips of several filling sections.

Leachate generation amount should be estimated based on runoff coefficient and other data for efficient planning of leachate treatment system

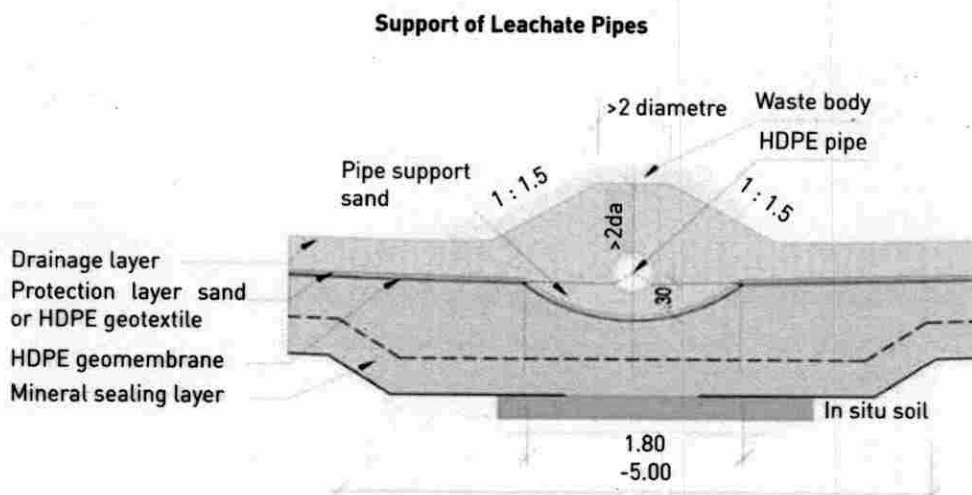
4.5.2.7.2 Leachate Collection

While designing the leachate collection system (LCS), it should be remembered that (i) a huge load would sit on top of this system and (ii) the system has to be operational for at least 15 years after final closure of the sanitary landfill. The base sealing system of the landfill should have a roof profile with a slope to the side or embankment. The leachate from the waste body will be collected in the drainage layer system and in the secondary drain pipes made of HDPE and will be directed to the main leachate pipes outside the waste body. The LCS consists of three main components: (i) a drainage layer, (ii) a series of collection pipes,



and (iii) a nonwoven geotextile (punched) separator layer as illustrated in Figure 4.6. The LCS layer is also to be laid along with the base, according to the phasing plan.

Figure 4.6: Support of Leachate Pipes⁹



The leachate collection system and its components are to be laid over the HDPE geomembrane.

Gravel Drainage Layer

The LCS layer consists of a 30 cm thick gravel drainage layer of 25–50 mm rounded gravel. The slope of the gravel drainage layer follows the minimum slopes required for the leachate collection system and inclines toward the collection point.

LCS Pipes

Drain pipes are made of HDPE and slotted or holed on 2/3 of the pipe circumference. The diameter should be minimum 200 mm for secondary and 250 mm for main leachate pipes. The mentioned diameters should not undercut to allow controlling by remote camera systems. The wall thickness of pipes has to be calculated under the consideration of the overburden stress due to filling height of waste.

Perforated HDPE pipes are embedded in this gravel layer. The networks of HDPE pipes collect the leachate and are connected to a LCS sump(s). Leachate from the sump(s) is to be pumped to the proposed leachate treatment plan for disposal.

The specified distance between the secondary drain pipes should be around 40 m.

⁹ Internal GIZ document for preparation of MSWM manual, GIZ-IGEP (2014).

At the end of the secondary leachate collection pipes, access windows for inspection and cleansing of pipes should be installed. The HDPE pipes are connected by welding.



Example Calculation: Estimation of Leachate Generation

Average Total Precipitation in Delhi	= 750 mm/year
Plan area of operating phase	= 10000 sq.m.
Assuming 80% precipitation in 4 months (monsoon period)	= 600 mm/4 months
Peak leachate Quantity (thumb rule basis) = $(0.6 \times 10000) / 120$	= 50 cu.m. per day

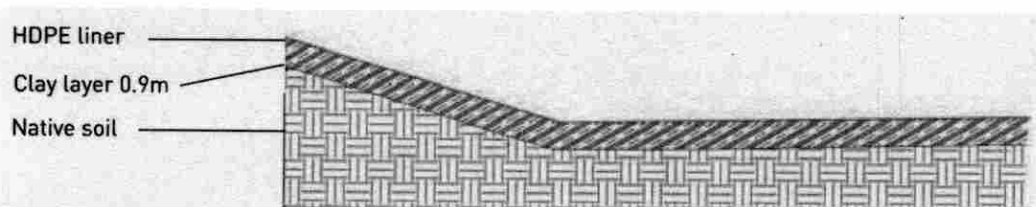
Geotextile Layer

Further protection from clogging in the LCS will be provided by a nonwoven geotextile installed above the entire stone drainage blanket. The geotextiles on top of the stone act as a separator layer between the drainage blanket and the solid waste and also provides additional filtering capacity to help maintain the high permeability of the underlying drainage layer.

At no time should vehicles be allowed to pass over the geotextile without a buffer layer in between.

The entire process of construction and arrangement of leachate collection system is illustrated in Figures 4.7–4.9. The leachate collection pipes could either rise along the side slopes of the landfill base as shown in Figure 4.9a, or through the liner as shown in Figure 4.9b. The leachate collection sumps, in some cases, are located within the foot print of the landfill as shown in Figure 4.9c. The actual design configuration should be according to the local site conditions and height and depth of the landfill.

Figure 4.7: Placement of the High density Polyethylene Liner over the Clay Liner¹⁰



¹⁰ Developed by the Expert Committee for revision of MSWM manual (2013-15)

Figure 4.8: Placement of the Gravel Drainage Layer and Geotextile over the Clay Liner¹¹

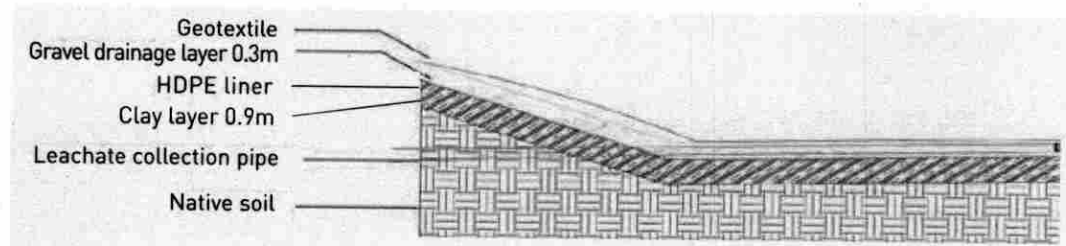


Figure 4.9a: Leachate Collection Pipes Connected to a Sump (through the liner)¹²

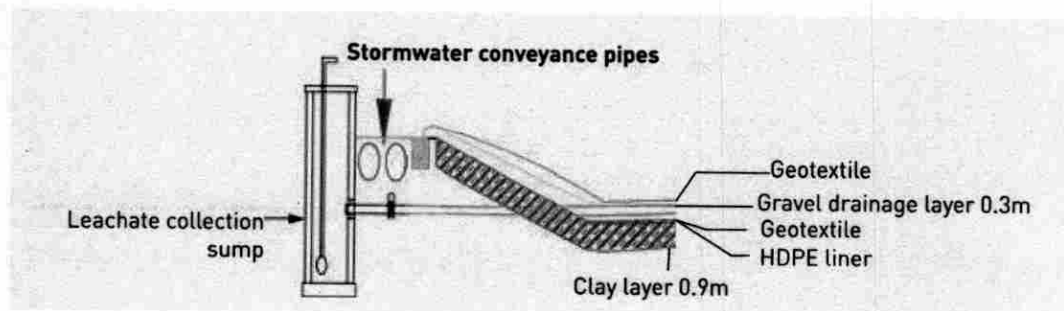
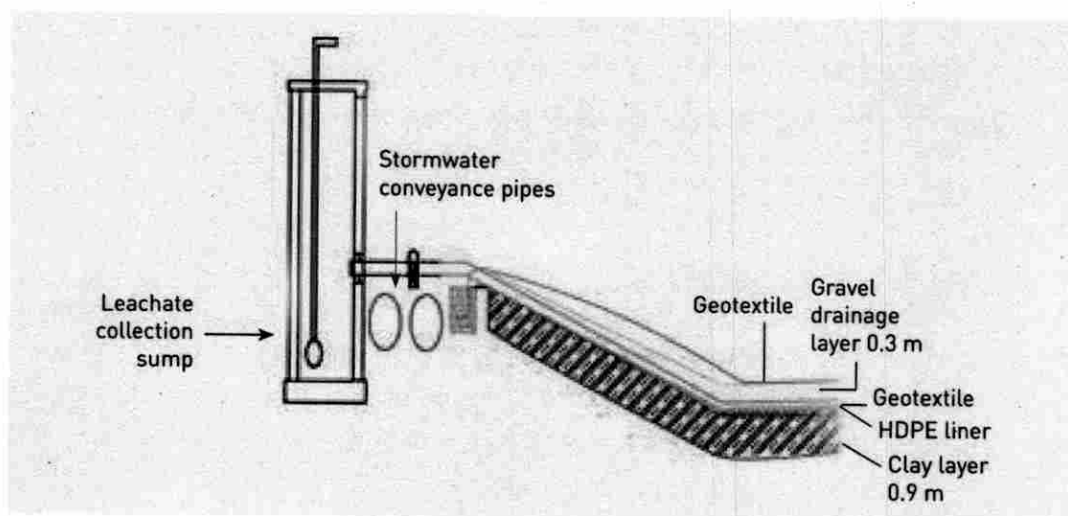


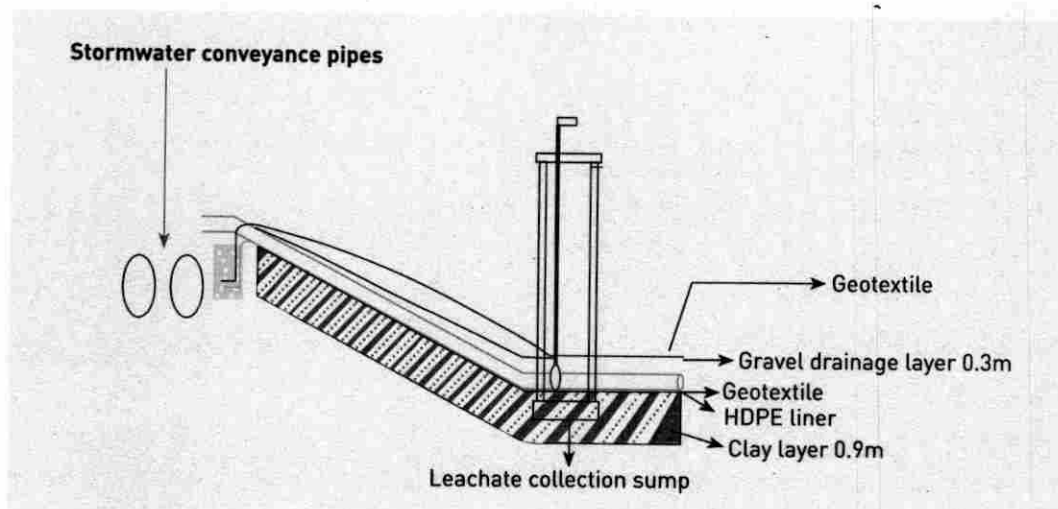
Figure 4.9b: Leachate Collection Pipes Connected to a Sump (through a riser on the side slopes)



11 Ibid.

12 Ibid.

Figure 4.9c: Leachate Collection Pipes Connected to a Sump (sump within the footprint of the landfill)¹³



The primary criterion for design of the leachate collection system is that all leachate should be collected and removed from the landfill at a rate sufficient to prevent a hydraulic head greater than 12 inches from occurring at any point over the lining system. The system is designed to remove the accumulation of storm water resulting from a 25-year, 24-hour storm, within 72 hours. Other design criteria include the following:

- Bottom of the leak detection layer and the leachate collection layer is sloped at a minimum 2%;
- Granular drainage layer is 1 foot thick with hydraulic conductivity of $>1 \times 10^{-2}$ cm/s;
- The system must be designed to minimise clogging;
- The system is located above the seasonally high water table;
- System must be designed to handle the runoff from a 25-year, 24-hour storm.

4.5.2.7.3 Leachate Pond

The leachate pond is a basin to retain and pre-treat leachate within several days. The pond allows sedimentation and biological stabilisation. Organic pollutants in the leachate are removed by microorganisms and by sedimentation processes. At the bottom of the pond, a mixture of mud and water will be settled and pumped to the landfill when the pond is cleaned.

The leachate pond should have two basins to achieve an optimal leachate management (Figure 4.10). Division of the leachate pond into two individual ponds will make it possible to clean the ponds and their associated pipes. One basin might be cleaned or repaired while

Leachate ponds help in sedimentation and biological stabilisation of leachate.

¹³ Ibid.

the other stays operational. The pond will be a necessary base for all further treatment methods.

Leachate could be

- discharged to waste water treatment system for co-treatment
- recirculated through the landfill
- treated using biological or physicochemical treatment
- evaporated in solar ponds

Figure 4.10: Sealed Leachate Pond with Two Basins¹⁴



4.5.2.7.4 Leachate Treatment

The type of treatment facilities to be used depends on the leachate characteristics and volume. Typically, treatment may be required (prior to discharge) to reduce the concentration of biodegradable and non-biodegradable organic material, specific hazardous constituents, ammonia and nitrate ions, sulfides, odorous compounds, and suspended solids.

The appropriate leachate treatment scheme would significantly depend on the organic content of the disposed waste. As per the SWM Rules, 2016, biodegradables should not be disposed in landfills. However, due to absence of processing facilities or the presence of organic content in rejects from processing facilities, landfills are not devoid of biodegradable material. The concentrations of these biodegradables would vary from landfill to landfill. Laboratory tests should be conducted to ascertain the quality and constituents of leachate in every landfill.

Based on the chemical characteristics of the leachate, treatment may include biological processes (e.g., aeration, activated sludge, nitrification or denitrification); chemical processes (e.g., oxidation, neutralisation); and physical processes (e.g., air stripping, activated adsorption, ultra filtration, etc.).

A leachate treatment facility should be designed by an experienced landfill engineer in cooperation with a waste water treatment specialist

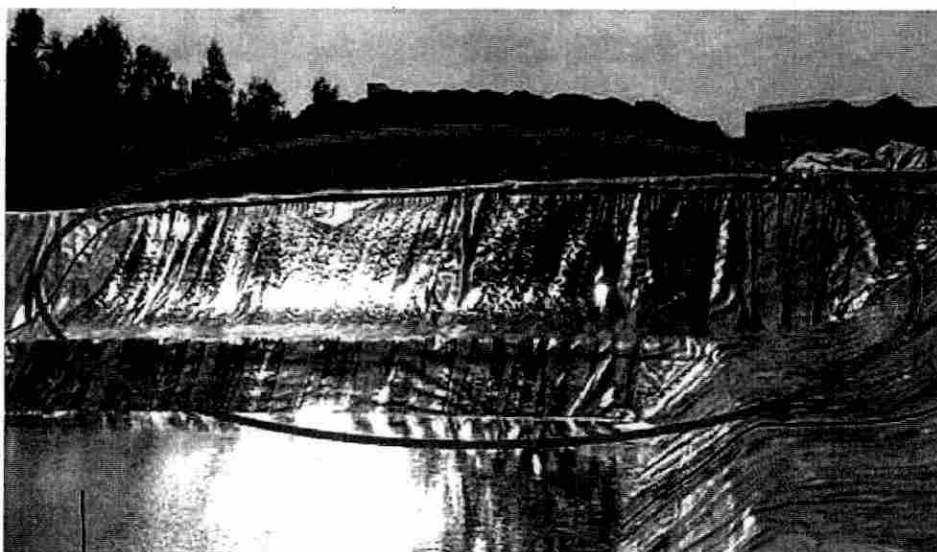
¹⁴ Taken from GIZ-ASEM project (2008).

Leachate treatment of large landfills require substantial area of land as well as investment. In case of smaller landfills, a more practical way could be to take the leachate to the nearest sewage treatment plant (STP). In many countries, co-treatment of leachate with sewage is practiced successfully. However, depending on the age of the waste, the chemical composition of the leachate varies and results in significant loads of different constituents at different times on the STP. The biochemical oxygen demand (BOD) and nitrogen load are critical and should be considered before assessing whether an existing STP can handle incoming leachate.

Evaporation of Leachate:

One of the simple techniques used to manage leachate is to spray it in lined leachate ponds and allow the leachate to evaporate. Additionally, the leachate can be irrigated on the slopes of the pond to intensify the evaporation rate as shown in Figure 4.11.

Figure 4.11: Irrigation of Leachate on the Slopes of the Pond.¹⁵



Such ponds have to be covered with geomembranes during high rainfall periods. The leachate is exposed during the dry and hot months to allow evaporation. Odour control has to be exercised at such ponds. However, spraying should not be done during high wind velocities to check air pollution.

The treated leachate may be discharged to surface water bodies, after ascertaining the quality as per the norms for discharge to inland water systems specified in the SWM Rules, 2016.

¹⁵ Internal GIZ document – Integrated Solid Waste Facility Manual for the operation of the sanitary landfill, GIZ-IGEP (2015).

4.5.2.8 WASTE PLACEMENT

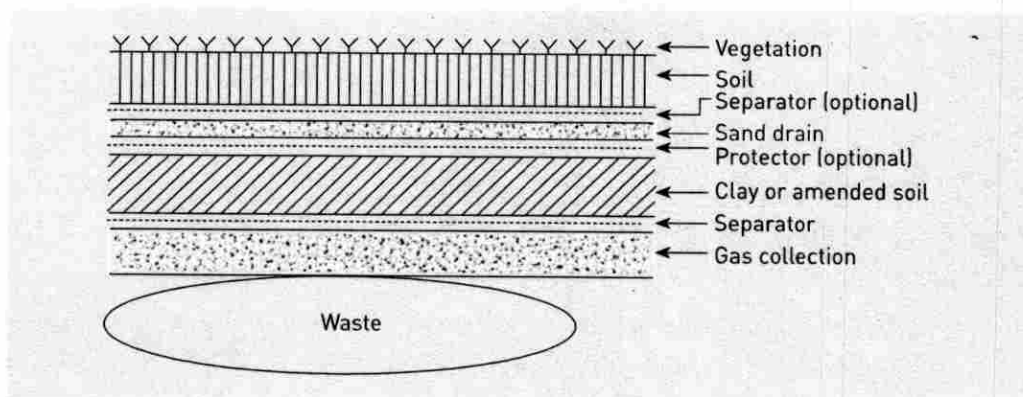
A 30 cm thick layer of select waste will be placed on the geotextile as and when the laying is completed. It is preferable that this select layer of waste be left without compaction. In order to dump subsequent layers of waste, soil should be pushed gently by a light dozer to make a path. Dumping of soil directly on the membrane should be avoided as much as possible. One or two main routes of soil should be created for use by heavier equipment for soil moving with 60–90 cm. Damage to the membrane due to traffic can be severe and undetectable and hence should be avoided at all times. The first lift of waste should be spread and compacted with light vehicles. It is preferable not to compact the first foot of waste. No bulky items should be dumped in the first lift.

4.5.2.9 SURFACE SEALING SYSTEM

The following layers are part of the surface sealing as illustrated in Figure 4.12:

- **Gas drainage layer:** The layer should be a 30 cm thick granular gas drainage layer formed by crushed gravel or crushed demolition waste to facilitate gas collection.
- **Mineral clay layer:** The mineral material (60 cm) should be clay or amended soil and should satisfy permeability requirements of $k = 10$ cm/s. If the available soil has higher permeability, additional layers of 1.5 mm HDPE can be installed over 60 cm thick soil layer. The overall equivalence of such design of soil plus additional layers has to be checked and certified by geotechnical experts. 1.5 mm HDPE liner should be covered with a 20 cm protection layer or geotextile.
- **Water drainage layer:** The water drainage layer should be 30 cm thick formed by crushed gravel. The gravel layer should be covered by a geotextile or alternate separator to prevent clogging of the drainage layer by the overlying soil. An alternative is a drainage mat (Secudrain), but it is more costly.
- **Vegetative soil layer:** The top layer should be 45 cm thick vegetative soil.



Figure 4.12: Surface Liner System¹⁶

4.5.2.10 INFRASTRUCTURE FOR SANITARY LANDFILL

4.5.2.10.1 Road Construction

Access Road

The access road to a sanitary landfill should be constructed in accordance with the following design parameters:

- 6.5 m width of roadways with two lines, and
- 20 cm stabilised sub-foundation layer, anti-freeze layer if located in frost-prone areas.

Roads within the site should have:

- 3.0 m width of roadways, and
- 40–50 cm foundation layer made of broken material or demolition waste.

4.5.2.10.2 Equipment and Resources

The Sanitary landfill should be supplied with:

- water supply,
- energy,
- communication,
- sewage system,
- external lighting, and
- fire fighting (external).

A sanitary landfill should provide basic infrastructure and resources like roads, water supply, energy, etc.

¹⁶ Guidelines and Check-list for evaluation of MSW Landfills proposals with Information on existing landfills, CPCB, 2008. Available at: http://cpcb.nic.in/upload/NewItems/NewItem_133_MSW-REPORT.pdf

4.5.2.10.3 Waste Inspection Area or Emergency Area

The incoming waste has to be controlled within the entrance area. This area will also be used for parking during bad weather conditions while waste disposal on the landfill site is not possible.

4.5.2.10.4 Security and Fencing

Site security is among the most important considerations in landfills. The site should be secured to implement a good standard of service. In order to achieve this, the site has to be peripherally fenced and access to the landfill should be limited to one entrance gate, which should be blocked when the site is unattended. The fence will also keep children, unwanted or unorganised scavengers, cattle, and other animals out of the site. It will also protect litter to be blown out of the landfill site.

Site should be peripherally fenced to ensure children, scavengers, and cattle outside the boundary

4.5.2.10.5 Tyre Cleaning Unit

The tyre cleaning unit consists of concrete and a removable horizontal steel grit. The water of the tyre cleaning unit will be discharged by a mobile pump to the leachate collection system. The mud will be excavated by a loader and disposed of at the landfill.

4.5.2.10.6 Sanitary Landfill Buildings

Weighbridge and Control Building

The control building should be next to the main entrance gate of the landfill and should have electronic installations inside for control of the weighbridge. The area of the control building should be about 25 m². The weighbridge should be adjacent to the control building.

Administration Building

The administration building should include manager's office, offices for manager's secretary and assistants, meeting room, cafeteria, kitchen, toilets and showers, dressing room, resting room and storage.

Garage and Workshop

The garage is needed to shelter and to repair all mechanical equipment in the landfill (except landfill compactor and bulldozer). The workshop or repair-centre in the garage should be a completely independent unit. Except for the costly or composite parts, the depots of the garage should carry spare parts of vehicles, compactors, and other equipment, according to the service contract signed by the suppliers of the equipment and the municipality.

Sanitary landfill buildings should have separate facilities for men and women, with adequate provision of toilets and shower rooms

Compactor Shed

The compactor shed should be located next to the disposal area. This building serves as a protection for the landfill compactor and bulldozer from bad weather conditions while they are not in operation.

An example of design and calculations for a sanitary landfill are given in Annexure 7.

4.5.3 CONSTRUCTION OF A SANITARY LANDFILL

The construction of a sanitary landfill (Figure 4.13) is a specialised activity that requires continuous coordination between the design engineer and the construction agency. Supervision of construction activity and third party evaluation of construction quality and adherence to design is required.

Figure 4.13: Sanitary Landfill under Construction¹⁷



4.5.3.1 SUPERVISION OF CONSTRUCTION WORKS

The construction of a sanitary landfill should be supervised by an independent engineer on behalf of the municipality or the employer. The main tasks are:

- approval of the drawings and the final design;
- quality assurance of all operations related to the landfill and their compliance with the SWM Rules, 2016;
- time scheduling, steering, and coordination of the construction sites; and
- acceptance of the construction work and supply.

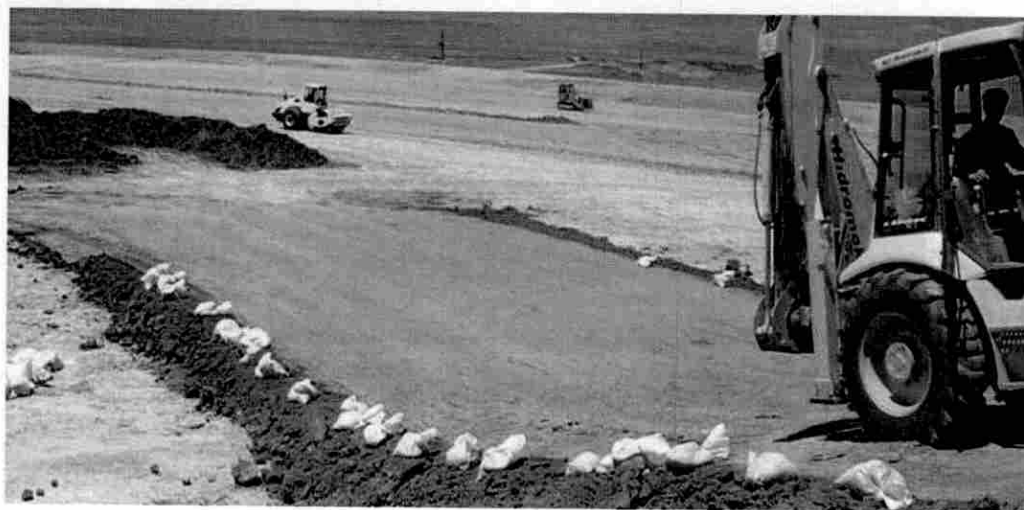
¹⁷ Taken from GIZ-ASEM project [2008].

4.5.3.2 QUALITY ASSURANCE

Test Field

In order to ensure the sanctity of the liner system after sealing operations, a test field may be established (Figure 4.14), which is to be included as a part of the standard operating procedure for designing the landfill. The costs for establishing the test field should be included in the overall project costs.

Figure 4.14: Construction of Test Field¹⁸



The test field has to be constructed outside of the sealing areas and have to be retained and protected for the entire duration of construction to prove the sanctity of the liner. Within a test field, the suitability of all materials for sealing must be proved under actual conditions of the site. The results of these tests should be considered as the basis for the detailed design.

Construction of the test field should start on the surface with 3 layers of clay. A trial pit shall be installed in the test field for visual check of the quality of the compressed layers.

Three samples of each test field (investigation area) must be examined for the following laboratory tests:

- truck drive tests,
- determination of density,
- determination of deformation module,
- proctor density,
- water permeability, and
- water content.

¹⁸ Taken from GIZ-ASEM project (2008).

All examinations required for each layer should be carried out by an independent engineer.

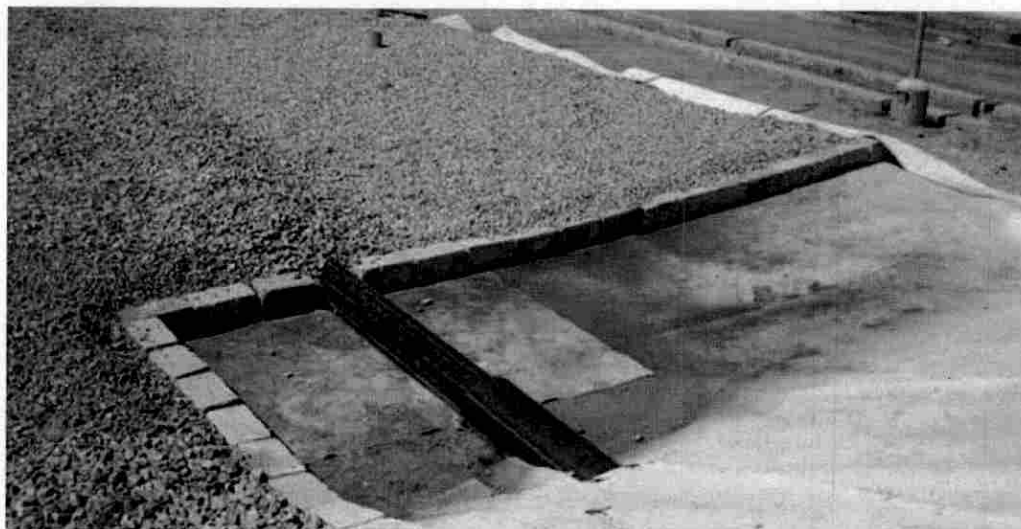
These results must be evaluated and documented including the following conclusions with regard to the design of the mineral sealing system:

- compacting methods,
- compacting equipment,
- number of compacting passes of roller,
- operation speed of compacting equipment, and
- thickness of compacted layers and those which are not compacted.

The test fields must be at least 20 m in length and the minimum width must be 2 machine widths. The ramps should be in the ratio of 1:10 and the embankments should be in the ratio of 1:5. Adequate care should be taken so that the distance of acceleration and deceleration with driving tracks is wide enough for the equipment to function properly if they were to be arranged alongside.

The test fields should be built in the bottom and embankment area of the landfill. They show the same slopes as the fields built later. After the mineral sealing material has been tested, the application of the other sealing compounds, protection layer, and drainage layer should be tested in the test field accordingly (Figure 4.15). This has to be done for the base sealing as well as for the surface sealing.

Figure 4.15: Test Field with all Sealing Components¹⁹



¹⁹ Taken from GIZ-ASEM project (2008).

Mineral Sealing Layer

For the sealing material as well as for the construction, the requirements are as follows:

- Selection of the grain size distribution of the mineral material should prevent micro substances from getting discharged (suffusion stability or dispersion stability) as well as from increasing the crack resistance.
- Soil containing coarse gravel and stones, wood, roots, and other impurities should not be applied. The digging locations provided for supply of the mineral material should be examined thoroughly.
- When the sealing material is introduced, it should be homogenous and show homogeneous water content.
- The water content must be higher than the optimum moisture content (OMC) determined by standard proctor test. Mineral sealing layers should not be constructed under bad weather conditions (rainfall).
- The top of the landfill surface bearing and of each completed layer of the mineral sealing system should be dewatered sufficiently. The required layer thickness, which should not exceed by more than 10 %, will be determined on the test field. Special attention should be paid to tight intermeshing (compound) of the layers built one on the other.
- If required, the mineral sealing material should be homogenized and crushed by a milling cutter.
- Compression with the sheepsfoot roller is of special importance because of its kneading and packing effect.
- The top layer surface of the sealing system should be flat and without driving tracks.
- After completion of each compacted layer, an acceptance test should be carried out before introducing the next layer or the placement work of the geotextiles.

High-density Polyethylene Geomembrane

For constructing the layer, the following items have to be considered:

- supervision of the constructing and placing of the liner;
- a suitable firm placing the plastic liner;
- material requirements or tests;
- not less than 1.5 mm thick HDPE geomembrane (Figure 4.15);
- proof of stamp-pushing-force or ensuring plunger puncture;
- a manufacturer certificate, including product name and specifications;
- ensuring static proof; and
- proof of stability and resistance to sliding during building and final state.



A storage area should be prepared on site according to manufacturer.

For placing the plastic layer, among other things, the following issues should be regarded:

- Welding of the HDPE liner is only carried out if the temperature is $> 5^{\circ}\text{C}$.
- On the surface of the HDPE liner, no water is allowed.
- The regulations of the manufacturer should be regarded (width of the overlapping, welding, etc.).
- The placed plastic liner has to be fixed (e.g., sandbags).
- It is forbidden to drive on the welded plastic liner with any equipment (only with the necessary equipment for welding).
- Every welding seam (Figure 4.16 and Figure 4.17) should be proofed (stability, density, thickness).

Figure 4.16: Welding of HDPE Geomembrane²⁰

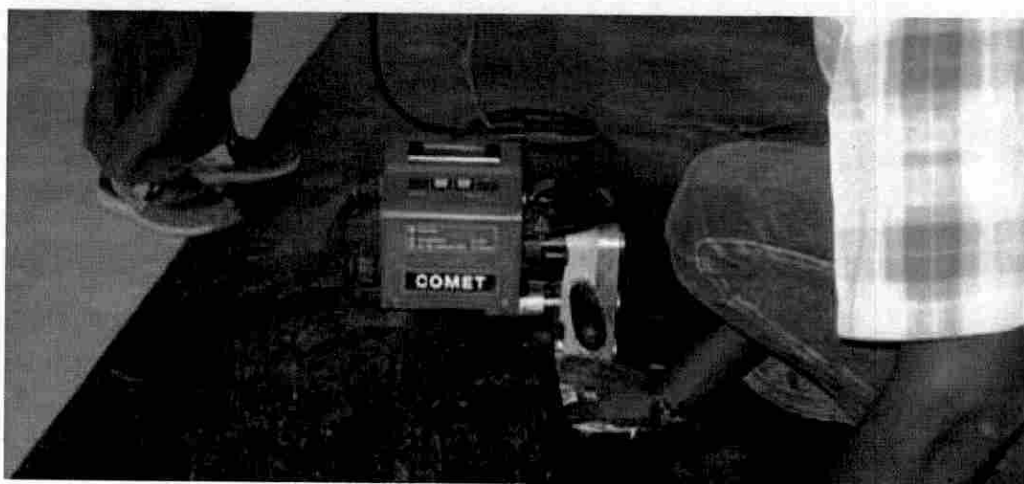


Figure 4.17: Proof of welding seams²¹



²⁰ Taken from GIZ-ASEM project (2008).

²¹ Ibid.

Geotextile

For protection of the HDPE liner, a geotextile should be applied when building the base sealing system. For the surface sealing system, the geotextiles are applied on the equalising and drainage layer.

The prescribed overlapping widths should adhere to each other. The geotextile should be laid in longitudinal roll direction with the inclination of the embankment. It is not allowed to drive on the webs laid, and equipment or machines should not be placed on the layers, under any circumstances. The web position must be secured by appropriate measures (i.e., sand bags) to prevent them from getting lifted.

Material requirements or tests

Where geotextiles are used to provide significant puncture protection to geomembranes, the determination of an appropriate mass per unit area of the geotextile is critical. A factor of safety (Fs) of 3 or above against the puncture of geomembrane is considered a good practise.

Method for Calculating Geotextile²²

$$FS = Pallow / Pact$$

Where:

FS = factor of safety against geomembrane puncture

Pallow = allowable pressure using different types of geotextile and site-specific conditions

Pact = actual pressure due to landfill contents

Note: Indicative methods for calculation may be found at http://www.landfilldesign.com/cgi-bin/gt_select.pl and <http://www.geosynthetic-institute.org/papers/paper14.pdf>

Based on real-world applications in India, the following geotextile specifications are found to be optimal, subject to further validation for site specific conditions:

- Weight of geotextile should be 800 g/m² (for height of waste: > 10m) and 400 g/m² (for height of waste: < 10m). Protection liner should be above the HDPE liner in the base sealing system.
- Protection layer should be 400 g/m² above the HDPE liner in case the HDPE liner is applied as surface sealing system.
- Separation liner should be 200 g/m² between the mineral drainage layer and the recultivation layer on the surface sealing system.

²² Indicative methods for calculation may be found at: http://www.landfilldesign.com/cgi-bin/gt_select.pl and <http://www.geosynthetic-institute.org/papers/paper14.pdf>



As per the SWM Rules, 2016, the geomembrane needs to be 1.5 mm thick, 1,440 g/m² HDPE. In case a landfill is planned to have more than 20 m height, the weight of the geotextile may have to be increased as per the ground situation.

4.5.3.3 DRAINAGE LAYER

For the base sealing system, the drainage layer is built on the protection layer. The drainage layer must comply with the following requirements:

- The chemical, physical, and mechanical stability of the material selected for the drainage layer must ensure that there is no negative effect on the drainage efficiency from the chemical and physical leachate characteristics and the mechanical load of the landfill body.
- For the drainage layer, washed material should be used and rounded grains preferred.
- Grain-size distribution of the material should be used for the drainage layer, with permeability greater than 10⁻² cm/sec.

4.5.3.4 LEACHATE COLLECTION SYSTEM

The leachate collection system at the landfill base, embedded within the drainage layer, consists of the following, from top to bottom:

- **Nonwoven geotextile:** The system should have nonwoven geotextile (punched).
- **Granular leachate collection layer:** The granular leachate collection layer should be 300 mm thick, with granular diameter of 25–50 mm, overlying a 1.5 mm thick geomembrane or geosynthetic liner, and a 900 mm layer of compacted clay layer (Figure 4.8). The granular leachate collection layer must be designed such that the calculated hydraulic head of leachate above the composite liner is less than 0.3 m.
- **Construction and demolition products:** As per SWM Rules, 2016 (Schedule III, Part B), construction and demolition (C&D) products can be used for construction and operation of sanitary landfill.
- **High-density polyethylene leachate collection pipes:** The HDPE leachate collection pipes should convey the leachate collected by the granular leachate collection layer to the leachate sump, where the leachate can drain freely and be removed.

Leachate collection pipes must have adequate flow capacity to convey the leachate and adequate structural resistance to withstand the applied loads. In addition, since collection pipes are usually perforated to permit flow of leachate into the pipes, the size of the perforations must be large enough to accept the flow of leachate into the pipe without the buildup of head, and small enough to prevent gravel from entering the pipe. Figure 4.18 depicts proper welding practices to be followed while



welding HDPE pipes. Figure 4.19 depicts the proper placement of holes in the leachate pipes.

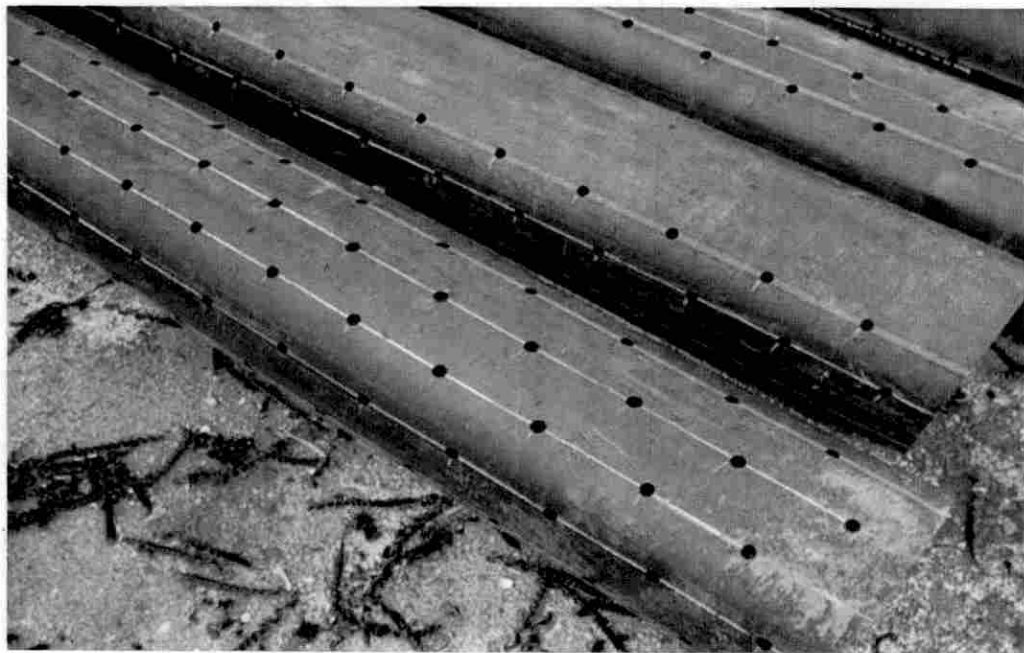
The leachate collection pipe and the granular material must be able to withstand the applied loads due to the overlying materials and equipment used at the facility throughout the entire design period. Three pipe failure mechanisms must be considered when designing a buried plastic pipe to be structurally stable under loads. These mechanisms are:

- wall crushing;
- wall buckling; and
- excessive ring deflection.

The following issues have to be considered while laying and attaching the HDPE pipes:

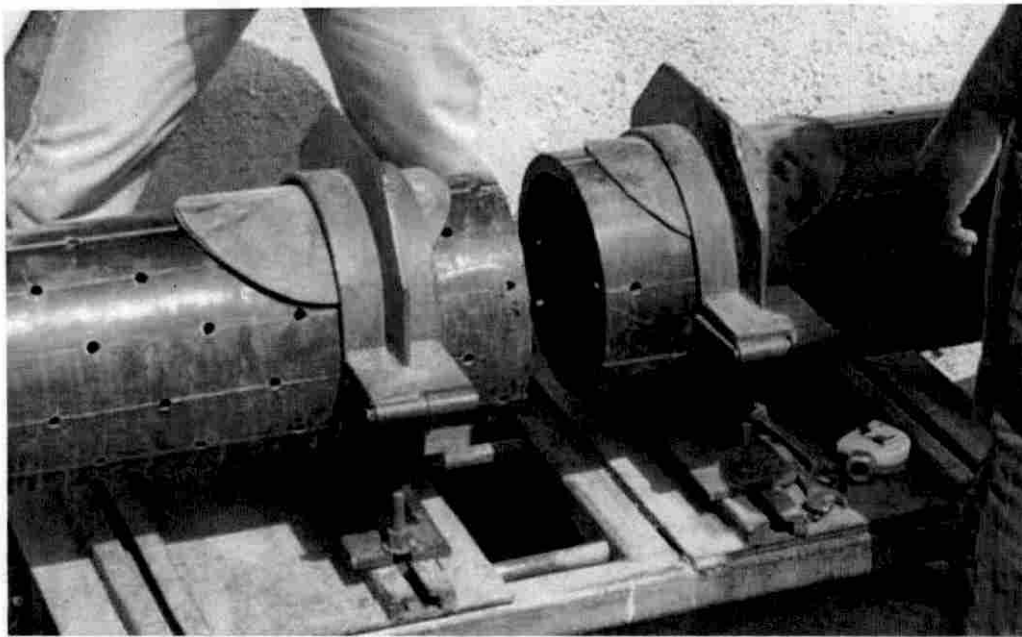
- permission for HDPE welding submitted by the construction firm;
- welding records for each welding seam made;
- pipes to be covered with filter gravel after each working day;
- visual check of position and slopes;
- check of the inside walls of the pipes and the welding seams with a movable video camera;
- pressure tests of the solid wall pipes of the leachate collector; and
- daily visual acceptance before covering and complete acceptance after submission of all build-in test results.

Figure 4.18: Welding of Leachate Pipes²³



²³ Taken from GIZ-ASEM project (2008).

Figure 4.19: Proper Holed Leachate Pipes²⁴



4.5.3.5 SLOPE STABILITY ASPECTS AND SEISMIC ASPECTS

The stability of a landfill should be checked for the following cases:

- stability of excavated or filled slopes,
- stability of liner system along excavated or filled slopes,
- stability of temporary waste slopes constructed to their full height (usually at the end of a phase),
- stability of slopes of above-ground portion of completed landfills, and
- stability of cover systems in above-ground landfills.

The stability analysis should be conducted using the following soil mechanics methods depending on the shape of the failure surface:

- failure surface parallel to slope,
- wedge method of analysis,
- method of slices for circular failure surface, and
- special methods for stability of anchored geomembranes along slopes.

²⁴ Taken from GIZ-ASEM project (2008).

4.5.4 SANITARY LANDFILL OPERATION

4.5.4.1 GENERAL REQUIREMENTS

4.5.4.1.1 Operation Manual

Before the operation of a sanitary landfill can be undertaken, it is important to develop the operating rules and methodologies, which has to be documented in an operation manual.

The operational manual should serve as a guidance document for the urban local body (ULB), private landfill operator, and personnel in the sanitary landfill sites to aid them in controlled landfill operations. It should also be part of any operation contract for private operators of the landfill site.

The operational manual should comprise the following main aspects:

- controlling and recording of landfilled waste;
- guide to use the remaining capacity in an optimised way with the support of filling plans and strategies;
- guide to undertake all operational duties required at the landfill site,
- basic health and safety measures; and
- maintenance of landfill facilities and landfill equipment if available.

4.5.4.1.2 Employee Assignments and Responsibilities

The composition and number of the landfill staff have to be designed according to the size and requirements of the sanitary landfill. Table 4.6 suggests the following staff for the operation of a landfill site.

Table 4.5: Provisional Staffing Table²⁵

DEPARTMENT	FUNCTIONS
Management	Landfill manager
Administration	Controller
	Weighbridge operator
	Night watchmen
Operation	Foreman
	Machine drivers (wheel loader, dozer)
	Spotter
	Unskilled worker
Total	Landfill staff

²⁵ Manual on Municipal Solid Waste Management (First Edition), Central Public Health and Environmental Engineering Organisation (CPHEEO), 2000.



An operational manual for ULBs should be developed by the landfill operator

4.5.4.1.3 Staff Responsibilities and Qualifications

The list in Table 4.7 indicates the major assignments and responsibilities of the various employees who work at the landfill. However, the table does not necessarily include all duties that may be required to safely and successfully operate the sanitary landfill. The list should be mandatory for private as well as municipal operators.

Table 4.6: Staff Qualification²⁶

FUNCTIONS	RESPONSIBILITIES	EDUCATION OR EXPERIENCES
Landfill manager	• Waste filling • Compliance with operation manual and filling plans • Daily (short-term) personnel planning • Supervision of the weighbridge operator or controller • Keeping of customers' contacts • Adherence of safety rules	• Civil engineering technician • Training in safety matters • Training in environmental issues • Knowledge of environmental legislation
Weighbridge operator or controller	• Control and record of incoming waste • Operating the weighbridge • Directing vehicles to the disposal area • Visual monitoring of delivered waste other than municipal waste	• Administration competencies • Training in environmental issues • Knowledge of environmental legislation
Night watchman	• Site security especially during night time	• Training in safety matters
Foreman	• Waste filling procedure • Daily personal and equipment planning • Control of landfill compaction • Cell construction • Road construction and control of the condition of the roads	• Trained foreman with long-time experience in construction works • Training in safety matters
Spotter	• Traffic regulation in the filling area and organisation of waste disposal • Checking of unloaded waste	• Special training in filling procedure • Training in distinction of different waste and of acceptable or unacceptable waste • Basic training in safety

²⁶ Manual on Municipal Solid Waste Management (First Edition), Central Public Health and Environmental Engineering Organisation (CPHEEO), 2000.

Table 4.7: Staff Qualification [contd.]

FUNCTIONS	RESPONSIBILITIES	EDUCATION OR EXPERIENCES
Bulldozer drivers	• Filling and the compaction of waste in the landfill • Waste unloading organisation together with the spotters • Daily inspection and maintenance checks of machinery • Cleaning machines	• Vehicle driver's license • Special training on compactor and bulldozer • Basic training in safety

4.5.4.1.4 Hours of Opening and Operation

The days and hours of opening of the landfill site for public deliverers should be determined by the municipality and the operator of the sanitary landfill. The opening hours should be published on a sign board and in the related newspapers and websites.

4.5.4.1.5 Site Notice Board

A notice board has to be installed at the entrance to the site, which should specify the following:

- (i) the name and contact information for the sanitary landfill site, including the telephone number;
- (ii) opening days and times; and
- (iii) site rules and regulations, e.g., "No Smoking," "Wear Safety Clothes," etc.

4.5.4.1.6 Site Security

The security has to ensure that the site is safe and secure at all times. The security staff will provide after-hours security patrol around the landfill site. The security staff will also be responsible for operating and maintaining the following:

- landfill entrance security;
- safeguarding the on-site vehicles and equipments;
- reporting any security-related incidents immediately to the landfill manager; and
- completing the daily site security check list for the entire facility.

4.5.4.2 WASTE RECEPTION AND CONTROL OF INCOMING WASTE

All deliveries from collection vehicles of the municipality and from private service providers should be documented by checking the (registered) license plate number, the respective labelling on the vehicles, or the respective license. Corresponding lists with the license plate numbers have to be compiled beforehand by the landfill supervisor to help the weighbridge operator identify the vehicles.

Waste deliveries from licensed commercial and industrial deliverers and private deliverers within the municipality are to be identified by checking the identity card of the driver as well as the license plate number. In case the presented documents do not fulfil the requirements of the waste permission, the deliverer has to be rejected. A rejection has to be documented in the operation diary.

A visual inspection has to be carried out in case of questionable origin or unclear waste type by examining the:

- appearance;
- consistency and composition;
- colour;
- smell.

If the visual inspection indicates noncompliance with the SWM Rules, 2016, the consignment has to be rejected. This process has to be documented in the operation diary.

4.5.4.2.1 Execution of the Weighing Process

The following data has to be recorded:

- license plate number;
- name of the corporation (in case of regional facilities);
- ward from which waste is collected;
- name of the weighbridge operator;
- gross and net weight of the vehicle; and
- date and time of entrance.

The deliverer has to follow the orders and instructions of the staff.

4.5.4.3 WASTE ASSIGNMENT

The spotters have to inform the deliverer about the location for waste unloading at the landfill. The following unloading areas should be available:



- waste disposal area;
- temporary storage areas for building materials, demolition waste, and earth excavation (cover material); and

Domestic hazardous waste requires a higher degree of containment. Ideally this waste fraction should be sent to the nearest TSDF. In case this is not possible the SLF should have a special storage area for domestic hazardous waste, to be transported to the nearest TSDF periodically. In the absence of a TSDF in the vicinity, to which this waste may be economically transported, it is preferable to construct a double liner cell for the domestic hazardous waste within the landfill site. The weighbridge operator will provide information regarding the temporary roads to be used. This has to be supported by corresponding traffic signs and by additional staff (spotters), who duly direct the vehicles. Driving on the loose landfilling area is not allowed.

4.5.4.3.1 Preparing of Filling Plans

A final structural plan of the waste body of the landfill site should be designed. Based on this plan, different filling sections can be developed to ensure that

- staff could efficiently undertake all operational duties required in the landfill site, and
- the filling follows the designed waste body to avoid secondary transfer of waste.

4.5.4.4 FILLING AND COMPACTION PROCEDURE OF WASTE

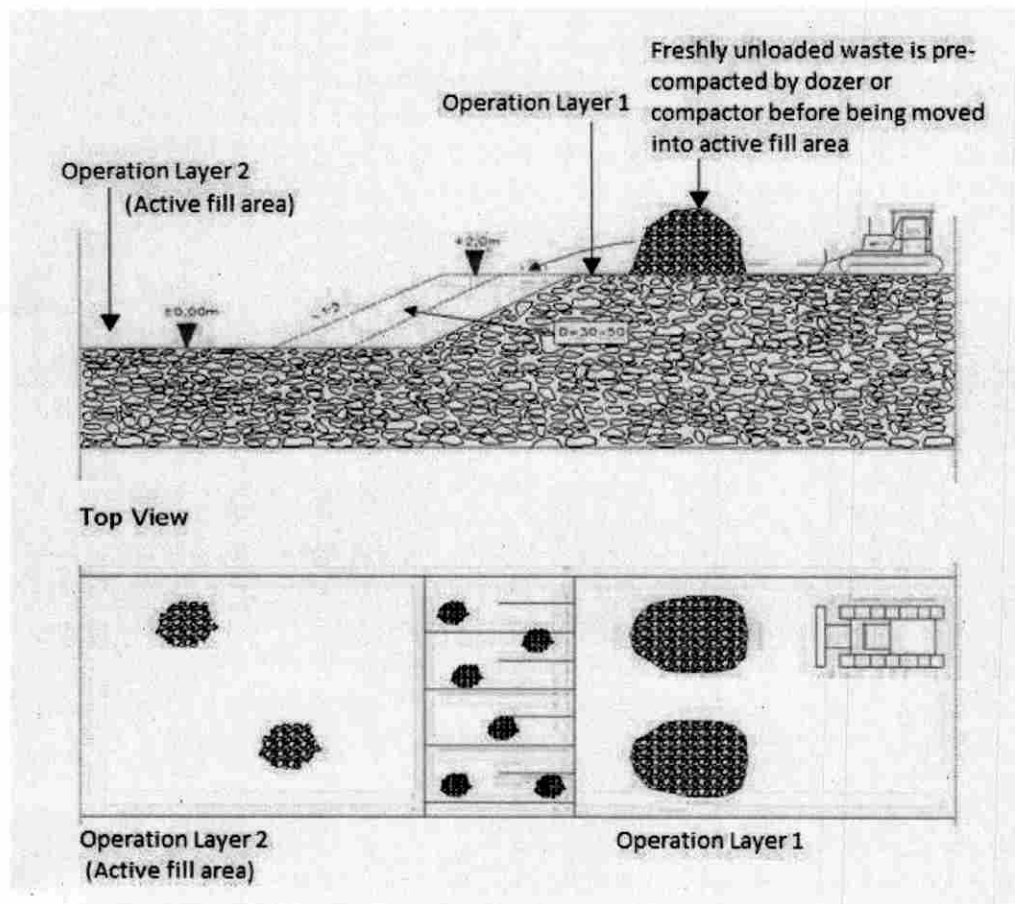
A high degree of waste compaction extends the lifetime of the landfill, reduces the need for cover material, reduces litter problems, and minimises long-term land requirements. Figure 4.20 illustrates the filling and compaction method to be employed, both along active flat fill areas and along slopes.

- The daily filling area should be determined every morning. It should be wide enough to prevent a backlog of vehicles. For safety reasons, the width of the landfilling face should not be reduced to less than 15 m.
- Incoming waste is unloaded in a pre-designated area (operation layer 1). This waste is then pre-compacted and moved to the active fill area (operation layer 2).
- Along slopes, to maximise compaction and to provide an optimal weight distribution of the bulldozer, the waste should be spread up a 1:3 slope in 50 cm layers.



- Good compaction is achieved by operating the landfill compactor up and down the filling area three to five times on the waste layers.
- The top view indicates the placement of freshly unloaded waste in operation layer 1 and its final placement and compaction along the slopes and in the operation layer 2.

Figure 4.20: Filling and Compaction Method²⁷



Soil and other inert material should be used as a 10 cm thick daily cover on top of waste

Figure 4.21: Landfill Compactor²⁸



²⁷ Internal GIZ document for preparation of MSWM manual, GIZ-IGEP [2014].

²⁸ Ibid.

4.5.4.5 COVERING OF WASTE

As an alternative to an intermediate soil cover, plastic or tarpaulin sheets can be used

Cover material includes imported cover such as (i) soil and other inert waste; and (ii) other material such as fine portion of C&D waste, street sweepings, and dry drain cleaning silt. The cover soil should be pushed by a bulldozer or wheel loader up the slope and spread out as evenly as possible. When constructing a body in an open area, the side slopes also require soil cover.

4.5.4.5.1 Daily Cover

Waste placed at the landfill should be covered at the end of operations each day. The daily cover should be at least 10 cm thick and may comprise of soil, crushed C&D waste, and other inert waste.

4.5.4.5.2 Intermediate Cover

In addition, the top and side surfaces of a completed structure of waste that is not intended to be covered within 180 days by another waste layer may be exposed to weather and truck traffic. These surfaces should be covered with a layer of at least 30 cm of compacted soil, street sweepings, dry drain silt, or compacted fine C&D waste. Surface water drainage should be built to minimise the volume of water entering the site.

The intermediate cover material should be removed as much as possible prior to applying waste over it. Soil removal or scarifying intermediate cover soil is essential to ensure controlled liquid conductivity between sections.

4.5.4.5.3 Temporary Surface Cover

When the waste body has reached the final planned grade, a temporary cover of compacted soil or compacted fine C&D waste should be placed. This cover is necessary to allow light traffic movement without exposing any waste. The temporary cover will also help keep the rain from seeping into the waste.

4.5.4.5.4 Covering during the Monsoon

Depending on the climatic conditions, the unused filling areas should be covered during the monsoon period. The recommended intermediate cover is 45 cm of soil or alternatively a waterproof cover material. The soil shall be tilled, compacted in at least two lifts, graded to promote runoff and limit infiltration, and either mulched or seeded to prevent erosion.



Prior to the area being used for disposal again, the intermediate cover shall be removed before any further landfilling can occur.

4.5.4.6 FINAL COVER (SURFACE SEALING SYSTEM)

To minimise infiltration of storm water in the landfill body and to allow storm water runoff, a surface sealing system has to be installed after the final completion of each landfill part. The main purposes of the final cover system are to:

- control the amount of storm water filtration into the waste to reduce leachate quantities;
- prevent erosion;
- To minimise the migration of greenhouse gases (GHG) into the atmosphere;
- protect the base sealing (impermeable) layer; and
- to minimise other emissions causing negative impacts on the environment.

4.5.4.7 LANDFILL GAS MANAGEMENT

A large part of mixed waste (50%–60%) consists of biodegradable parts which produce methane gas. With a view to reduce GHG emissions and thereby reduce environmental impacts, it is mandatory to install a degassing system for the sanitary landfill.

The gas management strategies should follow one of the following options:

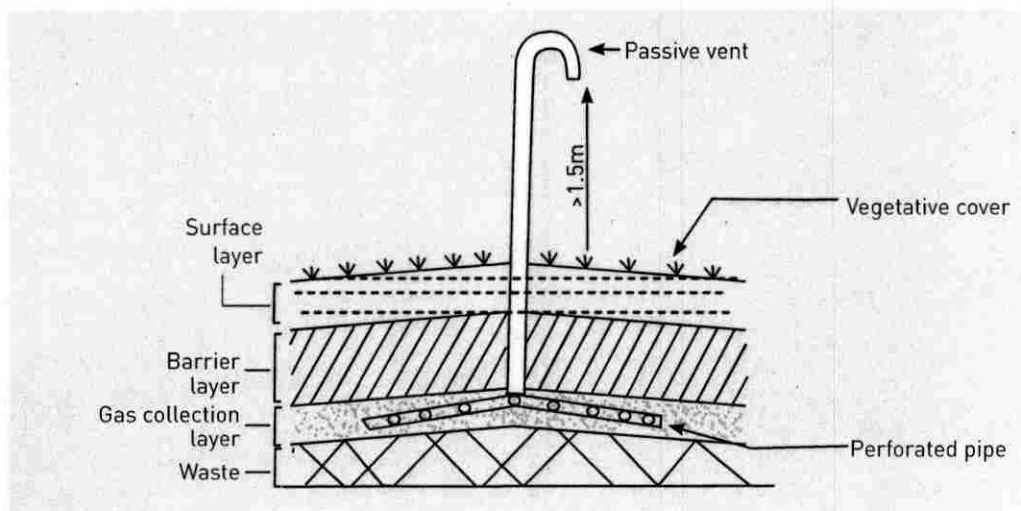
- controlled passive venting; or
- controlled active collection and treatment or reuse.

4.5.4.7.1 Controlled Passive Venting

For all sanitary landfills, controlled passive degassing systems in the form of gas windows covered by suitable passive gas vents is recommended. Figure 4.22 illustrates placement of passive vents in a landfill.

The gas windows are to be installed in the frame of the final covering. The gas windows are openings in the cover system which may be filled with compost to avoid the generation of bad odours. The size should be not less than 1 m x 1 m, and the distance between two gas windows should be about 20 m.



Figure 4.22: Placement of Passive Vent²⁹

4.5.4.7.2 Controlled active collection and treatment or reuse

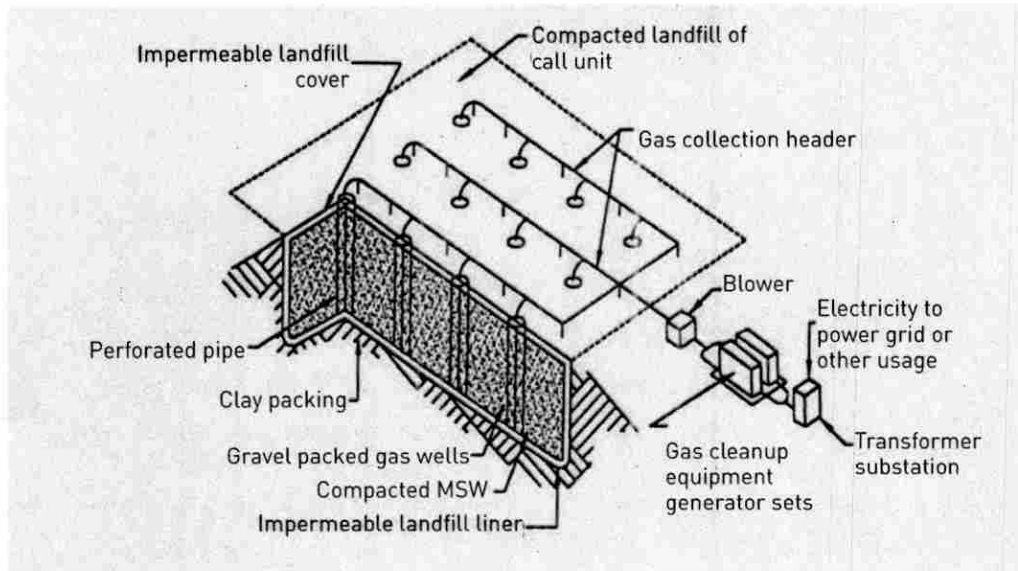
In order to reduce GHG emissions, especially methane with its very high global warming potential, future landfills should always install active gas collection systems. The active degassing system should contain the following elements as illustrated in Figure 4.23:

- **Gas collection wells:** Each well should cover a collection area of around 2,000 m².
- **Gas transporting pipes:** From each gas well, HDPE gas transporting pipes will be installed on the waste during the filling procedure and connected via the main collection pipe to the compressor station and the flare.
- **Compressor station and gas use or flare system:** The gas can be fed into a blower station and a flare, which burns the methane to carbon dioxide (CO₂) and water. This slightly reduces the warming potential, as CO₂ has lower warming potential than methane. Much better in terms of climate change mitigation and resource efficiency is the use of the gas to produce electric power through a generator.
- **Gas generator:** The installation of a gas generator can be profitable if after a landfill lifetime of 3–5 years, sufficient gas will be available.

²⁹ Manual on Municipal Solid Waste Management (First Edition), Central Public Health and Environmental Engineering Organisation (CPHEEO), 2000.

Figure 4.23: Gas Recovery through Wells-Active³⁰

Controlled collection and treatment or use should be adopted only based on a feasibility study by experts in this area.



4.5.4.8 SANITARY LANDFILL ROADS

4.5.4.8.1 Road Construction

An important part of the landfill operation activities is enabling vehicles to reach the landfilling area, which is progressing every day, and to cover the waste once it is landfilled. Therefore, continuous road construction is required.

4.5.4.8.2 Main and Temporary Roads

Access to the different filling sections and the top layers of the landfill site is possible by constructing main access roads. These roads, with a maximum slope of 10%, should have a hard surface and be protected with a lateral ditch to drain the surface water flowing from the temporary capping surface. These main access roads should be wide enough (7–8 m) for two-way vehicle traffic. Chained equipment should not be allowed to travel on the main access road, as this is likely to cause damage.

The temporary side roads lead from the main access roads to the disposal face and therefore have a short life. Placement of these roads has to be conducted based on the instructions of the operation manager. These roads are typically made of waste demolition material which has been delivered for disposal at the site. On the top, 20–30 cm of gravel or other similar waste type can be used.

30 Ibid.

4.5.4.8.3 Road Maintenance

The following road maintenance should be undertaken:

- (i) **Filling of potholes:** Potholes should be filled with materials compatible with the roadbed.
- (ii) **Filling of areas where settlement occurs:** When roads are built on filling areas, settlement of the waste body may cause cracks on a road or cause the slope of a road to change. Cracks should be filled with material that is compatible with the roadbed.
- (iii) **Maintenance of roadside ditches:** All ditches should be kept free of obstructions and debris. Inspections of all drainage ditches and structures should be made at least once a week, after the rain, or more frequently as required. Any debris should be removed from ditches.

4.5.4.9 STORM WATER MANAGEMENT

All surface water ditches, culverts, drainage channels, and settling ponds (storm water ponds) should be designed by a hydrologist using hydrometeorological data.

4.5.4.9.1 Surface Water Collection

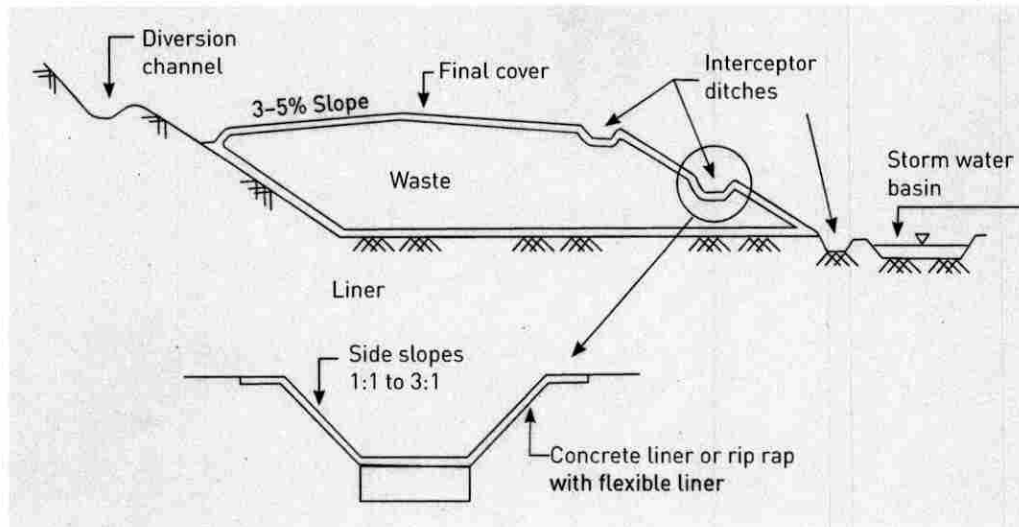
Surface water management is required to ensure that rainwater runoff does not drain into the waste from surrounding areas and that there is no water logging or ponding on covers of landfills.

These objectives should be achieved by the following:

- Rainwater running off slopes above and outside the landfill area should be intercepted and channeled to water courses without entering the operational area of the site. This diversion channel may require a low permeability lining to prevent leakage into the landfill.
- Rainfall on areas within the landfill site but on final covers of completed landfill segments should be diverted in drainage channels from active tipping areas, and directed through a settling pond to remove suspended silt, prior to discharge.
- Any drainage channels or drains constructed on any restored landfill surface should be able to accommodate settlement of the waste body, resist erosion, and cope with localised storm conditions.
- The final cover should be provided a slope of 2.5%–5.0% for proper surface water drainage. The final top cover slopes depend on the area of the top portion of the landfill; the larger the extent, the flatter the slopes. Figure 4.24 illustrates surface water drainage system in a landfill.



Figure 4.24: Surface Water Drainage System in Completed Landfill³¹



4.5.4.9.2 Storm Water Retention Pond

The storm water retention pond should be designed according to the local conditions. It should protect the downstream situated villages against flooding. The construction should be designed as a ground basin with a regular discharge to the receiving water course. However, the retained water can be used for irrigation purposes during dry climate conditions.

4.5.4.9.3 Maintenance of the Storm Water System

The landfill staff have to inspect the drains on a weekly basis. After heavy rainfall, the storm water system has to be inspected also and relieved from mud and sand. Regular cleansing is mandatory after heavy storm occurrences, as the pipes and ditches are most likely filled with papers and plastic bags. The storm water pond also has to be cleared of papers and plastics.

31 Manual on Municipal Solid Waste Management (First Edition), Central Public Health and Environmental Engineering Organisation (CPHEEO), 2000.

4.5.4.10 LANDFILL EQUIPMENT

4.5.4.10.1 Required Equipment

For controlled landfill operations, the equipment listed in Table 4.8 are required.

Table 4.7: Equipment Required on a Sanitary Landfill³²

EQUIPMENT	FUNCTIONS
Landfill Compactor	Spreading and compaction of waste
Dozer	Spreading of waste and daily cover
Backhoes and front end loaders	Excavation and maintenance of ditches Loading of waste and cover material
Tractor trailers; water tank	Internal movement of waste or daily cover Soil transportation Water transportation
Truck with tipper	Soil transportation
Light commercial vehicle or passenger vehicle	Staff transportation
Poiclains	Heavy-duty excavation and embankment construction
Soil compactors (sheepsfoot rollers and smooth steel drum rollers)	Finishing passes

The number of equipment required depend on the amount of landfilled waste and size of the landfill, and should be designed specifically for each sanitary landfill. An indicative list of equipment required based on the size of the landfill is given in Table 4.9.

Table 4.8: Equipment required based on size of Sanitary Landfill³³

EQUIPMENT	DAILY WASTE RECEIVED		
	200 Tons	201-500 Tons	501-1,000 Tons
Bulldozers ^a	2	2	2
Loaders	2	3	4
Excavators	2	3	3
Landfill compactors ^b	NA	3	5
Water tankers	1	1	2
Tractor trailers or tippers	2	4	6

Note: a. More than 10 tonnes operating mass.

b. More than 20 tonnes operating mass.

³² Developed by the Expert Committee for revision of MSWM manual (2013-15)

³³ Ibid.

4.5.4.10.2 Maintenance of Mobile Equipment

Regular mobile equipment inspections and operating records are critical for an effective preventive maintenance. To ensure maximum operating efficiency, inspections need to be thorough and accurately recorded by all operating personnel.

4.5.4.11 HOUSEKEEPING ON THE SANITARY LANDFILL

Housekeeping should be conducted in such a manner that it protects the public and surrounding environment from risks and nuisance emanating from landfill operations. A well-controlled landfill operation will enhance public perception and acceptance of the landfill site.

The following general measures should be considered:

- **Vector and vermin control:** The landfill site might attract vectors and vermin because of the presence of organic waste. To avoid or reduce vectors and vermin, the filling area should be minimised and the waste covered at regular intervals.
- **Litter control:** Offsite litter should be picked up on a regular basis.
- **Noise control:** Noise in the landfill site arises from landfill operations and waste vehicles entering and leaving the site. During landfill operations, equipment with faulty or worn-out exhaust systems can cause high noise levels. Hence, they need to be repaired.
- **Dust control:** The combination of vehicle movements and winds on temporary and un-surfaced roads can create dust. Dust within and around a landfill site can be a source of annoyance, harm, and physical discomfort to landfill staff and neighbourhood. Therefore, all precautions have to be taken to avoid dust generation.
- **Odour control:** The landfill should be operated in a manner that will minimise the odour from waste or associated items. Operational procedures include placing suitable cover material over the waste in a timely manner.

4.5.4.11.1 Health and Safety

The landfill management (municipality or private operator) should be responsible for all aspects of site safety, including public safety in areas adjoining the site. The safety officer of the municipality or of the private operator should also be responsible for the health and safety of landfill staff. He or she should support the landfill management in the following tasks:

- planning, operation, maintenance, and inspection of installations with regard to health and safety;



- organisation and realisation of training and instructions of landfill staff with regard to occupational health and safety;
- assessment and evaluation of accidents; and
- internal reporting on safety aspects.

4.5.4.11.2 General Safety Measures

General safety measures have to be applied during landfill operations, regardless of the nature of ongoing activity or location. Below is a list of priority measures, which should be elaborated, based on site-specific conditions:

- Maximum traffic speed should be 20 kilometers per hour (km/h).
- Every person working at the landfill should have a yearly medical examination.
- No one should be allowed to operate at the landfill without a mobile communication system (either radio or mobile telephone).
- Smoking should be prohibited except in designated smoking areas.
- Ingestion of food is restricted outside designated areas.
- General hygienic requirements have to be applied while working at the landfill.

4.5.4.11.3 Person Related Safety Measures

The workers have to be equipped with the following personal protection equipment:

- safety boots (always to be used while working outside the buildings);
- reflective vests (always to be used while working outside the buildings);
- safety helmets (to be used in case of risk of head injuries, e.g., during construction, loading or unloading activities, while operating machinery, etc.);
- gloves (to be used in case of risk of hand injuries, e.g., during loading or unloading, or maintenance activities);
- ear protectors (to be used while working in noisy areas); and
- disposable dust mask (to be used in case of exposure to dust).

The landfill management has to strictly enforce the use of personal protection equipment.

4.5.4.11.4 First Aid

The landfill workers should be trained in first aid, so that they themselves can properly provide first aid. Considering the specific conditions at a

sanitary landfill, it is strongly recommended that landfill staff working on a regular basis be trained on first aid. All vehicles working at or entering the landfill have to be equipped with a first-aid kit.

All vehicles working or entering the landfill have to be equipped with a first aid kit.

4.5.4.11.5 Personnel Accidents

In case of accidents involving injuries, the following procedures have to be applied:

- stop work immediately;
- inform first aider;
- inform management; and
- call medical services (ambulance emergency number should be duly filled in and maintained by the responsible landfill operator).

4.5.4.11.6 Fire Prevention and Protection

General Requirements

The following descriptions provide an overview of fire prevention and protection procedures. In any case, the actual firefighting operation is under the responsibility of the fire brigade of the urban local body (ULB).

To prevent fire incidents, the following rules have to be applied:

- Banning smoking in all areas of the sanitary landfill.
- Handling material on fire as well as setting fire to materials on the landfill are strictly forbidden.
- Waste that has been unloaded in the filling area has to be examined visually for potential fire sources (glowing ash or glowing burning remains). If fire sources are located, these have to be neutralised with cover material immediately.
- All mobile equipment or vehicles should be furnished with a fire extinguisher.
- Fire Control.

In case of fire, the following basic rules of conduct have to be complied with:

- Every fire has to be reported immediately.
- The preservation and protection of lives and health have priority over firefighting.
- Alarm signals should be heeded.



4.5.4.12 ENVIRONMENTAL MONITORING

The environmental monitoring of landfills should be performed as per SWM Rules, 2016 requirements (Section 4.1 of this chapter). In addition, hydrogeology and surface water quality at the landfill site should be monitored as discussed in Section 4.5.1.9 of this chapter.

4.5.5 CLOSURE AND POST CLOSURE PLAN

Determination of the end use of a landfill site is an essential part of the plan for landfill closure and post-closure maintenance. A closure and post-closure plan for landfills involves the following components:

- plan for vegetative stabilisation of the final landfill cover,
- plan for management of surface water runoff with an effective drainage system,
- plan for periodical inspection and maintenance of landfill cover (settlements) and facilities,
- plan for quantity and quality of leachate monitoring in the landfill,
- plan for quantity and quality of landfill gas monitoring,
- plan for groundwater quality (up gradient and down gradient), and
- plan for surface water quality at the periphery of landfill and at receiving water bodies.

The regulatory limits for various parameters of quality and the monitoring frequency will have to be agreed or stipulated by the regulatory authorities.

The post-closure care of landfill site shall be conducted for at least 15 years in line with the SWM Rules, 2016 as mentioned above. The authority or concessionaire that operated the sanitary landfill shall be responsible for post-closure activities and monitoring.

4.5.5.1 PLANTATION AT LANDFILL SITE

As per the SWM Rules, 2016 Schedule I (g), there is a defined criteria for plantation at the landfill site which needs to be adhered to. Please refer to Section 4.1 of this chapter.

4.5.6 CONSIDERATIONS FOR LANDFILL COSTING

Landfill construction includes several cost elements. An indicative list of elements or components of a sanitary landfill is provided in Table 4.10.

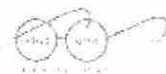


Table 4.9: Components of a Sanitary Landfill³⁴

1.	Earthworks
1.1	Site clearing or cleaning
1.2	Excavation and fill (as per plan)
2.	Landfill liner
2.1	Clay liner and bentonite mix (if applicable)
2.2	Leachate collection system (LCS)
2.3	Granular or sand drainage placement
2.4	High-density polyethylene (HDPE) liner material
2.5	Geotextile filter fabric
3.	Leachate collection system
3.1	LCS gravel placement
3.2	HDPE raiser pipe
3.3	HDPE header pipe
3.3	HDPE lateral pipe
3.4	Leachate transfer pump
3.5	Leachate holding tank (sump)
3.6	Piping from holding tank to lagoons or treatment plant
3.7	Leachate treatment plant
4.	Top cover
4.1	Impermeable clay layer (mixed with bentonite if needed)
4.2	Gas venting system (passive venting, flaring, or treatment system)
4.3	Top cover drainage gravel placement
4.4	Top soil placement
5.	Storm water control
5.1	Peripheral storm water drains or collection system
5.2	Storm water detention pond
5.3	Pumps
5.4	Berm construction
6.	Buildings or structures
6.1	Administration building
6.2	Temporary hazardous waste storage
6.3	Repair and maintenance, parking
6.4	Stockpile room
6.5	Truck tyre washing facility
6.6	Culverts
6.7	Administration building parking
6.8	Boundary fencing
6.9	Landscaping
6.10	Roads
7.	Fire control
7.1	Fire control equipment
8.	Contracted or purchased equipment
8.1	Excavator
8.2	Site waste haulage truck
8.3	Water tanker
8.4	Landfill compactor
8.5	Weighbridge
8.6	Bull dozers
8.7	Personal protective equipment

³⁴ Developed by the Expert Committee for revision of MSWM manual [2013-15]

4.5.7 EXISTING DUMPSITE CLOSURE OR RECLAMATION

Many open solid waste dumpsites in India do not have an engineered liner system, leachate collection system (LCS), or an appropriately designed cover system, thus posing a threat to the environment and human health. Such dumpsites should be immediately closed to minimise their impact on land, groundwater, and surface water quality and on air quality in the vicinity of the dumpsite. Repeated burning of wastes on dumpsites cause deleterious environmental impacts.

4.5.7.1 DUMPSITE CLOSURE

Closure of municipal solid waste (MSW) dumpsite assumes great importance because each city has more than one dumpsite, which create significant health and environmental degradation. This activity requires huge logistics depending on the size of the heap, climatic condition of the place, and the plan for its future use. The requirement of logistics and time frame increases multifold in case site reclamation is planned. Some options are mentioned below, although more options can be worked out depending on the site conditions and prospects of utilisation of the retrieved material in case of reclamation.



As per Schedule I of SWM Rules, 2016:

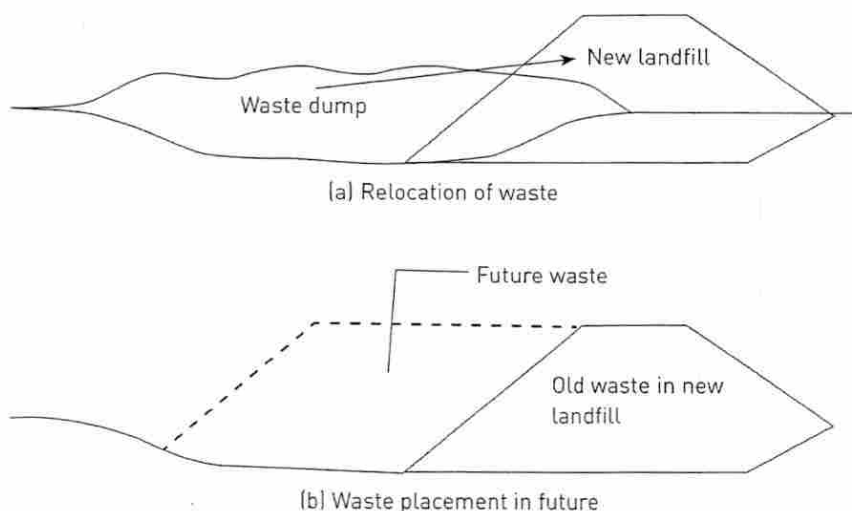
J. Closure and Rehabilitation of Old Dumps- Solid waste dumps which have reached their full capacity or those which will not receive additional waste after setting up of new and properly designed landfills should be closed and rehabilitated by examining the following options:

- (i) Reduction of waste by bio mining 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 / utilisation 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.

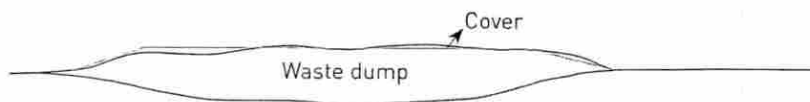
Dumpsite closure may be carried out through any of the following means, as may be feasible at the site:

- The waste has to be placed in a new landfill with liner and cover in accordance with SWM Rules, 2016 (Figure 4.25). Attempts are being made towards adopting appropriate process for dumpsite closure, however, this area need definite guidelines.



Figure 4.25: Old Waste in New Landfill³⁵

- Closure should be by re-grading to a stable slope of minimum 1:3, and top cover system should be provided to reduce percolation of rainwater (Figure 4.26). In areas close to water bodies, creek, and coastal zones, a vertical cutoff wall should be planned at an appropriate depth.

Figure 4.26: Closure of Old Waste Dump with Cover³⁶

- Closure by other means should be with approval from the concerned State Pollution Control Board (SPCB) and committee.
- Leachate generation from old and existing dumpsites is the biggest environmental hazard. However, it is not possible to lay a bottom liner below an existing dumpsite. One effective way is to stop ingress of rainwater from the top.
- Provide top cover to prevent rainwater infiltration. Over time, leachate generation from such covered dumps will be reduced. Ensure the presence of a HDPE liner in the top cover of the landfill, above the drainage layer.
- Gas wells have to be sunk into the waste dump, equivalent to the average height of the landfill from ground level.
- There should be grading of the existing dumpsite to ensure slope stability.

35 Guidelines and Check-list for evaluation of MSW Landfills proposals with Information on existing landfills, CPCB, 2008. Available at: http://cpcb.nic.in/upload/NewItems/NewItem_133_MS-W-REPORT.pdf

36 Ibid.



- Dumpsite closure should ideally be planned after incoming waste is no longer accepted. In case fresh waste is allowed at the dumpsite, the waste should be placed only in select zones.
- Like for other sanitary landfill, post-closure care should be 15 years with monitoring of leachate (to be treated or sent to a sewage treatment plant [STP]), gas generation, and groundwater quality (in monitoring wells).
- There should be inspection for subsidence, cracks, and fissures in the top cover to ensure their prompt repair.
- If vegetation is planned in the top cover, adequate provision for irrigating the plants should be made.

4.5.7.2 DUMPSITE RECLAMATION

Dumpsite reclamation or mining creates additional space for future landfilling needs and avoids or reduces the cost of acquiring land for dumping of municipal waste. Further potential for groundwater contamination is reduced through remediation of unlined open dumpsites. In addition, it also reduces the cover requirements for existing dumps by reducing the footprint of the landfill.

Dumpsite reclamation involves excavation, screening, and separation of material from dumpsites into various components such as soil, recyclable materials, and residues.

4.5.7.3 METHOD FOR DUMPSITE RECLAMATION

Dumpsite reclamation involves sorting out mixed municipal waste according to material size (oversized material, intermediate sized waste and soil or humus) by using a trommel. The size and type of screens used depend on the end use of the recovered material. Dumpsite reclamation typically consists of two basic operations: excavating waste and screening waste.

4.5.7.3.1 Excavation

The old waste dump contains leachate at different layers and various gases and odor-causing substances. Before starting excavation, it is necessary to vent out the gases and drain out the leachate. Ventilation systems for application to such situations have been developed. Basically, it comprises blowing or sucking air from designated areas for 2 days before breaking open the dump for excavation. The exhaust air is passed through filters (preferably bio-filter) to tap the harmful gases. Excavation of waste material from the dump is then initiated. A frontend loader then organises the excavated materials into manageable stockpiles and separates oversized or bulky material.



4.5.7.3.2 Screening

Waste screening begins with the segregation of excavated material into discrete streams. An electromagnet is used to segregate ferrous material from the main stream of waste. The nonferrous fraction is processed through an air classifier that separates light materials from heavy organics. A trommel or vibrating screen separates soil from solid waste. Trommel screens are more effective than vibrating screens.

The sizes and types of screens used depend on the end use of the recovered material. For example, if the reclaimed soil is used as landfill cover, a 50 mm screen is used for separation. If, however, the reclaimed soil is sold as construction fill or for another end use requiring fill material with a high fraction of soil content, a smaller mesh screen is used to remove small pieces of metal, plastic, glass, and paper. Operation costs can be retrieved by the sale or reuse of the recovered materials such as recyclables, soil, and waste. The recovered land may also be monetized to recover costs of remediation.

Further use of recovered land is to be carefully considered after assessing the nature and impact of any site contamination (soil or hydrological) due to the reclaimed dumpsite. In many cases, such sites may be found suitable only for the construction of engineered sanitary landfills for MSW or hazardous solid waste.

Material recovery depends on the composition of waste, effectiveness of mining technology, and efficiency of mining technology. The material recovery ranges from 50% to 90%, while average soil fraction in recovered municipal waste from landfill tends to be around 50%–60%. However, it can vary between 20% and 80% depending on moisture content and decomposition rate. The success of dumpsite reclamation projects depends on the age of the dumpsite and composition of the decomposed waste.³⁷

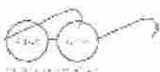
It is to be noted that dumpsites which are subject to repeated burning, spontaneous or not, will have minimal potential for reclamation and recovery of material. Unless the recovered organic material is proved to be free from contamination (items indicated in Fertilizer Control Order [FCO], 2009 and 2013), it should not be used as manure for food crops.

Advantages of Dumpsite Reclamation

- Dumpsite reclamation results in recovery of land for further use, e.g., constructing engineered landfills.
- Revenue is generated from the sale of recyclable material such as ferrous metals, plastics, and soil.

Success of dumpsite reclamation depends on the age of the dumpsite and composition of waste. Therefore, waste characterisation before reclamation is essential

37 Anna University, Dumpsite Rehabilitation and Landfill Mining, Centre for Environment Studies, Chennai.



- Reclaimed soil can also be used as daily cover material in landfill cells, thus avoiding the cost of importing cover soil.
- Combustible waste from the landfill can be used for the production of refuse derived fuel (RDF) and sold to cement or power plants for co-processing or co-incineration.
- Dumpsite reclamation avoids or reduces costs of dumpsite closure and post-closure care and monitoring.

Disadvantages of dumpsite reclamation

However, dumpsite or landfill reclamation can result in excessive costs, which are not justified by the sale of soil or recyclables, unless the recovered land is of a significant economic value. Inherent hazards of pockets of landfill gas and exposure to hazardous and explosive material are also to be considered, depending on the level of control on waste disposal at the facility and location of the dumpsite or landfill.

Dumpsite or landfill reclamation can result in excessive costs, which are not justified by the sale of soil or recyclables, unless the recovered land is of a significant economic value

An Example of Scientific Landfill Closure and Methane Capture: Gorai Dumping Ground, Mumbai

Background: Closure and scientific capping of garbage dumpsite is essential for containing its pollution potential. Usually, old dumpsites are left without any remedial steps and allowed to degenerate over the years in terms of leachate percolating down to groundwater, vector breeding, and air pollution. Some dumpsites have been covered with thin layer of soil and vegetation to beautify the area. However, generation of leachate continues. With ingress of rainwater, more leachate is formed. This goes on for years until the material in the landfill is stabilized, which may be 20–50 years in warm climates.

The first known example of scientific capping of a garbage dumpsite in India happened in Mumbai at Gorai dumpsite. This is a specific example where an ongoing dumpsite was systematically closed and then capped. Normally, this procedure would be well suited for already closed dumpsite where dumping of fresh garbage has been stopped.

Operational since 1972, Gorai dumpsite is in the western suburbs of Mumbai. The 19.6-hectare site is adjacent to Gorai creek and is very close to habitation. Approximately 2.34 million tons of waste up to an average height of 26 m was lying at the site, causing significant environmental damage to the creek and the neighborhood. The capacity of the dump was already exhausted. The creek waters had been polluted due to inflow of leachate, and the air quality had deteriorated from the frequent burning of garbage.

The Municipal Corporation of Greater Mumbai (MCGM) took up this challenge and, with technical assistance of Infrastructure Leasing & Financial Services Ltd (IL&FS) (Environment Division), worked out a scientific plan for controlled closure and scientific capping based on detailed survey and consultation.



Gorai dumpsite: before closure

Design Strategy and Action Plan

Since it was not possible to go under the huge dump to lay a containment layer, gradual reduction of leachate was planned by restraining rainwater from entering the dump by providing a multilayered cover over the dump. At the same time, a leachate collection system (LCS) was planned in the best possible manner. Ingress and inundation of tidal water was controlled by putting vertical concrete sheet piling on the creek side.

The scientific closure plan included the following components:

- (i) fresh dumping stopped and relocation and slope reformation (1:3) of existing waste;
- (ii) laying of construction and demolition (C&D) waste and compaction;
- (iii) laying of liner system consisting of:
 - (a) top vegetation layer;
 - (b) 300 mm thick top soil layer;
 - (c) geocomposite layer;
 - (d) 1.5 mm geomembrane layer;
 - (e) 200 g/m² and 400 g/m² geotextile; and
 - (f) 300 mm thick drainage layer;
- (iv) installation of landfill gas collection, venting, and flaring system;
- (v) installation of LCS using perforated pipes along the periphery of the fill, followed by storage in a leachate tank and transportation to the nearest sewage treatment plant (STP);
- (vi) sheet piling on the seaward side to prevent leachate from entering the creek;
- (vii) surface water drainage for channeling storm water;

- (viii) construction of bunds, access roads, and compound wall on the landward side of site;
- (ix) landscaping and greenery, irrigation, and lighting of the area; and
- (x) post-closure care for 15 years with close monitoring of the indicative parameters like leachate, watering and maintaining the greenery, checking leakage of landfill gas, checking subsidence of the cover layer, etc.

The construction and operation and maintenance (O&M) contract for this work was awarded through open competitive bidding to a consortium of an Indian and a German company. The construction was completed in 24 months with a cost of about Rs.50 crore, with the O&M estimated at Rs.12 crore for 15 years of post-closure care.



Gorai Dumpsite: After Scientific Closure

Outcome

The following are the outcomes of the project:

1. There has been a marked improvement in quality of life of people living in the vicinity.
2. The project has created 19 hectares of green space and restored mangroves which had degenerated due to toxic leachate from the dumpsite.
3. The project has improved public health and hygiene; eliminated foul odor, fire, and vermin nuisance; improved the quality of creek water; and increased avian fauna population.
4. Property value in the area increased with higher property tax collection for the MCGM.

An important aspect of this project is the demonstration impact, which can be modified for local requirements and replicated across old open dumpsites in the country.

Source: MCGM and IL&FS.

4.5.7.4 EXPANSION OF LANDFILL OPERATIONS IN EXISTING WASTE DUMP OR LANDFILL

Expansion of landfilling operations at an existing site should only be undertaken after closure of the existing waste dump or existing landfill without liner. The expansion can take place in the form of (i) a new landfill adjacent to the existing dump which has been closed (Figure 4.27), or (ii) a new landfill constructed adjacent to the existing dump by making space for it by relocating existing waste from the sides of the waste dump to its top and then closing the waste dump (Figures 4.28, 4.29 a and b). In both such cases, the new landfill should conform to the check list as prescribed by CPCB in the guidelines and check-list for evaluation of MSW landfill proposals. For option (ii), the operator shall list the steps for odour control during relocation of the waste.

Vertical expansion of an existing waste dump or existing landfill should not be undertaken by placing a cover on the waste dump and filling on top of the cover. This is so because the cover between the old waste and the new waste would be subjected to large settlements and may not perform satisfactorily. Wherever it is stated that large settlements will not occur or that these can be withstood effectively, the proposed design should be checked by an expert.

Figure 4.27: Expansion of Waste Dump³⁸

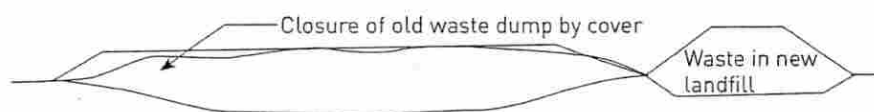


Figure 4.28: Relocation of Waste³⁹

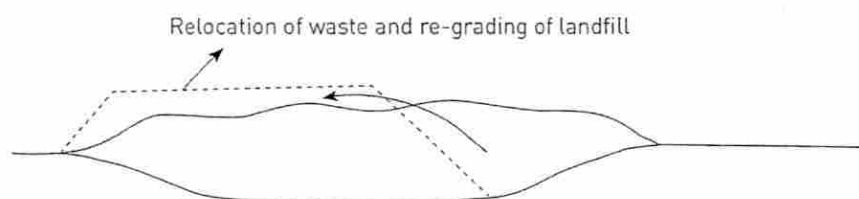
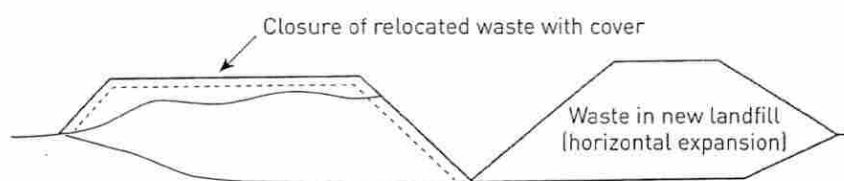


Figure 4.29a : Horizontal Expansion (Option A - preferred)⁴⁰



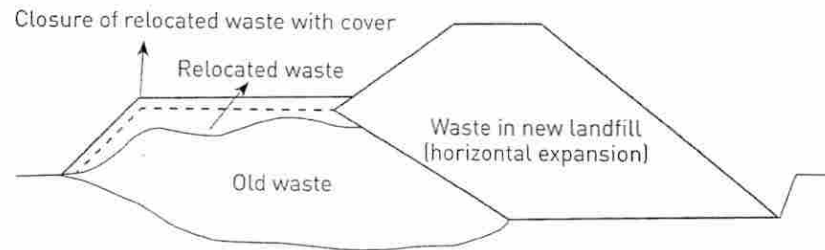
38 Guidelines and Check-list for evaluation of MSW Landfills proposals with Information on existing landfills, CPCB, 2008. Available at: http://cpcb.nic.in/upload/NewItems/NewItem_133_MSW-REPORT.pdf

39 Ibid.

40 Ibid.



Figure 4.29b: Horizontal Expansion (Option B)⁴¹



4.5.7.5 ASSESSING UTILITY OF THE CLOSED OR COVERED DUMPSITE – POST 15 YEARS

- Leachate generation from the closed dumpsite and the year in which leachate generation has stopped should be recorded.
- The closed or covered landfill should be assessed for its stability, and a record of the subsidence over the past 15 years should be evaluated.
- Groundwater quality in wells on-site and in the neighbourhood should also be monitored throughout the 15 years.
- Structural experts should evaluate the stability, strength, and load-bearing capacity of the area. Based on this evaluation, the ULB should decide on appropriate use of the closed dumpsite.
- The town planning department should take cognizance of all existing and potential reclaimed dumpsites and include the same in the master plan or land use plan of the ULB. Strict development controls of such areas should be adhered to.
- No borewell should be allowed within the footprint of the reclaimed dumpsite and within 500 metres of its boundary. Where groundwater extraction is inevitable within the 500 m zone, groundwater flow direction should be considered. Borewells should not be established downstream to the dumpsite, along the flow path.
- The closed landfill may be used for the following development, which should be taken up 3 years after complete cessation of leachate generation:
 - development of local markets;
 - development of urban parks; and
 - development of office, commercial, or institutional space (after ascertaining safety and assessing requirement of relevant controls).

⁴¹ Ibid.



4.6 ACTION POINTS FOR AWARENESS GENERATION THROUGH INFORMATION, EDUCATION, AND COMMUNICATION ACTIVITIES FOR MUNICIPAL SANITARY LANDFILLS

- Explain the role of landfill in the waste management scheme of the city to ensure citizens' support.
- Consult public for resettlement and compensation issues related to earmarking spaces for landfill.
- Ensure an understanding that only inert wastes shall be disposed in the landfill.
- Educate the public on the environmental and safety provisions of the landfill.
- Educate the community to ensure maintenance of no-development buffer zones around the landfill area.



5

**Municipal
Solid Waste
Management Plan
Implementation**

IN THIS SECTION

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5. MUNICIPAL SOLID WASTE MANAGEMENT PLAN IMPLEMENTATION

The chief executive of the urban local body (ULB), i.e., municipal commissioner or secretary or executive officer, is responsible for implementing the municipal solid waste management (MSWM) plan, which is to be developed in line with guidance given in Section 1.3 of Part II. The chief executive should operationalize the plan through the solid waste management (SWM) department or cell of the ULB.

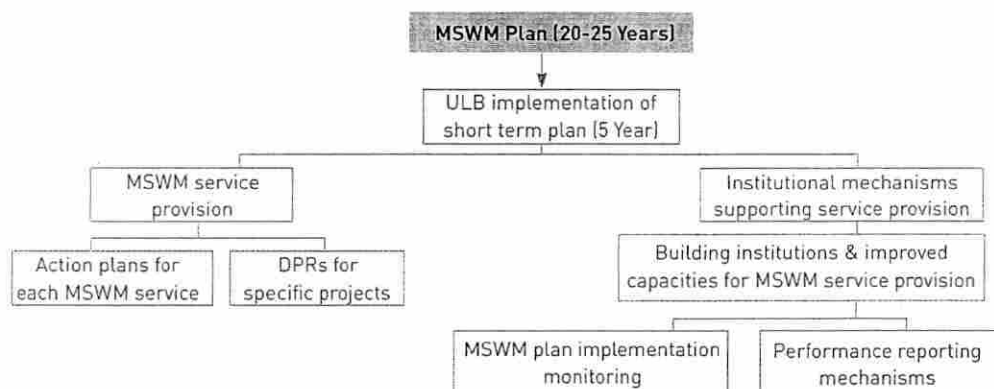
The chief executive of the ULB is responsible for the successful implementation of the MSWM plan

The MSWM plan is meant as a long term plan for 20–25 years. The implementation of the MSWM plan is guided by short term MSWM plans for 5 years, which are made in line with the goals of the long term plan. These short term MSWM plans can be reviewed midterm once every 2–3 years. An indicative list of actions that can be undertaken to develop a short term MSWM plan is given in Table 5.1 below.

Table 5.1: Actions for Preparation of Short term Municipal Solid Waste Management Plan¹

ACTION	IMPLEMENTING AGENCY
Identification of specific actions for 5 years (short term plan) to ensure planned SWM service provision as per the long term plan	ULB
Preparation of detailed project reports for specific projects (e.g., transfer station, processing, treatment, and disposal facilities) and action plans for service provision (e.g., transportation)	ULB or private implementing agency, as the case may be
Identification of institutional mechanisms to support provision, monitoring, and reporting on specific SWM services	ULB
Implementation of programmes for SWM staff capacity building (service provision, monitoring, reporting)	ULB

Figure 5.1: Components of Municipal Solid Waste Management Plan²



¹ Developed by the Expert Committee for revision of MSWM manual (2013-15)

² Ibid.





Obtaining statutory and environmental clearances is a prerequisite for establishing any MSWM facility

5.1 OBTAINING STATUTORY CLEARANCES FOR MUNICIPAL SOLID WASTE MANAGEMENT FACILITIES

MSWM processing, treatment, and disposal facilities require legal or statutory clearances and approvals for their establishment, depending on the type of facility to be created. SWM Rules, 2016 and the Environmental Impact Assessment (EIA) Notification, 2006 of the Ministry of Environment & Forests and Climate Change (MoEFCC) provide guidance on the statutory requirements for establishing storage, processing, treatment, and disposal facilities.

As per SWM Rules, 2016:

Clause 15: Duties and responsibilities of local authorities:

- (y) make an application in Form-I for grant of authorisation for setting up waste processing, treatment or disposal facility, if the volume of waste is exceeding five metric tones per day including sanitary landfills from the State Pollution Control Board or the Pollution Control Committee, as the case may be;
- (z) submit application for renewal of authorisation at least sixty days before the expiry of the validity of authorisation;

Clause 21: Criteria for waste to energy process:

- (3) The local body or an operator of facility or an agency designated by them proposing to set up waste to energy plant of more than five tones per day processing capacity shall submit an application in Form-I to the State Pollution Control Board or Pollution Control Committee, as the case may be, for authorisation.
- (4) The State Pollution Control Board or Pollution Control Committee, on receiving such application for setting up waste to energy facility, shall examine the same and grant permission within sixty days.

As per Schedule I of the EIA Notification, 2006, the municipal solid waste (MSW) handling, storage, treatment, and disposal activities fall under the items of 7(d) and 7(i) and require clearance from the State Level Environment Impact Assessment Authority (SEIAA).

An indicative list of clearances and approvals to be obtained are given in the box below:



An Indicative List of Statutory Clearances or Applicable Acts and Non-statutory Approvals Required by all Municipal Solid Waste Management Processing, Treatment, and Disposal Facilities

Statutory Clearances

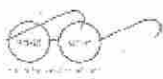
- Environmental Clearances: The Water (Prevention and Control of Pollution) Act, 1974; The Water (Prevention and Control of Pollution) Cess Act, 1977; The Air (Prevention and Control of Pollution) Act, 1981; The Environment (Protection) Act, 1986, and Rules; Environmental Impact Assessment (EIA) Rules, 2006
- Clearance from the State Pollution Control Board (SPCB)- "consent to establish" and "consent to operate"
- Clearance from Airport Authority
- Fertilizer Control Order (FCO) Clearance for compost based plants
- Land use from the Revenue Authority
- State Electricity Authority Clearance for providing grid connectivity
- The Public Liability Insurance Act, 1991 and Rules, 1991
- The Industries (Development and Regulation) Act, 1951
- The Factories Act, 1948
- The Motor Vehicles Act, 1938, amended in 1988 and Rules, 1989
- The Petroleum Act, 1934
- The Energy Conservation Act, 2001

Non-statutory Approvals

- Proof of Possession of Site
- Bank Loan Sanction Letter and Agreement
- Bank Appraisal Note
- Water Supply Agreement
- Power Purchase Agreement
- Municipal Solid Waste Supply Agreement with Municipal Authority

5.1.1 IDENTIFICATION OF LAND FOR MUNICIPAL SOLID WASTE MANAGEMENT PROCESSING, TREATMENT AND DISPOSAL – PRELIMINARY ENVIRONMENTAL ASSESSMENT

Suitable, encumbrance-free land within the ULB's jurisdiction should be identified for locating waste processing and treatment facilities. The requirement of land is to be calculated based on a tentative assessment of possible disposal options available to the ULB. The identified land should be checked for environmental compliance.



As per SWM Rules, 2016:

Clause 19: Criteria for duties regarding setting-up solid waste processing and treatment facility.-

- (1) The department in- charge of the allocation of land assignment shall be responsible for providing suitable land for setting up of the solid waste processing and treatment facilities and notify such sites by the State Government or Union territory Administration.

Schedule 1A criteria for site selection:

- (i) The department in the business allocation of land assignment shall provide suitable site for setting up of the solid waste processing and treatment facilities and notify such sites.
- (viii) The sites for landfill and processing and disposal of solid waste shall be incorporated in the Town Planning Department's land-use plans.

The following aspects should be evaluated at a minimum:

- location with respect to buffer area requirements as indicated in Section 1.4.5.11 and 4.1 of Part II;
- land terrain characteristics;
- site hydrogeological status; and
- groundwater and ambient air quality.

Land clearance from concerned authorities for establishment of MSWM facilities is to be obtained by the ULB at the earliest possible instance.

5.1.2 ENVIRONMENTAL IMPACT ASSESSMENT REQUIREMENTS FOR MUNICIPAL SOLID WASTE MANAGEMENT FACILITIES

EIA Notification, 2006 has divided all infrastructure projects or activities into two categories—Category A and Category B based on the spatial extent and potential impacts on human health, natural, and manmade resources. Category B projects are further divided into B1 and B2 based on requirement of conducting and submitting an EIA report and conducting a public consultation as decided by the State Expert Appraisal Committee (SEAC) at the project screening stage. Category B1 projects are required to submit an EIA report to the SEAC prior to establishing the facility and consent has to be obtained from the SEAC.³ B2 category projects do not require an EIA clearance. For categorisation of projects into B1 or B2, the MoEFCC shall issue guidelines from time to time.

3 For more details, please refer to EIA Notification, 2006.

Infrastructure projects are divided into two categories: A & B based on their spatial extent and potential impacts on human health and environment

Common MSWM facilities are usually considered Category B projects, unless they fall partially or fully within 10 km from the stipulated eco-sensitive areas or other critical areas



All common MSWM facilities are considered Category B projects. However, facilities are considered Category A projects if they are located wholly or partially within 10 km from the boundary of following:

- wildlife reserves or protected areas (under The Wildlife Protection Act, 1972);
- critical polluted areas identified by the Central Pollution Control Board (CPCB);
- eco-sensitive areas as notified under Section 3 of the Environment (Protection) Act, 1986;
- interstate boundary (this will not be applicable if states or union territories allow project setup in their land); and
- international boundary.

Projects involving capping of existing dumpsites or capture of landfill gas for power generation are designated as Category B projects

All MSW projects that deal with capping of existing dumpsites and capture of landfill gases for power generation fall under Category B, as defined by the EIA Notification.

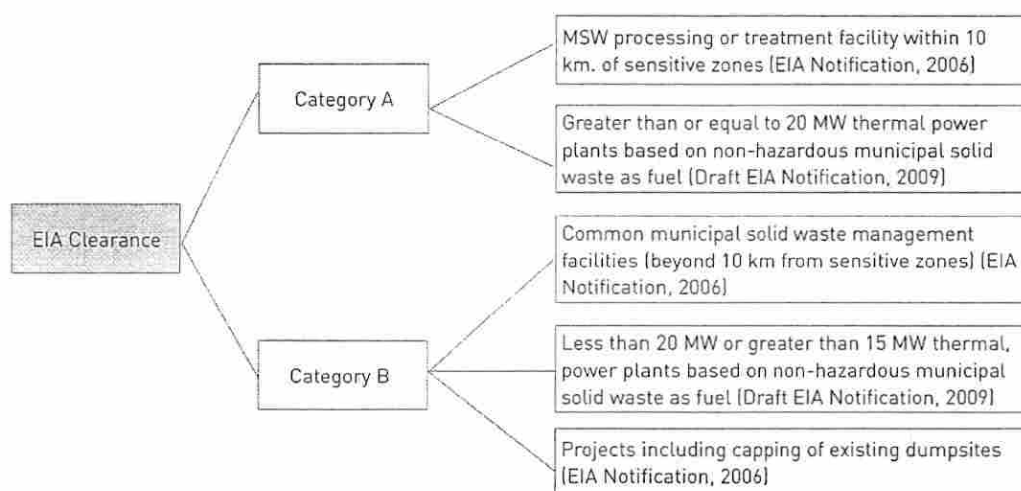
The draft EIA notification issued in January 2009 (as an amendment to EIA Notification, 2006) suggests categorisation of the following thermal power plants based on non-hazardous MSW as fuel:

- Category A: greater than or equal to 20 megawatts (MW)
- Category B: less than 20 MW and greater than 15 MW

Power plants up to 15 MW based on non-hazardous MSW are exempt from EIA requirements

Power plants upto 15 MW based on non-hazardous municipal waste and using auxiliary fuel such as coal, lignite and petroleum products upto 15% are exempted from EIA requirements.

Figure 5.2: Environmental Impact Assessment Clearance Requirements for Municipal Solid Waste Management Projects⁴



⁴ Adapted from Environmental Impact Assessment Notification 2006, MoEFCC

5.1.2.1 ROLES AND RESPONSIBILITIES OF STAKEHOLDERS INVOLVED IN ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

The environmental clearance process involves many stakeholders such as the Central government, State government, State Level Environment Impact Assessment Authority (SEIAA), Expert Appraisal Committee (EAC), State Level Expert Appraisal Committee (SEAC), State Pollution Control Board (SPCB), etc.

The roles and responsibilities of SEIAA and SEAC involved in EIA are briefly discussed below:

- SEIAA is constituted by the MoEFCC based on the state's recommendation, which makes a final decision regarding acceptance or rejection of environmental clearance for all Category B projects. SEIAA shall receive application from the project proponent, communicate SEAC's views for finalising the ToR, upload the EIA report to their website in cases of Category B projects and shall take a final decision regarding the project clearance.
- EAC or SEAC is a multi-disciplinary independent committee (at the centre and state or union territory level) which reviews each developmental activity and offers its recommendations for consideration of the central government and SEIAA respectively. EAC or SEAC reviews Form 1 of the EIA Notification, 2006 and its attachments, undertakes site visits if necessary to finalize scoping and the ToR, and reviews updated EIA and environmental management plan (EMP) reports.

Stages at which SEAC is consulted:

- Screening
- Scoping
- Appraisal and clearance

5.1.2.2 PROCEDURE FOR ENVIRONMENTAL IMPACT ASSESSMENT (EIA) CLEARANCE

All MSW project proponents (ULBs and private contractors) should follow the steps laid out in the EIA Notification, 2006 and its amendments as shown in Figure 5.3.

The entire environment clearance process consists of five stages:

1. Screening
2. Scoping
3. EIA
4. Public consultation
5. Appraisal



However, all these stages might not be required in some cases.

Screening

Screening is a process of categorising the project into A or B, and into B1 or B2 under Category B.

Scoping

Potential environmental and health-related impacts of the proposed facility are assessed during this phase. Results of the scoping exercise shall also be used to:

- identify alternative project designs or sites,
- obtain local knowledge of site and surroundings, and
- prepare a plan for public or community involvement.

The scoping will further support preparation of the ToR for the EIA. The SEAC determines the ToR to ensure that all environmental concerns will be addressed in the EIA report.

The EAC or SEAC is the final appraising authority with powers to stipulate further improvements, where required, for final consent or rejection by SEIAA. The EAC or SEAC scrutinizes all the application and documents submitted during the environment clearance process and decides on whether the project is to be granted a clearance and, if so, specifies the conditions for the clearance. Where the proposed project is deemed to impact the environment without scope for due remedies, environment clearance may be denied by the EAC or SEAC.

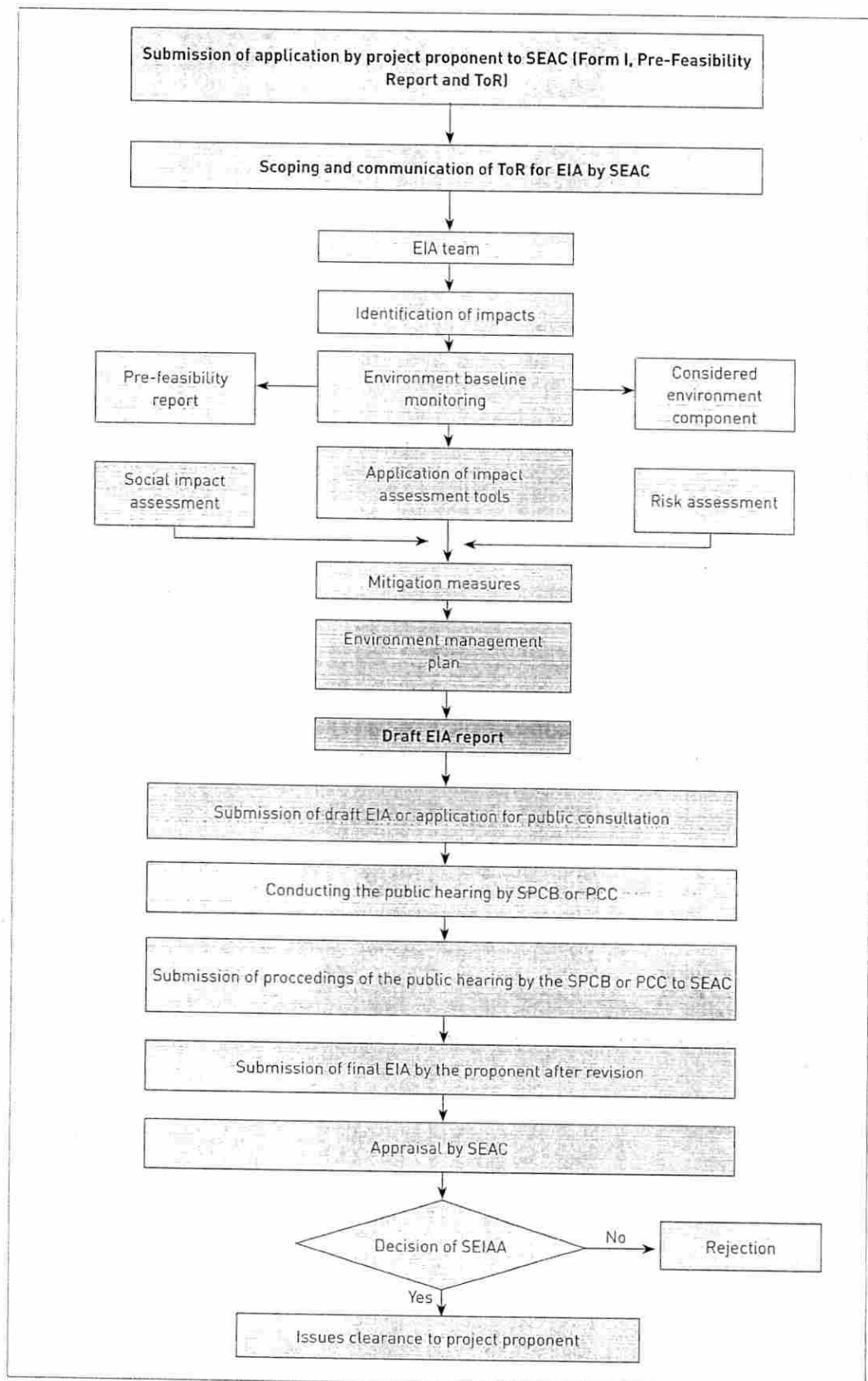
Environmental Impact Assessment

EIA is a detailed multistage process to identify and quantify specific impacts of the proposed project on the environment or ecosystem. Public consultation is an important step in the EIA approval process. Concerns of locally affected people and others who have a plausible stake in the environmental impacts of the project or activity are solicited. These concerns are to be addressed in the project's EMP.

Figure 5.3 illustrates the sequence of steps for conducting an EIA to obtain environment clearance.

Stages at which SEIAA is consulted:

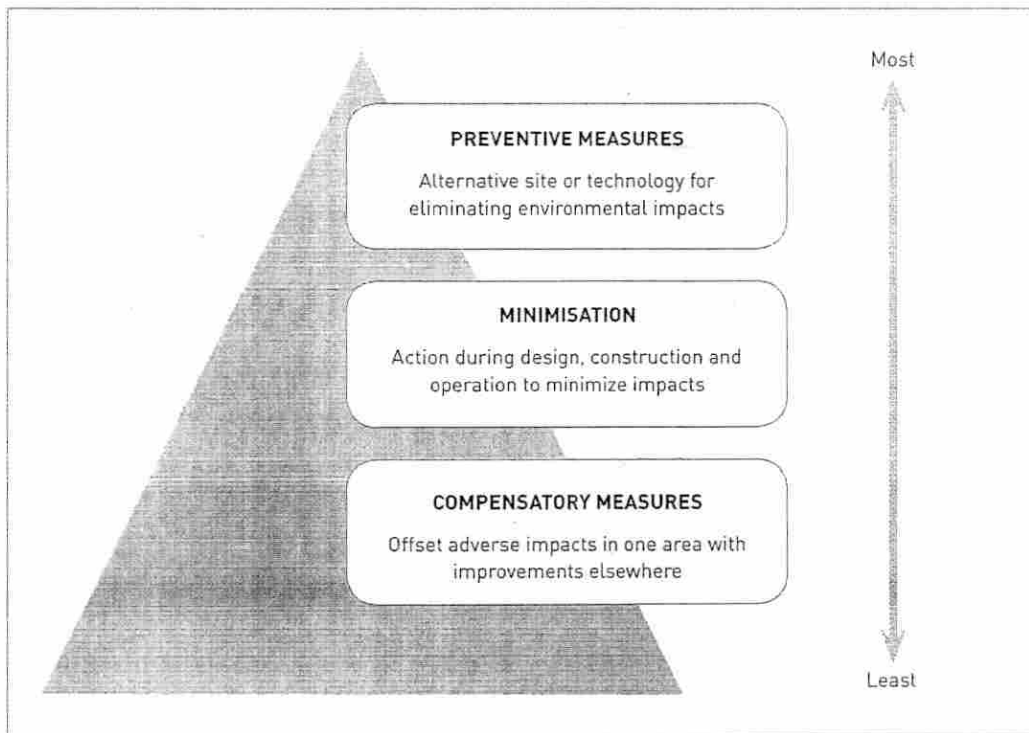
- Screening
- Scoping
- EIA report & public hearing
- Appraisal and clearance

Figure 5.3: Steps for Conducting an Environment Impact Assessment (EIA)⁵

⁵ Adapted from Technical EIA Guidance Manual for Common Municipal Solid Waste Management Facility, Infrastructure Leasing & Financial Services (IL&FS) (2010).

The scope of the environment baseline monitoring is defined by the ToR approved by the SEAC. The impacts of the proposed facility are superimposed over the baseline scenario to assess the actual impacts on the receptors. Identification of appropriate mitigation measures is a key output of the EIA process. Mitigation of environmental impacts is central in achieving an environmentally sound design (Figure 5.4).

Figure 5.4: Hierarchy of Environmental Impact Mitigation Options



Identified environmental impacts and proposed mitigation measures constitute the EMP. The final EIA report addresses environment baseline conditions, potential impacts, and sets of mitigation measures for the proposed project.

5.2 PREPARATION OF ACTION PLANS AND DETAILED PROJECT REPORTS

The five year short term plan should be further detailed into task specific actions plans (e.g., road sweeping and transportation for service provision) or detailed project reports (DPRs) for major infrastructure related services such as transfer stations, processing or treatment facilities, and scientific waste disposal facilities.

5.2.1 ACTION PLANS FOR MUNICIPAL SOLID WASTE MANAGEMENT SERVICE PROVISION

Action plans for specific services should address the following:

- nature of service provided;
- level of service provision like duration of service provision, staffing requirement, equipment requirement, and timings;
- mode of service delivery—whether the service is to be provided by the ULB staff or staff contracted by the ULB, and whether the service is through public private partnership (PPP) mode or private sector participation (PSP) mode;
- contractual obligations, if any;
- cost estimates to the ULB, private entity, or contractor; and
- details of land allocation and the statutory and non-statutory clearances required.

Based on the provisions of the action plans, the ULB should determine the future course of action for enabling service provision.

5.2.2 ASSESSMENT OF SUITABILITY OF PROJECTS FOR IMPLEMENTATION THROUGH PUBLIC PRIVATE PARTNERSHIP MODE

The ULB will have to decide whether specific projects requiring considerable capital costs, long design life, and complex operational and management systems are suited for implementation through the PPP mode or through the ULB's own resources.

A pre-feasibility study is recommended to help analyse the suitability of projects for PPP mode. It would provide recommendations on all public or private options that would be available for project implementation. A pre-feasibility study would address the aspects given in Table 5.2.

Suitability of MSWM projects for implementation through PPP mode should be ascertained through pre-feasibility and feasibility studies

Table 5.2: Indicative Contents for Pre-Feasibility Study⁶

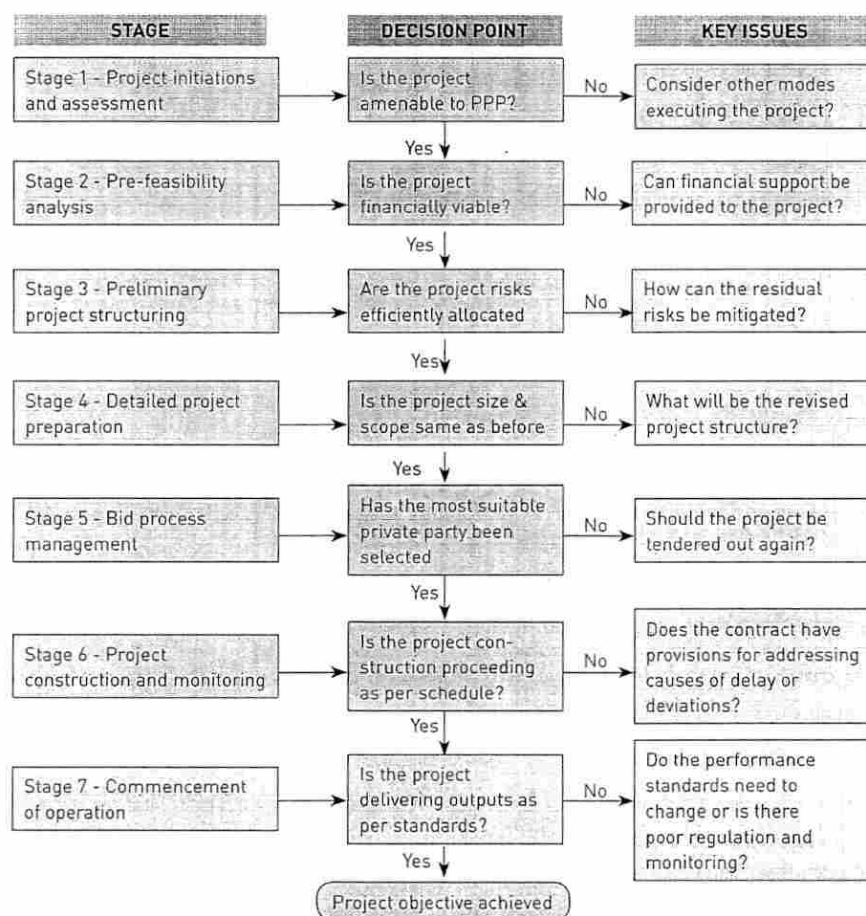
S.NO	CONTENT
1.	Preliminary Analysis of Technical and Operational Practicality of the Project
1.1.	Engineering and technical aspects of the project
	Manageability of operational aspects of the project
	Preliminary assessment of all likely technical and operational risks
2.	Environmental and Social Safeguard Activities
2.1	Socio-economic assessment and analysis
2.2	Environmental assessment scoping

⁶ Draft National Public Private Partnership Policy (2011). Department of Economic Affairs. Government of India. Available at: <http://toolkit.pppinindia.com/solid-waste-management/module2-pfcaa-ppfa.php?links=pfcaa1b>.



Table 5.2: Indicative Contents for Pre-Feasibility Study [contd.]

3.	Preliminary Assessment of Financial and Economic Viability of the Project
3.1	Cost recovery or income generation assumptions of the project
3.2	Likely private sector interest in the project
3.3	Overall project cost (capital + operations + maintenance)
3.4	Possible financial risks
3.5	Identification of likely economic benefits generated by the project
4.	Possible Arrangements for Private Sector Participation (PSP)
4.1	Role of the private sector
4.2	Contractual framework for the PSP arrangement
4.3	Outlined procedure for ensuring competition in the selection of the private sector partners
4.4	Legal documentation required to allow participation of the private sector
5.	Next Steps
5.1	Resources required to complete project preparation
5.2	Parties responsible for completing next steps
5.3	Roles and responsibilities of involved parties
5.4	Time frame for completing project preparation

Figure 5.5: Public Private Partnerships – Stages of Implementation.⁷

⁷ Toolkit for Solid Waste Management, Jawaharlal Nehru National Urban Renewal Mission, Ministry of Urban Development, Government of India. <http://jnurm.nic.in/wp-content/uploads/2012/11/SWM-toolkit.pdf>

The outcomes of a pre-feasibility study would determine whether the project is suitable for implementation through PPP mode or through the ULB's own resources. If at the pre-feasibility stage it is decided that the project has to be undertaken in a PPP mode, the next step is to conduct a feasibility study to ascertain the broad structure of the PPP project. The information from a feasibility study can then be used to prepare bidding documents.

Generic aspects to be addressed by a feasibility study include the following:⁸

- **Market analysis and project scope:** This is to assess the appropriate scope of the project, building on the work already done at the strategic planning and pre-feasibility stage. This would include the following:
 - Needs analysis - Does the project meet an end-user need? Does it contribute to meeting the objectives of the sponsoring authority? Who will the users be?
 - Options analysis - What is the best option for meeting the service need: a no-asset solution, existing assets, or new assets?
 - Output definition - What services will the project provide?
 - Demand estimate and forecast - What level of demand is there for the outputs or services from the project, and how much are users willing to pay?
- **Social and environmental feasibility:** This includes the requirements for impact assessments and for associated mitigation.
- **Technical feasibility and technical parameters:** These are based on the market analysis and include specification of required facilities and scenarios of project size for use in preliminary project design.
- **Risk studies and refined public private partnership mode:** These include assessment of the risks associated with the project, study of which party is best able to bear each risk, and refinement of the PPP mode selected at the pre-feasibility stage.
- **Preliminary cost assessment:** This is within a $\pm 5\%$ range based on the technical specification and assessed project risks.
- **Financial analysis and due diligence:** These include incorporating a projected revenue structure (e.g., proposed tariff, required annuity) and assessing any need for financial support from the public sector.
- **Economic feasibility:** This includes an assessment of overall net economic benefits of the project, incorporating estimated project benefits and costs including non-market factors such as those from the social and environmental assessment.

⁸ Draft National Public Private Partnership Policy (2011), Department of Economic Affairs, Ministry of Finance, Government of India. <http://toolkit.pppinindia.com/solid-waste-management/module2-pfcaa-ppfa.php?links=pfcaa1b>



- **Other public private partnership due diligence activities:** This includes value for money or value addition analysis if data is available.
- **Project implementation schedule:** This includes an outline of the proposed PPP procurement and award process through technical and financial closure, an outline of the construction schedule and target operation date, and any phasing that is planned for project extensions or ongoing development.



While carrying out a feasibility study it is also important to consider these provisions as prescribed under SWM Rules, 2016:

Clause 7a) provide market development assistance on city compost

b) ensure promotion of co-marketing of compost with chemical fertilizer in the ratio of 3 to 4 bags: 6 to 7 bags by the fertilizer companies to the extent compost is made available for marketing to the companies.

Clause 8(a) provide flexibility in the fertilizer control order for manufacturing and sale of compost propagate utilisation of compost on farm land.

Clause 9(a) decide tariff or charges for the power generated from the waste to energy plants based on solid waste.

(b) compulsory purchase power generated from such waste to energy plants by distribution company.

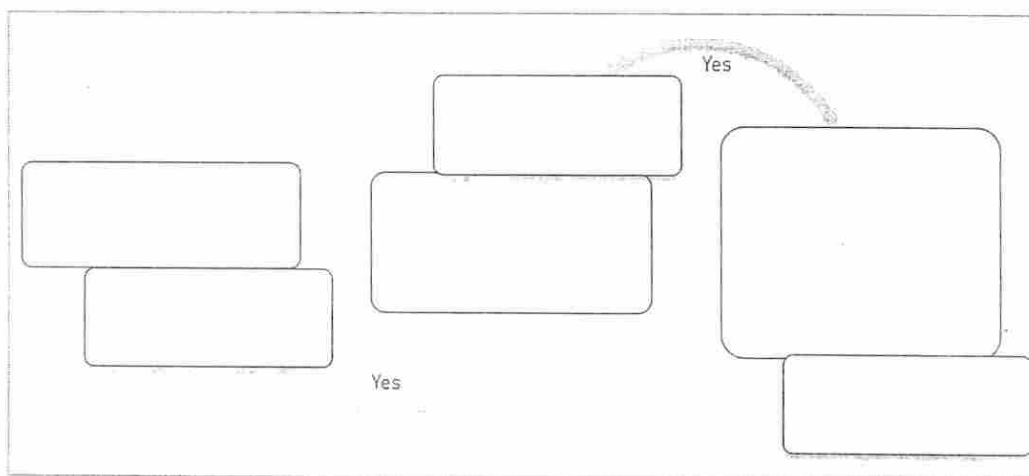
Clause 21. Criteria for waste to energy process.-

(1) Non recyclable waste having calorific value of 1500 K/cal/kg or more shall not be disposed of on landfills and shall only be utilised for generating energy either or through refuse derived fuel or by giving away as feed stock for preparing refuse derived fuel.

(2) High calorific wastes shall be used for co-processing in cement or thermal power plants.

Based on inputs from the pre-feasibility or feasibility reports, the ULB should decide whether to pursue the PPP route or the PSP route for project implementation. Information from these reports is used to define a well-structured bid. Selected private operators are then responsible for preparing a detailed project report (DPR) for further approval by the designated authorities. Where the project is found unsuitable for a PPP, PSP may be called for. Private entities are also required to prepare a DPR on the proposed implementation. Figure 5.6 depicts the process for determining suitability of projects for PPP mode.

Figure 5.6: Process for Determining Suitability of Projects for Public Private Partnership Implementation



5.2.3 DETAILED PROJECT REPORTS FOR INFRASTRUCTURE BASED PROJECTS

All infrastructure based facilities require the preparation of a DPR with sufficient details to ensure appraisal, approval, and subsequent implementation of the project in a timely and efficient manner. The major sections that should be covered in a DPR are:

- sector background, context, and broad project rationale;
- project definition, concept, and scope;
- institutional framework for implementation;
- resource requirements – land, capital, machinery, and staffing;
- project cost – lifecycle cost assessment;
- financial structuring;
- project phasing;
- operation and maintenance (O&M) framework and financial implication;
- project financial viability;
- project sustainability – social and environmental; and
- project benefits assessment – environmental and socio-economic benefits, resource intensity, etc.

Additional details can be incorporated as per the requirements of the ULBs. An indicative checklist for DPRs is listed in Table 5.3. Subsequent sections of this chapter address specific issues that would facilitate the implementation of the short term MSWM plan.

Table 5.3: Indicative Checklist for a Detailed Project Report⁹

1. INTRODUCTION TO THE PROJECT (EXECUTIVE SUMMARY)		
1.1	Definition of MSWM	
1.2	Status and issues of MSWM	
1.3	Provisions of MSWM plan – long term and short term	
1.4	Project background and link to the MSWM plan	
1.5	Project formulation justification (need for the project)	
2. CITY PROFILE (DETAILED DATA OF WARDS OR ZONES)		
2.1	History and importance of the project town	
2.2	Geographical and climatic conditions	
2.3	Location and extent	
2.4	Population	
2.4.1	Population projections	
2.4.2	Population density	
2.4.3	Floating Population	
2.5	Settlements in city	
2.5.1	Number of households, shops, commercial establishments and institutions	
2.5.2	Number of hotels, restaurants, banquet halls	
2.5.3	Number of large markets (vegetables, meat and fish)	
2.5.4	Slums and other informal settlements	
2.5.5	Industries and their profile	
2.5.6	Health care establishments	
2.5.7	Slaughterhouses	
2.6	Land use plan	
2.7	Physical infrastructure	
2.7.1	Roads	
2.7.2	Storm water management	
2.7.3	Sewage management	
2.7.4	Water Supply System	
2.7.5	Electricity	
2.8	Urban economy	
2.9	Information about ULB	
2.9.1	Political Setup	
2.9.2	Administrative setup of ULB	
2.9.3	Administrative setup of Sanitation Department of the ULB	
2.9.4	Financial status of ULB	
2.9.5	Administrative and financial aspects of MSWM	

⁹ Developed by the Expert Committee for revision of MSWM manual (2013-15)

Table 5.3: Indicative Check-list for a Detailed Project Report [contd.]

3 STATUS OF EXISTING SOLID WASTE MANAGEMENT IN THE CITY		
3.1		Waste generation(based on actual sample survey)
3.1.1		Approach adopted for estimation of waste generation
3.1.2		Residential areas –colonies, apartment complexes
3.1.3		Commercial establishments, malls
3.1.4		Hotels, restaurants, banquet hall
3.1.5		Institutional areas- offices, schools, universities
3.1.6		Fruit and vegetable markets, fish and meat markets
3.1.7		Hospitals and nursing homes (excluding biomedical waste)
3.1.8		Slaughterhouses
3.2		Quantification and characterization of waste
3.2.1		Sampling criteria
3.2.2		Physicochemical characteristic of MSW
3.3		Existing MSW collection system
3.3.1		Primary waste collection system
3.3.2		Primary Waste Storage at Generation
3.3.3		Secondary waste collection system
3.4		Street sweeping and drain cleaning
3.5		MSW secondary storage system
3.5.1		Transfer Station Details
3.5.2		Waste Storage Depots
3.6		MSW transportation system
3.7		Existing MSW processing system
3.7.1		Recyclable Waste
3.7.2		Biodegradable Waste
3.7.3		Non-biodegradable waste
3.7.4		Construction and Demolition Waste
3.7.5		Any Other Waste (Domestic Hazardous, sanitary waste)
3.8		Infrastructure existing for SWM
3.8.1		Manpower
3.8.2		Equipment/Vehicles
3.8.3		Equipment repair facility
3.9		Status of present disposal and proposed landfill site
3.10		Overall compliance of SWM Rules
4. PROJECT DEFINITION		
4.1		Project objectives
4.2		Scope of project
4.3		Approach and methodology

Private sector participation is beneficial especially in newly developed areas and underserved areas, where the ULB has not been providing services through its own labour force

Table 5.3: Indicative Check-list for a Detailed Project Report [contd.]

5. GAP ANALYSIS		
5.1	Manpower and Vehicle requirement for door to door collection, street sweeping and drain cleaning	
5.2	Sufficiency of Secondary Collection Bins	
5.3	Sufficiency of Secondary Collection Vehicles	
5.4	Sufficiency in treatment, processing & disposal facilities	
5.5	Gaps in Awareness among city residents and civic authorities	
5.6	Gaps in Institutional Structure	
5.7	Gaps in Capacity Building for ULB	
6. PROPOSED MUNICIPAL SOLID WASTE MANAGEMENT SYSTEM		
6.1	Segregated Storage of Waste at Source	
6.2	Street Sweeping and Drain Cleaning	
6.3	Segregated Waste Collection	
6.4	Segregated MSW Transport system and Secondary Collection	
6.5	Transfer Station if required, as per SWM Rules 2016	
6.6	Processing of MSW	
6.6.1	Criteria for selection of processing technology	
6.6.2	Availability of land	
6.6.3	Process design for proposed processing plant	
6.6.4	Design of processing plant and leachate management	
6.6.5	Required infrastructure and equipment	
6.6.6	Environmental Monitoring and control	
6.6.7	Socio-economic Benefits	
6.6.8	Product Utilisation	
6.7	Municipal sanitary landfill	
6.7.1	Conceptual design of landfill	
6.7.2	Availability of land	
6.7.3	Technical specification	
6.7.4	Environmental monitoring and control	
6.7.5	Socio-economic benefits	
6.7.6	Biomining and Bioremediation plan for existing dumpsites	
6.7.7	Capping old dumpsites	
6.8	Staffing Requirements	
6.9	Community Awareness and Public Participation	
6.9.1	Overview	
6.9.2	Objective	
6.9.3	Public Participation and awareness through IEC programs	
6.9.4	Project Implementation Plan	

Table 5.3: Indicative Check-list for a Detailed Project Report [contd.]

7	INSTITUTIONAL ASPECTS AND CAPACITY BUILDING	
	7.1	Proposed organizational setup
	7.2	Training and capacity building of ULB
8	OTHER O&M ASPECTS	
	8.1	Management Information System
	8.2	Complaint Handling System
	8.3	Environmental Health and Safety Aspects
9	COMMUNITY AWARENESS AND PUBLIC PARTICIPATION	
	9.1	Overview
	9.2	Objective
	9.3	Public Participation and awareness through IEC programs
	9.4	Project Implementation Plan
10	COST ESTIMATES	
	10.1	Cost Estimates for Collection and Transportation
	10.1.1	Capital Expenditure
	10.1.2	O&M Expenditure
	10.2	Cost Estimates for Processing and Disposal
	10.2.1	Capital Expenditure
	10.2.2	O&M Expenditure
	10.3	Total Revenues Generated
	10.3.1	Operation and Maintenance cost and revenue generation from residents, apartments
	10.3.2	Proposed Tariff Charges
	10.3.3	Revenue from Sale of Products
	10.3.4	Revenue from User Charges
11	FINANCIAL ASPECTS	
	11.1	Current MSW Expenditure
	11.2	Project financial structuring including PPP Decisions
	11.3	Funds for capital expenditure
	11.4	Possibilities for cost sharing
	11.5	Finance for operation & management
	ANNEXURE	

**Adequate Service Provisions for Waste Processing, Treatment and Disposal Facilities**

- Provision of good quality or metalled access road leading to the processing or treatment and disposal facility
- Adequate power supply for carrying out the day to day activities in the plant
- Adequate supply of drinking water for the staff
- Adequate provision of storm water management at the plant site
- Adequate provision of toilets for male and female staff. Adequate sewerage disposal system for smooth functioning and operation of the plant. However, in absence of the sewer line, onsite sewer system should be provided.

5.3 CONSIDERATIONS FOR CONTRACTING A MUNICIPAL SOLID WASTE MANAGEMENT SERVICE

Following essential aspects may be considered by the ULB while deciding to contract out municipal solid waste management services:

- The ULB should identify services that can be effectively provided by the existing staff and available financial resources.
- Subsequently, services which would need to be outsourced due to limited in-house technical know-how, capability, and financial resources should be identified.
- Benefits and potential issues with outsourcing services which the ULB cannot provide (as identified above) should be fully evaluated and understood. Justification note for the need to contract out identified services should be prepared.
- Commercial or economical feasibility of the services to be contracted out has to be ascertained. The appropriate contract models and their benefits need to be assessed for each of the services that has to be contracted out.
- Where contract labour is hired, the ULB should ensure compliance with the provisions of the Contract Labour (Regulation & Abolition) Act, 1970.
- Sharing of all possible risks (technical, operational, and financial) between ULB and the operator should be detailed out.
- Where land acquisition or community rehabilitation is involved, the ULB has to stand in for the contractor in addressing such aspects.
- Contracts should specify the range of technology or technologies that can be adopted after the ULB undertakes a thorough assessment of available technologies for specific services.



- In ULBs with population of over 1 lakh, at least two contractors may be considered for every outsourced service. However, this is not relevant for processing and treatment facilities in small and medium towns.
- For cities with more than 10 lakh population, ULBs should prepare a feasibility report for the services or projects to be contracted. Depending on the feasibility report, the ULB should prepare a DPR including the detailed engineering report for minimising risks associated with the project. Cities with less than 10 lakh population may directly prepare a DPR to minimize costs associated with the feasibility study, provided the project can be appropriately defined. The ToR for the services to be contracted should be based on the DPR developed.
- On ascertaining the benefit of outsourcing services, the ULB shall prepare a ToR which shall include at least the following:
 - detailed description of scope of work;
 - specific outcomes or outputs of the services and performance standards for the services to be contracted;
 - specified duration of the service to be contracted and time lines for project execution or provision of services;
 - minimum qualification and experience of the bidder required for plan of work and methodology;
 - minimum staffing and equipment required for delivering the services;
 - envisaged monitoring and evaluation requirements;
 - management structure and reporting;
 - tender evaluation procedure;
 - payment mechanism;
 - adequate social and environmental safeguards to ensure equitable service provision;
 - confidentiality clause; and
 - service level guarantee mechanisms.

Pre-requisites for Contracting

- Cost benefit analysis of the existing solid waste management system is necessary.
- Services to be outsourced shall be identified.
- Characterisation and physicochemical analysis of municipal waste should precede tendering of any waste processing, treatment, and disposal facilities.
- Detailed project development is the key to successful implementation. Detailed project definition and key performance indicators have to be established.
- Land requirement for 20-25 years for proposed facilities shall be assessed and identified.
- Complete ownership of all projects by the ULB (not just ownership of property, but active commitment and monitoring) is crucial.

An overview of different kind of contracts specific to different MSWM services and their characteristics are given in Section 1.4.5.7 of Part II.

5.3.1 CONTRACTING ARRANGEMENTS FOR MUNICIPAL SOLID WASTE SERVICE PROVISION

Not all contracting models are suitable for each of the MSWM operations. Municipal authorities may adopt one or more of the following contracting models:

- Service contract (door-to-door collection and transportation of waste)
- Management contract (door-to-door collection, construction and demolition [C&D] waste collection, secondary storage, and transportation of waste)
- Build and transfer (transfer station, sanitary landfill)
- Build-Operate-Transfer (BOT) (biomethanation, composting, sanitary landfill)
- Build-Own-Operate (BOO) (composting, refuse derived fuel [RDF], incineration)
- Design-Build-Own-Operate-Transfer (DBOOT) (large compost plants, RDF plants, incineration, and sanitary landfill)
- Design-Build-Finance-Operate-Transfer (DBFOT) (large compost plants, RDF plants, incineration, and sanitary landfill)

ULBs may decide to bundle certain services while contracting out MSWM operations to build accountability and efficiency in the system. Table 5.4 indicates a typical mix of services that are bundled and the most relevant contracting models for outsourcing these services:

Contract Models for MSWM

Services:

- Service contract
- Management contract
- Design-Built-Operate (DBO)
- Build-Own-Operate (BOO)
- Build-Own-Operate and Transfer (BOOT)
- Build-Operate-Transfer (BOT)
- Lease
- Concession



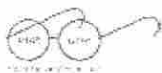
Table 5.4: Typical Services Bundled for Contracting

S. NO.	TYPE OF PROJECT	DESCRIPTION OF PROJECT	ADVANTAGES	RISKS	UNIT OF MEASUREMENT
1	MSWM: Model 1 (ISWM)	This model consists of the following: 1. Collection 2. Transportation 3. Processing 4. Sanitary landfill	- It increases accountability of a single party. - It minimizes hassles among different contractors. - With a single party responsible for all activities, there is no scope for issues regarding operational or process deficiencies in executing any of the services. Poor performance cannot be blamed on upstream deficiencies or issues of quantity and quality of waste. - It is easier, more efficient, and less time-consuming for the ULB to deal with a single party for managing all MSWM services.	- This creates a monopoly of the contractor and increases the scope for defaults and further negotiations, given that the entire MSWM service chain is in the hands of a single contractor. - The entire city service may get disrupted if the contractor fails to perform, or in case of any other unforeseen circumstances. - If the principal contractor off-loads certain services to associates, risks (cost & monitoring) might increase substantially. - Delay in execution of one service will result in overall system delays. - There is scope for the contractor to recover full fees though he or she may not perform certain functions on a daily basis.	- Quantity of waste collected and transported on a daily basis - Tonnes of waste received at the processing plant and product produced - Tonnes of waste landfilled Using only a single monitoring measure as the basis to pay the contractor could be risky and against the interest of the ULB.
2	MSWM: Model 2	This model consists of two packages: Package 1: Collection and transportation Package 2: Processing and disposal (P&D)	- ULBs can hire suitable agencies that have experience and expertise in distinct areas of MSWM services. - ULB could also retain package 1 within its own scope and outsource only P&D to specialized agencies. - Alternately, package 1 can be divided among multiple players (on an area basis), leading to a better control of the waste collection and transportation. The ULB can then depend on any of the operators if one fails to perform.	Adequate care should be taken to ensure that the collection and transportation of segregated wastes should be regular and in sync with the requirements of the processing facility.	- Package 1: Tonnes of waste collected and transported - Package 2: - Tonnes of waste processed per processing plant and product produced - Tonnes of waste at disposal facilities



Table 5.4: Typical Services Bundled for Contracting [contd.]

S. NO	TYPE OF PROJECT	DESCRIPTION OF PROJECT	ADVANTAGES	RISKS	UNIT OF MEASUREMENT
3	MSWM: Model 3	This model consists of three packages: Package 1: Collection and transportation Package 2: Processing Package 3: Sanitary landfill	1. ULBs can select agencies having expertise in MSWM service areas at a very competitive rate. 2. It provides scope for competition between multiple service providers. 3. It does not create a monopoly of a single service provider. 4. It enables the ULB to replace a nonperforming contractor without disrupting all other MSWM services	Same as above	Package 1: Tonnes of waste collected and transported Package 2: Tonnes of waste processed per processing plant or product produced Package 3: Tonnes of waste at disposal facilities
4	MSWM: Model 4 (decentralised project)	The model has four packages (each process is considered an individual project): Package 1: Collection Package 2: Transportation Package 3: Processing Package 4: Sanitary landfill	1. ULB can select agencies having expertise in MSWM service areas at a very competitive rate. 2. It provides scope for competition between multiple service providers. 3. It does not create a monopoly of a single service provider. 4. It enables the ULB to replace a nonperforming contractor without disrupting all other MSWM services. 4. Each service can be operated by specific specialists. 5. There is scope to ensure provision of cost-effective services due to competition and to replace nonperforming contractors.	The risk of lack of synchronisation between waste collection and transportation agencies can disrupt overall service provision. This in turn can adversely affect the processing and disposal services.	Package 1: Persons employed or tonnes of waste collected Package 2: Tonnes of waste transported Package 3: Tonnes of waste processed per processing plant and tonnes of product produced, if any Package 4: Tonnes of waste at disposal facilities



5.4 TENDERING, CONTRACT MANAGEMENT AND SUPERVISION

As per SWM Rules, 2016:

Clause 15: Duties and responsibilities of local Authorities:

- (v) facilitate construction, operation and maintenance of solid waste processing facilities and associated infrastructure on their own or with private sector participation or through any agency for optimum utilisation of various components of solid waste adopting suitable technology including the following technologies and adhering to the guidelines issued by the Ministry of Urban Development from time to time and standards prescribed by the Central Pollution Control Board.
- (w) undertake on their own or through any other agency construction, operation and maintenance of sanitary landfill and associated infrastructure as per Schedule 1 for disposal of residual wastes in a manner prescribed under these rules;
- (x) make adequate provision of funds for capital investments as well as operation and maintenance of solid waste management services in the annual budget ensuring that funds for discretionary functions of the local body have been allocated only after meeting the requirement of necessary funds for solid waste management and other obligatory functions of the local body as per these rules;

ULBs may enter into contract with private service providers for provision of specified MSWM services such as collection, transportation, treatment, processing, and disposal of waste (for more details, refer to Section 1.4.5.7 of Part II). Private service providers have to be held accountable for maintaining required standards of services as well as its effectiveness and efficiency.

Adequate care should be taken while preparing tender documents to ensure that only those firms with requisite qualifications and experience are considered. The following aspects should be kept in mind:

- The tender should clearly specify the technical and financial capability required to perform the task proposed to be outsourced. The qualification criteria should be standardized. It should provide equal opportunity to all those who have a capability to undertake the task. It should not restrict competition between big players; at the same time, it should not allow incompetent, inexperienced, or unqualified parties to enter the fray. The eligibility criteria should be limited to what is required to perform the obligation; this shall enhance healthy competition and create a pool of entrepreneurs to provide MSWM services.

Standardise pre-qualification criteria should support only those firms having adequate resources and expertise



- Selection of bidders should be based on technical and financial bids and specified criteria. This could be done in several ways:
 - The ULB may prescribe minimum qualifying standards for technical bids; financial bids of only those bidders who meet the minimum qualifying standard may be opened unless otherwise justified.
 - ULB may give higher weightage to qualifications and experience in cases where higher skills are necessary.
- Awarding contracts to single party covering all aspects of MSWM in the city may be avoided, as it can create unmanageable situation if the contractor ceases to operate. Multiple contracts are desirable so that if one contractor fails, another can take over until other arrangements are made. However, it may not be feasible in case of processing and landfilling.
- A transparent and stringent monitoring and evaluation system should be developed to ensure that contractors perform their obligations.
- Long term contracts should provide for a periodic revision of tariffs based on predetermined parameters and create implementation mechanisms to ensure sustainability of the contract.
- ULBs should ensure timely payments for contracted services.
- ULBs should ensure adequate in-house capabilities for appropriate contract monitoring.



Selection of bidders should be based on both technical and financial criteria



Multiple contracts for MSWM services should be encouraged to ensure duplicate competencies, which can be relied on during times of failure of contractual obligations by any of the contractors



The ULB itself should provide door-to-door collection and transportation of wastes in a few wards in the city to maintain in-house capacity for providing crucial services in times of crisis (e.g., dispute in contract provisions, when the service provider does not discharge his obligations, etc.). Contingency plans should be prepared by the ULB for appropriate storage of waste to tide over situations of non-performance of the processing, treatment, and disposal facilities.



Depending on the project structure and time or cost considerations, ULBs can adopt a single-stage process or a two-stage process for contracting

5.4.1 ENGAGING WITH A PUBLIC PRIVATE PARTNER

After a DPR, a transparent procurement process should be adopted for the selection of a PPP partner, preferably through a transaction advisor, by following these standard procedures:

- Preparation of expression of interest (EoI), request for proposal (RFP), and concessionaire agreement
- Obtaining approval from concerned authority
- Issue of notice for pre-qualification or EOI
- Short-listing of firms
- Issue of RFP to the shortlisted firms
- Conducting pre-bid meeting



Contents of a typical request for qualification (RFQ):

- Introduction
- Instruction to applicants
- Fraud & corrupt practises
- Pre-bid conference
- Miscellaneous

- Receiving technical and financial bids in separate packets in response to the RFP and opening of technical bids
- Evaluation of the technical bid document received
- Opening of financial bids of the bidders (minimum three bids would be desirable)
- Evaluation of financial bids
- Selection of most preferred bidder
- Negotiation and signing of agreement
- Award of contract

5.4.2 TENDERING PROCESS FOR PUBLIC PRIVATE PARTNERSHIP PROJECTS

The ULB has an option of adopting a single stage selection process or a two-stage selection process for awarding contracts to the PPP player.

5.4.2.1 SINGLE STAGE PROCESS

In a single stage bidding process, technical and financial bids are submitted simultaneously in response to a RFP. The selection of the preferred bidder is envisaged through an evaluation of a three-part proposal received from interested bidders:

- **Part I – Response to qualification:** Pre-qualification will be based on the documents received from bidders in response to the qualifying criteria laid down by the ULB. The technical and financial offers of bidders, who do not qualify at this step, will be returned unopened.
- **Part II – Technical offers:** Technical offers in the proposals from bidders who qualified at the end of first stage will be opened and

Indicative Schedule for Bidding: Single Stage Process

- Sale of bid or request for proposal (RFP) to short-listed applicants: zero date
- Submission of query by the perspective applicants: +15 days
- Pre-bid meeting: +20 days
- Authority response to queries: +30 days
- Bid submission due date: +60 days
- Opening of technical bids: +60 days
- Acceptance of technical evaluation report by Tender Committee: +80 days
- Financial bid opening: +90 days
- Letter of intent (LOI): within 30 days of bid opening date
- Issue of letter of award to bidder: +30 days of issue of LOI
- Contract signing: within 30 days of award of LOI

Notes:

1. The bidding process takes 4 months minimum. However, depending upon the urgency and requirement of the project execution the bidding process could be done within 60 days.
2. +“x” days means time duration from the zero date, i.e., RFP’s date of publication.



evaluated against predetermined criteria. Financial offers of bidders, who do not qualify at this step, will be returned unopened.

- **Part III – Financial offers:** Financial offers from proposals of those bidders whose technical offers are qualified shall be opened and scrutinized. Only those financial offers which are in accordance with criteria laid down in RFP shall be evaluated.

5.4.2.2 TWO STAGE PROCESS

The two stage selection process is characterised by an initial pre-qualification stage, followed by RFP stage, which is applicable only to pre-qualified bidders.

Stage 1: Qualification stage: The request for qualification (RFQ) specifies the minimum qualifications required for participation in the tender. Suitability of interested parties or consortia will be assessed by the tenderer in accordance with the provisions of the RFQ. At the end of this stage, the authority will shortlist suitable pre-qualified applicants who are then eligible for participation in the second stage of the bidding process (the “bid stage”).

Stage 2: Letter of invitation: After the bidders have been shortlisted under the RFQ for the aforesaid project, ULB should invite the bidders to procure the RFP with the objective of submitting a technical and financial proposal.

RFQ contains useful information required by bidders for formulating their application for qualification

Indicative Schedule for Bidding – Two Stage Process

Stage 1: Pre-Qualification Stage (Minimum: 3 months)

- Sale of request for qualification (RFQ): zero date
- Submission of query by the perspective applicants: +15 days
- Pre-bid meeting: +20 days
- Authority response to queries: +30 days
- Bid submission due date: +60 days
- Opening of technical qualification bids: +60 days
- Acceptance of technical qualification evaluation report by Tender Committee: +80 days

Stage 2: Bid Stage (Minimum: 6 months)

- Sale of request for proposal (RFP) short-listed applicants: +90 days
- Submission of query by the perspective applicants: +105 days
- Pre-bid meeting: +110 days
- Authority response to queries: +130 days
- Bid submission due date: +150 days
- Opening of bids: +150 days
- Letter of Intent (LOI): within 30 days of bid opening date
- Contract signing: +30 days of award of LOI

Notes:

1. The bidding process takes 6 months minimum. However, depending upon the urgency and requirement of the project execution the bidding process could be done within 60 days.
2. +“x” days means time duration from the zero date, i.e., date of publication of RFP.



5.4.3 REQUEST FOR PROPOSAL (RFP) FROM ULBs

The RFP is a document that ULBs prepare to elicit bids from potential vendors. The quality of an RFP is very important for successful project management because it clearly delineates the deliverables that will be required. This RFP includes statements that reflect various assumptions and assessments by the authority in relation to the project. Such assumptions, assessments, and statements do not contain all the information that each bidder may require.

The RFP should be organized into three volumes:

- Volume I: Instruction to bidders
- Volume II: Minimum mandatory technical and performance specifications or project information memorandum
- Volume III: Concession agreement

5.4.3.1 VOLUME I: INSTRUCTION TO BIDDERS (ITB)

The instruction to bidders specifies procedures to be followed by bidders in preparation and submission of their proposals and provides information on submission, opening, evaluation of proposals, and award of concession.

Indicative contents of the instruction to bidders include the following:

- General conditions
 - General responsibilities of bidding
 - Fraud and corrupt practices
- Contents and submission of proposal
 - Cost of proposal
 - Language and currency
 - Number of proposal
 - Eligibility and pre-qualification
 - Bid security
 - Performance guarantee
 - Guidelines for submission of proposal: The bidder shall submit the proposal in accordance with the guidelines prescribed in the RFP and ensure that the proposal is complete in all aspects. The authority reserves the right to reject proposals that do not conform to the guidelines prescribed.
 - The proposal shall be submitted in three parts, viz.,
Part I: Response to pre-qualification requirements

RFP provides information to the bidders that is useful for preparing their financial offers

Part II: Technical offer and

Part III: Financial offer

- Proposal due date and validity period
- Late submission of proposal
- Modifications, substitution or withdrawal of proposal
- Verification of information and site visit
- Right to accept or reject any or all bids
- Eligibility and pre-qualification
 - Technical capacity as per eligibility criteria
 - Financial capability
 - Change in ownership
 - Lock in periods
- Evaluation of bids
 - Confidentiality and non-discriminatory process to be defined
 - Clarifications
 - Evaluation: Part I – Response to pre-qualification requirements
 - Evaluation: Part II – Technical offer
 - Evaluation: Part III – Financial offer
 - Notification and issue of LoI
 - Conditions precedent for issue of letter of award
 - Authority's right to accept or reject proposal

5.4.3.2 VOLUME II: MINIMUM MANDATORY TECHNICAL AND PERFORMANCE SPECIFICATIONS OR PROJECT INFORMATION MEMORANDUM

- Brief description of the project
 - Scope of work
- General technical design requirements and standards
- Specific design requirements and standards for each facility
- Operation and performance requirements
- Existing infrastructure

5.4.3.3 VOLUME III: DRAFT CONCESSION AGREEMENT

The draft concession agreement specifies various details pertaining to the project in its various articles. Formats for information to be provided by the bidder are specified in the various schedules of the concession



agreement. A list of articles to be included in the concession agreement is given in Table 5.5:

Table 5.5: List of Articles in the Concession Agreement¹⁰

ARTICLES	DESCRIPTION
ARTICLE I: General terms	Definitions
	Interpretations
ARTICLE II: Concession	Grant of concession
	Rights associated with the grant of concession
	Concession period
	Extension of concession
	Acceptance of concession
	Conditions precedent for waste processing & landfill (WPLF)
	Non-compliance with conditions precedent
ARTICLE III: Project site	Applicable permits
	Lease of land
	Handover of project site
	Rights, title and use of project site
	Peaceful possession
ARTICLE IV: Monitoring of the project facility	Composition of committee
	Specific obligations of the committee
	Frequency and expenses related to meetings
	Role of the committee
ARTICLE V: Concessionaire's obligations	Right to appoint an external consultant
	Performance bank guarantee
	General obligations
	Arrangement for finances
	Operation and maintenance
	Insurance
	Clearances, permits, etc
	Specific obligations
	Miscellaneous obligations
ARTICLE VI: Municipal body's obligations	No breach of obligations
	Specific obligations
ARTICLE VII: Payments to the developer	General obligations
	Payments terms
ARTICLE VIII: Force majeure	Payment mechanism
	Force majeure events
	Duties of parties during force majeure events
	Costs during the force majeure events
	Termination due to force majeure events

¹⁰ Adapted from Draft National Public Private Partnership Policy (2011). Department of Economic Affairs, Government of India. Available at: <http://toolkit.pppinindia.com/solid-waste-management/module2-pfcaa-ppfa.php?links=pfcaa1b>.



Table 5.5: List of Articles in the concession agreement [contd.]

ARTICLES	DESCRIPTION
ARTICLE IX: Events of Default	Events of default
	Termination due to events of default
	Rights of municipal body upon termination
	Rights of parties
ARTICLE X: Transfer of Project Facility	Ownership of project facility
	Contractor's obligations
	Municipal body's obligations
ARTICLE XII: Dispute Resolution	Amicable resolution
	Arbitration proceedings
	Performance during dispute
ARTICLE XI: Representation and Warranties	Contractor's representations and warranties
	Municipal body's representations and warranties
	Obligation to notify change
ARTICLE XIII: Miscellaneous	Sub-contract
	Labour (interests and rights of labours be laid out clearly)
	Interest and right of set off
	Governing law and jurisdiction
	Waiver
	Survival
	Amendments
	Notices
	Severability
	Language
	No partnerships
	Exclusion of implied warranties, etc
	Counterparts

The various Schedules to be included in the concession agreement shall include:

- Schedule I: Details of project sites
- Schedule II: Construction requirement for waste processing facilities
- Schedule III: Fees (format)
- Schedule IV: Land license agreement (format)
- Schedule V: Authorisation
- Schedule VI: Scope of work of monitoring authority
- Schedule VII: Format for performance bank guarantee
- Schedule VIII: Technical scheme for MSWM facility
- Schedule IX: Approach and methodology for construction of MSWM facility
- Schedule X: Service level condition and penalties
- Schedule XI: Operation & maintenance for MSWM facility

5.4.4 SUGGESTED CONTENTS OF PROPOSALS FROM BIDDERS

The proposal shall include the following contents in the formats prescribed by the municipal authority:

Response to pre-qualification requirement

- Bid security (as defined)
- Fees for RFP (as defined)
- Form I: Covering letter for proposal submission
- Form II: Details of bidder or bidding consortium
- Form III: Power of attorney of authorized signatory of bidder
- Form IV: Memorandum of association (in case of proposal submitted by a consortium)
- Form V: Power of attorney of lead member (for consortium proposal)
- Form VI: Format for board resolution of bidder or bidding consortium members
- Form VII: Format for non-criminality
- Form VIII: Format for anti-collusion certificate
- Form IX: Details and proof of technical capacity
- Form X: Details and proof of financial capacity
- Form XI: Litigation history
- Certificates from a practising Chartered Accountant in India certifying net worth as per clause 3 (a) supra, along with the documents (if any) as required under relevant clauses. For the purpose of this tender, the term net worth means the shareholders equity plus reserves and surplus
- Copy of memorandum and articles of association or registration document

Technical Offer

- Form XI A: Formats for technical proposal
- Form XI B: Technical plan for project facilities
- Form XII: Details of expert team with curriculum vitae

Financial Offer

- Form XIII: Project cost break-up sheet indicating costs of all services or components of the contract
- Form XIV: Detailed break-up of operating costs & revenues





National Guidance for Contracting Public Private Partnership Projects

- Toolkit for public private partnership (PPP) frameworks in municipal solid waste management (MSWM) developed by the Department of Economic Affairs, Ministry of Finance, and Ministry of Urban Development (MoUD) with the support of the Government of India-ADB PPP initiative.
- Government of India, MoUD. 2012. Toolkit for Solid Waste Management: Jawaharlal Nehru National Urban Renewal Mission.
<http://jnnurm.nic.in/wp-content/uploads/2012/11/SWM-toolkit.pdf>
- Government of India, Ministry of Finance. 2011. PPP Toolkit for Improving PPP Decision-Making Processes.
<http://toolkit.pppinindia.com/solid-waste-management/module1-intro.php?links=intro1>

5.4.5 COST ESCALATION

Cost of service provision may increase as a result of an increase in the general costs or in specific cost components of a contract such as fuel or wages, which form the major cost component of any MSWM contract.

5.4.5.1 ANNUAL ESCALATION IN GENERAL COSTS

In order to enable stable service provision even in the face of annually escalating general costs, the concessionaire may be allowed an annual increase in the contract value. The following guidance may be used to calculate the allowed increase.

'y'% increase in the base rate 'X' may be given annually to cover the increase in general costs. The increase may be calculated as per these examples:

After 1 year X plus y% of X

After 2 years X plus 2y% of X

After 3 years X plus 3y% of X

After 10 years X plus 10y% of X

After 14 years X plus 14y% of X

Where X is the "base rate" accepted at the time of award of contract as against rate per tonnes quoted by the selected bidder.

MSWM contracts are sensitive to fluctuations in labour and fuel costs; contracts should build in mechanisms to enhance the cost of the contract when there is an escalation of these prices, otherwise contracts may fail



5.4.5.2 PRICE INCREASE ON ACCOUNT OF INCREASE IN DIESEL OR STAFFING COSTS

Besides the general costs, the concessionaire shall be given an increase or decrease in the diesel component as well as minimum wages component as and when the rates are increased or decreased.

For the purpose of calculations (as per formula given below), the cost component of diesel may be taken as 25% of base rate X and the cost component of minimum wages of workers may be taken as 45% of base rate X. The increase in price of diesel or minimum wages will be compensated by giving a proportionate increase in the aforesaid percentage component of diesel and minimum wages.

If the price of diesel or alternate fuel (for the vehicle and equipment used for providing MSWM services) reduces, the tendering authority could on its own motion order review of the diesel or fuel price and

Calculating Price Increase on Account of Increase in Diesel and Minimum Wage

$$E(Rs) = A \times B \left\{ \frac{C}{D} - 1 \right\}$$

New Rate payable on account of price increase = $A \pm E$

Diesel

- A = base rate at the time of signing the Concession Agreement
- B = % of diesel component in 'base rate' fixed at the time of signing the Concession Agreement i.e. 25%
- C = Actual rate of diesel at the time of price increase
- D = Rate of diesel at the time of award of Concession or previous revision whichever is later
- E = Increase/decrease in diesel component

A =	800
B =	25%
C =	60.00
D =	55.00
$= 800 \times 0.25 \times (1.09 - 1)$	
$= 800 \times 0.25 \times 0.09$	
$= 800 \times 0.0227$	
= 18.16	

Minimum Wage

- A = Base rate at the time of signing of the Concession Agreement
- B = Percentage of Minimum Wage component in 'base rate' fixed at the time of signing of the Concession Agreement i.e. 45 %
- C = Minimum wages as increased now by Govt.
- D = Minimum wages at the time of award of the Concession or previous review
- E = Increase/decrease in Minimum Wage component

A =	800
B =	45%
C =	180.00
D =	160.00
$= 800 \times 0.45 \times 0.125$	
$= 800 \times 0.45 \times 0.125$	
= 45	

Therefore, further increase in the base rate at the time of review will be Rs. 18.16 as Diesel component + Rs. 45/- as minimum wage component = Rs. 63.16

The Base Rate of 800 /- will now is 863.16 from the date of such increase.



minimum wages and reduce the increase in the base rate already given, subject to the condition that the final base rate X shall not be reduced below the original rate accepted or granted by the tenderer.

5.4.6 EVALUATION AND SELECTION

An evaluation team, appointed by the municipal authority, will scrutinize the tender documents. The team will assess the applications for completeness and eligibility of the tendering bidders as per conditions mentioned in the terms of references (ToR). This process from publication of the expression of interest (EoI) to the selection of the final contractor usually takes about 6 months.

The evaluation committee shall shortlist all eligible bidders. Final selection may be based on specific criteria specified in the (ToR). The following criteria may be considered:

1. Relevant qualification and experience of the bidder
2. Expertise of the bidding team
3. Financial capability of the bidder
4. Approach and methodology suggested
5. Reliability of the bidder (based on previous conduct)
6. Proposed pricing structures and cost to the ULB
7. Environmental and social safeguards provided or ensured
8. Assumption of risk liability and proposed mitigation measures

The ULB may enter into further negotiations with the highest ranked bidder. The contracting and service agreement should be finalized based on the agreements subsequent to the negotiation process.

Enabling Conditions for Successful Public Private Partnership Contracts

- A transparent bidding process
- Timely handover of facilities free from encumbrances (physical and legal)
- Expeditious clearances, approvals, and decision-making process (delays have serious consequences)
- A sustainable project structure and revenue model with appropriate risk allocation
- Price sensitivity of the financial proposal, specifically with respect to capital, subsidies, or sale of products (a robust indicator of the financial viability of proposed projects, even when there is a change in the assumed circumstances)
- Political and stakeholder involvement and acceptance (crucial pre requisites)
- Cost recovery or revenue mechanisms based on a real-world assessment
- Transparent subsidies and credit enhancement to expedite financial closure
- Clear performance-based indicators
- Appropriate incentives

5.4.7 CONTRACT MONITORING

A contract monitoring cell should be established within the MSWM department to monitor performance or clauses as specified in the contract

Contract models detailed above and in Step 4 of the planning process are only as effective as their implementation. In this context, monitoring plays an important role in ensuring delivery of services which meet required specifications.

Based on specifications of the contract, the ULB should develop checklists, milestones, and inspection schedules. A specific monitoring cell should be established within the MSWM department, with a clear definition of roles and responsibilities. Table 5.5 gives an indication of specific activities that the contractor and the ULB should perform to ensure successful project implementation.

Table 5.6: Contract Monitoring – Activities or Clauses

SL. NO	ACTIVITIES/ CLAUSES	SPECIFIC ACTIONS	PRIMARY RESPONSIBILITY	MONITORING AGENCY
1	Applicable permits other than land clearances	- List applicable permits under various laws and rules, respective authorities, validity of permits, fees payable, and persons responsible to obtain the permits. - Obtain necessary permits.	Contractor	ULB
2	Appointment of project in-charge, engineer, or independent engineer	Select or identify a suitable person from within the department or appoint a qualified person to be responsible for monitoring project implementation.	ULB	ULB
3	Performance bank guarantee	PBG to be furnished by contractor	Contractor	ULB
4	Project design	- Project engineer or in-charge shall approve project design drawings, equipment specifications, spares list, electrical drawings, and operating plan. - Standard operating procedure(SOP) are to be prepared for all activities. - ULB officer-in-charge shall approve and sign all project design documents.	Contractor	ULB
5	Insurance	Obtain valid insurance and covering risks, and ensure timely renewal of validity.	Contractor	Contractor



Table 5.6: Contract Monitoring – Activities or Clauses [contd.]

SL. NO	ACTIVITIES/ CLAUSES	SPECIFIC ACTIONS	PRIMARY RESPONSIBILITY	MONITORING AGENCY
6	Environmental compliance	Carry out regular environmental, social, health, and safety audits and safety and first aid trainings, and ensure use of personal protective equipment (PPEs).	Contractor	ULB
7	General obligations	- Valid Public Liability Insurance and renewal; - Employee State Insurance (ESI) & Employees' Provident Fund (PF) payments - List of persons responsible for these actions to be maintained by the contractor and submitted to the ULB.	Contractor	Contractor
8.	Specific obligations	- ULB shall declare and enforce a "no development zone;" develop a buffer zone; and ensure that biomedical, industrial hazardous, and construction and demolition (C&D) waste are not brought to the MSW processing facility. - Ensure timely notice on events of defaults or force majeure. - ULBs are to make timely payments.	ULB	ULB
9.	Maintenance of records	- Maintain daily record of human resources, equipment deployed, incoming vehicle details (vehicle number and driver), net weight of incoming and outgoing waste, and timing of entry and exit of vehicles. - A ULB representative, who is to be stationed at treatment or processing facility, shall ensure maintenance of separate registers for waste delivered at processing facilities and disposal site, and outgoing processed products and outgoing rejects from the processing plants with triplicate gate pass.	Contractor	ULB

Table 5.6: Contract Monitoring – Activities or Clauses [contd.]

SL. NO	ACTIVITIES/ CLAUSES	SPECIFIC ACTIONS	PRIMARY RESPONSIBILITY	MONITORING AGENCY
10	Operations & maintenance	- There must be approved standard operating procedures (SOP), recommended spares list and minimum inventory, and regular audit of these stocks. - Ensure maintenance of equipment.	Contractor	ULB
11	Service levels	- Verify and certify achieved service levels. - Identify defaults. - Assess compliance. - Issue notices and follow up on previous notices or assurances.	ULB	ULB

Identifying and mobilising financial sources is central to the MSWM plan implementation

5.5 OPERATIONALISING THE FINANCIAL PLAN

About 10%–50% of the municipal budget of all ULBs is spent on MSWM, depending on the ULB's functions and income sources. A financial operating plan gives details of estimated costs and expected revenue sources for all activities indicated in the MSWM plan. Full cost accounting (FCA) principles outlined in Section 1.4.5.6.1 of Part II shall be applied while costing individual actions. Section 1.4.5.6.3 of Part II describes various sources of funding that ULBs could avail.

The ULB should mobilize financial resources identified in the financial operating plan to ensure timely implementation of the plan and service delivery. Public private partnerships (PPPs) and private sector participation (PSP) should be carefully monitored to ensure timely execution of contracted services and avoid cost overruns. ULBs should take necessary precautions to ensure disbursement of funds in time for implementation.

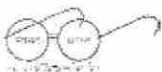


Double entry accrual based accounting shall be followed by the ULB for recording revenues and expenses, in accordance with norms established in the National Municipal Accounting Manual. Municipal solid waste management is assigned a specific function code (41) under the function-group: Sanitation & Municipal Solid Waste Management (40). As per the manual, while recording revenues and expenditure, major revenue and expense heads from the Chart of Accounts shall be indicated along with the function code or budgeting centre code.



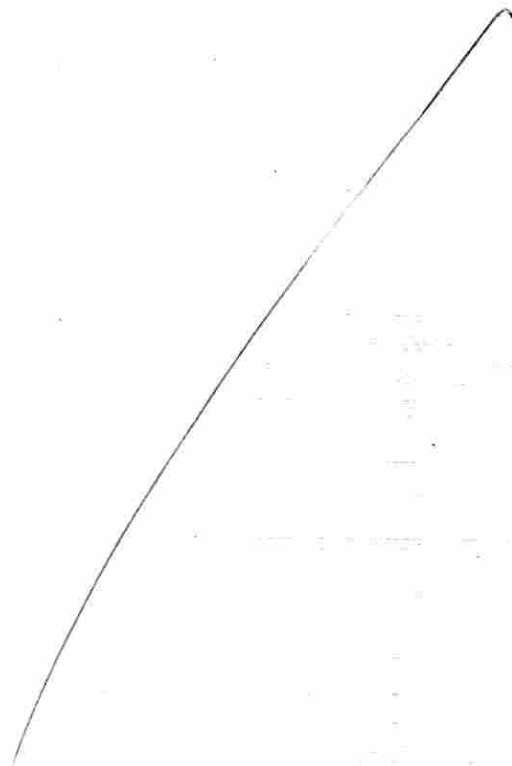
5.6 ACTION POINTS FOR AWARENESS GENERATION THROUGH INFORMATION, EDUCATION, AND COMMUNICATION ACTIVITIES FOR MUNICIPAL SOLID WASTE MANAGEMENT PLAN IMPLEMENTATION

- Community should be involved through consultations for deciding the final contours of the MSWM plan.
- Community should be made aware of the socio-economic and environmental safeguards of proposed MSWM initiatives through regular mass communication and information, education, and communication (IEC) campaigns.
- Community should be made aware of their responsibilities for ensuring success of proposed incentives. The impacts of their actions on the success of MSWM plants should be made evident through IEC campaigns.



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6

Management Aspects:
Monitoring Municipal
Solid Waste
Management Service
Provision

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6. MANAGEMENT ASPECTS: MONITORING MUNICIPAL SOLID WASTE MANAGEMENT SERVICE PROVISION

6.1 MONITORING MUNICIPAL SOLID WASTE MANAGEMENT SERVICE PROVISION

Institutionalising appropriate quality assurance systems is essential to ensure a continuous and efficient municipal solid waste management (MSWM) system. The performance of all components of MSWM system, from collection to processing and disposal, should be ensured on a daily basis. This might appear to be very cumbersome, but with a proper system in place, things move routinely and there is assurance of quality. Provision of citizen-centric services should also be monitored through a routine feedback mechanism. This should primarily focus on concerns of the community regarding doorstep collection, primary storage, and transportation of waste.

A comprehensive monitoring and evaluation (M&E) system should be adopted for proper implementation of the MSWM plan and for assessing progress toward meeting the targets of the plan.

The monitoring system adopted should facilitate or include the following:

- regular collection of data by the identified staff, e.g., ward-wise collection of waste;
- analysis of collected information to assess the efficacy of the overall system, e.g., reasons for not reaching 100% collection in an area;
- reporting of data and its analysis to senior officials; and
- mechanisms for proposing corrective action as needed, e.g., contingency plan for extra efforts wherein lagging, rerouting or changing the timings for collection in a particular ward so that 100% collection can be achieved.

The head of the MSWM department should be responsible for M&E. A dedicated M&E team should be constituted from amongst the MSWM department staff, with distinct roles and responsibilities. Field level staff from wards should be inducted from time to time, and reporting schedules should be fixed. Field staff can be reverted to operations once efficiency is achieved.

Ward level committees, constituted as per the directives of the 74th Constitution Amendment Act, should also be actively involved in ensuring and monitoring MSWM service provision including segregation, collection, transportation, street sweeping, drain cleaning, and prohibition of littering. Such a process should be institutionalised

through a council resolution, as is being practiced in Bengaluru. Community involvement in monitoring service provision has also been found effective in some states. Andhra Pradesh had implemented a “Know Your Sanitary Worker” programme, under which all residents of an area were introduced to the concerned sanitary workers in that area. Contact details of these workers and their supervisors were also made available to facilitate reporting of service delivery issues and to reduce the response time in redressal of complaints.

6.1.1 DATA COLLECTION AND ANALYSIS FOR MONITORING



A MSWM system has several aspects which are to be monitored on a daily, weekly, monthly, or annual basis. This information should be appropriately analysed to assess service provision and make requisite improvements

The first step towards implementing a monitoring and evaluation (M&E) system is to acquire the requisite data for assessing the performance of the MSWM system. Reports generated should contain critical information and should be effectively used for decision making, identifying gaps and corrective measures. Standard formats should be developed for producing reports on daily, monthly, quarterly, or annual basis as per the requirement. This information can be collected and analysed at the city level, zone level, or ward level depending on the monitoring requirements.

The best way to achieve this is through a computerised management information system (MIS). The information collected and reported through MIS should also be used as a basis for midterm review of the MSWM plan and for defining goals of future planning.

There is considerable overlap between data required for monitoring MSWM service provision and data required to establish a baseline for MSWM service provision. Table 6.1 highlights the key information that must be periodically collected and analysed by urban local bodies (ULBs) to operate and monitor MSWM systems as prescribed in SWM Rules, 2016.

The table also includes a visual indication for Service Level Benchmarks (SLB) for identifying data elements which are used directly in the computation of service level benchmarks (SLBs) for MSWM service provision. SLB indicators are stipulated by the Ministry of Urban Development (MoUD) to assess the level of service provision and resource efficiency.

Table 6.1: Municipal Solid Waste Management Data Collection and Analysis¹

DATA REQUIRED	MINIMUM FREQUENCY OF MEASUREMENT	POINT OF DATA COLLECTION	DATA USE AND POTENTIAL ANALYSIS
GENERAL ULB INFORMATION 			
- Area of the ULB - Number of wards, their area and population - Population of the ULB - Decadal growth of population - Number of households - Average size of households - Number of slum households - Number of commercial establishments - Number of markets (vegetable, meat, wholesale, flower, etc.) and slaughterhouses - Number of institutions (offices, schools, colleges, etc.) - Number of health care establishments - Number of industries including cottage industries	At least once in 3 years	ULB (from weighbridge)	Baseline information to be used for further analysis and as a basis for calculating SLB indicators
DOOR TO DOOR COLLECTION			
- Total amount of waste generated in the ULB  - Quantity of waste collected from different sources at doorstep: - Household, shops, and establishments  - Vegetable and food market - Meat, fish and slaughter houses - Construction and demolition waste  - Hospitals - Industries - Quantity of waste collected in segregated fractions  - Average number of carcasses removed each day	Monthly Semi-annually Monthly Daily	Ward level (from weighbridge) Ward level (from weighbridge) Ward level (from weighbridge) Processing or disposal facility	Assess household collection efficiency Assess household collection efficiency Assess requirement or capacity of waste management facilities needed by the ULB Extent of segregation of waste Assess requirement for management of carcasses along with slaughterhouse wastes

¹ Developed by the expert committee for revision of MSWM manual (2013-15)

Table 6.1: Municipal Solid Waste Management Data Collection and Analysis [contd.]

DATA REQUIRED	MINIMUM FREQUENCY OF MEASUREMENT	POINT OF DATA COLLECTION	DATA USE AND POTENTIAL ANALYSIS
• Total number of vehicles, tricycles and human resources allotted for door to door collection of waste SLB	Daily	Ward	Assess sufficiency of infrastructure for primary collection of waste
• Capacity of vehicles dedicated to primary, secondary and tertiary collection SLB	Monthly	Ward	Assess sufficiency of infrastructure for primary collection of waste
• Number of trips made per day per vehicle type SLB	Monthly	Ward	Assess sufficiency of infrastructure for primary collection of waste
• Number of vehicles, tricycles and human resources actually reporting for duty	Daily	Ward	Assess utilisation rates of existing infrastructure
• Short fall in human resources	Daily	Ward	Assess sufficiency of existing staffing
• Areas left unattended	Daily	Ward	Assess efficiency of door-to-door service provision and identify problem areas
• Arrangements made or proposed to be made for clearing the backlog of pending work	Daily	Ward	Ensuring daily management of service provision
• Number of sites designated for secondary waste storage	Monthly	Ward	Data to be used to assess sufficiency of secondary collection points or storage depots
• Type and size of containers / storage depots in each ward	Monthly	Ward	
• Quantity of waste deposited at storage depots on a daily basis SLB	Monthly	Ward	
• Number of unauthorised waste dumping points in each ward	Monthly	Ward	
STREET SWEEPING			
• Number of sanitation workers on duty for street sweeping (contractual vs pay-roll)	Daily	Ward	Ensuring efficiency and daily management of street sweeping service provision
• Number of sanitary workers absent	Daily	Ward	
• Arrangements made or proposed for clearing the backlog of street sweeping	Daily	Ward	
SILT REMOVAL OR DRAINAGE CLEANING			
• Number of sanitation workers on roll for silt removal in the ward	Daily	Ward	Ensuring efficiency and daily management of street sweeping service provision
• Number of persons found absent or on leave	Daily	Ward	
• Arrangements made or proposed for clearing the backlog of silt removal	Daily	Ward	

Table 6.1: Municipal Solid Waste Management Data Collection and Analysis [contd.]

DATA REQUIRED	MINIMUM FREQUENCY OF MEASUREMENT	POINT OF DATA COLLECTION	DATA USE AND POTENTIAL ANALYSIS
CONSTRUCTION AND DEMOLITION WASTE (C&D WASTE)			
• Number of designated C&D sites identified in the city with capacity and location	Monthly	Ward	Assess the demand for C&D waste management in the ULB and identify illegal or non-notified dump sites to prevent such dumping
• Number of unauthorised disposal sites for C&D waste in the city (permanent or semi-permanent)	Monthly	Ward	
• Quantity of C&D waste lying unattended (based on truckloads) at designated sites and unauthorised sites	Weekly	Ward	
TRANSPORTATION OF WASTE			
• Number and type of vehicles and equipment allotted	Daily	Ward /ULB	Assess the sufficiency and efficacy of: 1. Secondary waste collection and transportation 2. Amount of waste collected and transported versus waste generated 3. Efficiency of the vehicle maintenance system
• Number and type of vehicles and equipment that actually reported for duty	Daily	Ward /ULB	
• Number of trips made to the processing site or disposal site by each vehicle in one shift	Daily	Ward /ULB	
• Number of vehicles used in first, second, and third shift	Daily	Ward /ULB	
• Total quantity of waste transported from weighbridge records	Daily	Ward /ULB	
• Number of vehicles that did not make adequate trips	Daily	Ward /ULB	
• Number of vehicles that transport waste but were not totally full	Daily	Ward /ULB	
• Number of bins cleared during the day	Daily	Ward /ULB	
• Number and location of bins left uncleared	Daily	Ward /ULB	
• Breakdown reported during the day and action taken	Daily	Ward /ULB	
• Arrangements made or proposed for clearing the backlog	Daily	Ward /ULB	
WORKSHOP FOR VEHICLES AND EQUIPMENT			
• Total number of vehicles or equipment on the road	Weekly	ULB	1. Assess the road worthiness of vehicles based on number of breakdowns 2. Assess operational issues with equipment 3. Sufficiency of workshop facilities 4. Efficiency and time taken to repair vehicles or equipment as compared to proposed tentative time
• Number of vehicles or type of equipment under repair	Weekly	ULB	
• Nature and duration of breakdown	Weekly	ULB	
• Time taken to repair vehicle or equipment	Weekly	ULB	
• Alternate arrangements made for vehicle or equipment	Weekly	ULB	

Table 6.1: Municipal Solid Waste Management Data Collection and Analysis [contd.]

DATA REQUIRED	MINIMUM FREQUENCY OF MEASUREMENT	POINT OF DATA COLLECTION	DATA USE AND POTENTIAL ANALYSIS
PROCESSING SITE			
• Number of waste processing sites in the ULB	Annually	ULB	Assess the sufficiency of existing facilities to process/dispose collected waste
• Distance of the processing plants from the ULB	Annually	ULB	
• Area/Capacity of the sites / facilities	Annually	ULB	
• Total operating hours of the processing plant	Weekly	Plant	1. Assess capacity and efficiency of processing plant 2. Assess process efficiency 3. Assess quality of the products 4. Identify potentially hazardous situations w.r.t. type of incoming waste or waste handling/ process mechanisms
• Quantity of waste received at the plant	Daily	Plant	
• Quantity of end products (compost, RDF) produced at the plant	Monthly and per batch	Plant	
• Quality of end products (compost, RDF) produced at the plant	Monthly and per batch	Plant	
• Quantity of end products sold	Monthly	Plant	
• Quantity of end product in stock	Monthly	Plant	
• Quantity of reject material	Monthly	Plant	
• Number of staff employed (Sex disaggregated data and the of work allotted)	Monthly	Plant	1. Assess sufficiency of existing waste disposal sites 2. Assess quantity of waste disposed vis a vis amount of rejects from processing facilities/ inerts to be disposed 3. Identify remaining life of the landfill 4. Extent of scientific disposal of municipal solid waste
• Any irregularities noticed	Monthly	Plant	
WASTE DISPOSAL SITE			
• Number of waste disposal sites in the ULB	Annually	ULB	1. Assess sufficiency of existing waste disposal sites 2. Assess quantity of waste disposed vis a vis amount of rejects from processing facilities/ inerts to be disposed 3. Identify remaining life of the landfill 4. Extent of scientific disposal of municipal solid waste
• Number of dumpsites			
• Number of sanitary landfills			
• Distance of the disposal or landfill site from the ULB	Annually	ULB	
• Area of the disposal or landfill site	Annually	ULB	
• Quantity of waste disposed each day	Daily		
• Expected life of each landfill site	Annually	ULB	

Table 6.1: Municipal Solid Waste Management Data Collection and Analysis [contd.]

DATA REQUIRED	MINIMUM FREQUENCY OF MEASUREMENT	POINT OF DATA COLLECTION	DATA USE AND POTENTIAL ANALYSIS
FINANCIAL ASPECTS			
• Operating Cost	Annually	ULB	1. Assess cost of MSWM services in the ULB
• Cost of collection per tonnes per day SLB	Quarterly (once in three months)	ULB	2. Assess collection efficiency of waste management charges
• Cost of transport per tonnes per day SLB	Quarterly (once in three months)	ULB	3. Assess which of the MSWM services are financially viable
• Cost of disposal per tonnes per day SLB	Quarterly (once in three months)	ULB	4. Extent of cost recovery for the ULB in the MSWM services
• Human resource costs SLB	Quarterly (once in three months)	ULB	
• Cost of operations and maintenance for services managed by the ULB (recurrent fuel, electricity and maintenance costs) SLB	Quarterly (once in three months)	ULB	
• Cost recovery for MSWM service through tax, user fees, etc. SLB	Quarterly (once in three months)	ULB	
• Allocation of revenue and capital budget	Quarterly (once in three months)	ULB	1. Assess that the budget addresses all priority services
			2. Extent of cost recovery for the ULB in the MSWM services
COMPLAINTS REDRESSAL			
• Number of MSWM related complaints received SLB	Daily	ULB	1. Assess and identify repeated problem areas
• Types of complaints received	Daily	ULB	2. Assess efficiency of complaint redressal
• Time taken for issues to be resolved and appropriate actions taken SLB	Daily	ULB	
• Number of defaults for which penalties are collected	Quarterly (once in three months)	ULB	Assess efficiency of penalising defaulters, as a deterrent to future non-compliance
LEGAL MATTERS			
• Number of cases filed in the courts each month for violation of provision of rules and applicable laws	Monthly	ULB	Assess and ensure legal compliance
• Corrective measures taken	Monthly	ULB	

6.1.2 MONITORING ACHIEVEMENT OF SERVICE LEVEL BENCHMARKS

Eight SLB indicators are defined by the MoUD to assess MSWM service provision in a ULB

Assessment of service level benchmarks (SLBs) is based on the analysis of information collected to monitor the municipal solid waste management (MSWM) system on a regular basis, as discussed in the previous section. State governments use SLBs to monitor long-term progress of MSWM service provision in ULBs. Release of funds from the Finance Commission is partially contingent on achievement of predefined goals of SLBs. Indicators stipulated by the Ministry of Urban Development (MoUD) for benchmarking MSWM service provision are the following:

1. Household level coverage of solid waste management services
2. Efficiency of collection of municipal solid waste efficiency
3. Extent of segregation of municipal solid waste
4. Extent of municipal solid waste recovered
5. Extent of scientific disposal of municipal solid waste
6. Efficiency in redressal of customer complaints
7. Extent of cost recovery in SWM services
8. Efficiency in collection of SWM charges

A framework for monitoring and reporting on these indicators is given in Table 6.2. Detailed guidance on data requirements and calculation methods may be found in MoUD's "Handbook of Service Level Benchmarking".

Table 6.2: Monitoring Achievement of Service Level Benchmarks for Municipal Solid Waste Management Service Provision²

PERFORMANCE INDICATORS	UNIT	DEFINITION	MINIMUM FREQUENCY OF PERFORMANCE MEASUREMENT AND REPORTING	SMALLEST GEOGRAPHICAL AREA FOR MEASUREMENT
Household level coverage of SWM services	100%	Doorstep collection in percentage from households and other establishments	The monitoring of performance – monthly Reporting and Evaluation – quarterly	Ward level
Efficiency of collection of municipal solid waste	100%	Collection efficiency is defined as percentage of waste collected by the municipal authority or authorised private waste collector excluding waste recycled by the households or informal waste pickers	The monitoring of performance – daily Reporting and Evaluation – monthly	Ward level

² "Handbook of Service Level Benchmarking", MoUD, 2008.



Table 6.2: Monitoring achievement of Service Level Benchmarks for Solid Waste Management Service Provision [contd.]

PERFORMANCE INDICATORS	UNIT	DEFINITION	MINIMUM FREQUENCY OF PERFORMANCE MEASUREMENT AND REPORTING	SMALLEST GEOGRAPHICAL AREA FOR MEASUREMENT
Extent of segregation of municipal solid waste	100%	Percentage of households and other establishments that segregate their garbage into wet and dry waste at the source.	Monitoring of performance - daily Reporting and Evaluation - monthly	Ward level
Extent of municipal solid waste recovery	80%	Percentage of municipal waste recovered or processed by the ULBs, households and informal sector	Monitoring of performance - daily Reporting and Evaluation: monthly	Ward level
Extent of scientific disposal of municipal solid waste	100%	Percentage of waste disposed at the landfill, which is designed, operated and maintained as per set standards	Monitoring of performance - daily Reporting and Evaluation - monthly	ULB level
Efficiency in redressal of customer complaints	80%	Percentage of complaints related to municipal waste management redressed within a given time period	Monitoring of performance - daily Reporting and Evaluation - monthly	Zone or ULB level
Extent of cost recovery in SWM services	100%	This indicator denotes the extent to which the ULB is able to recover all operating expenses relating to SWM services from operating revenues of sources related exclusively to SWM.	Monitoring of performance - quarterly Reporting and Evaluation - annually	ULB level
Efficiency in collection of SWM charges	90%	It is defined as current year revenues collected, expressed as a percentage of the total operating revenues, for the corresponding time period.	Monitoring of performance - quarterly Reporting and Evaluation - annually	ULB level

6.1.3 MANAGEMENT INFORMATION SYSTEM

Collection and analysis of data related to MSWM is required to assess the existing situation and propose adequate measures for improving service delivery. Management information system (MIS) is a computerised system which can help capture, store, and retrieve data or information for decision makers. MIS can manage large amounts of data such as waste collection points, location of bins, designated secondary storage





MIS is a computerised system which stores and retrieves information from a database; this data can be analysed for identifying problem areas and improving service delivery efficiency



All cities need to maintain a basic MIS system either through manual records or electronically. Integrated systems will include GIS, GPS, RFID, and GPRS developed over this MIS system

points, ward level vehicle movement, information on transportation of waste and its weightment, and other related information as specified in Table 6.1. MIS helps in establishing a strong and reliable information database necessary to facilitate planning, midcourse corrections, and decision making. It enhances transparency and accountability of officials in the MSWM system. Information is the foundation of an MIS system. Therefore, for any ULB to have a sound MIS on solid waste management, it should have a good compilation of basic information ranging from a ward to a city level. Details on the minimum data requirement to establish a MIS is elaborated in Figure 6.1. Essentially all the information that was earlier kept and updated manually in the ULB has to be now available electronically. Creation and maintenance of such information and database is not very resource intensive and requires basic technical expertise at the ULB level.

All cities need to maintain a basic MIS system either through manual records or electronically. Once this system has been established, level two is to connect this basic database on solid waste to be analysed through map based tools and applications. The use of integrated technologies over the basic MIS system such as geographic information systems (GIS), global positioning system (GPS), radio frequency identification (RFID), and general packet radio services (GPRS) have resulted in the development of integrated and comprehensive solutions for MSWM. GIS and remote sensing imageries (visual capture of information using cameras) are now being integrated with MIS to provide spatial and visual validation for provision of services. A GIS system is actually a visual representation of information (attributes) on maps which are geo-referenced (show location coordinates). Data collected for monitoring and evaluation (M&E) of MSWM systems can thus be linked to the geographical locations on a map created in the GIS system. Data on maps can be used to analyse the spatial information and identify patterns, trends, and relationships in the existing information. GIS systems are useful in planning for door-to-door collection, waste transportation routes, location for waste collection bins, etc.

Once the GIS has been linked to the MIS, the system can be further advanced to show real-time spatial information captured through a global positioning system (GPS), e.g., real-time data regarding vehicle movement, secondary collection bin pickup, and transportation to processing and disposal sites can also be linked to the GIS system. Waste transport vehicles may be fitted with a GPS linked to the GIS system to enable real-time monitoring of vehicle movement.

In several advanced MIS systems, radio frequency identification (RFID) tags are used to identify equipment. These are electronic tags which can carry preloaded information specific to the equipment they are tagged to, e.g., secondary collection bins. Electronic scanners equipped with

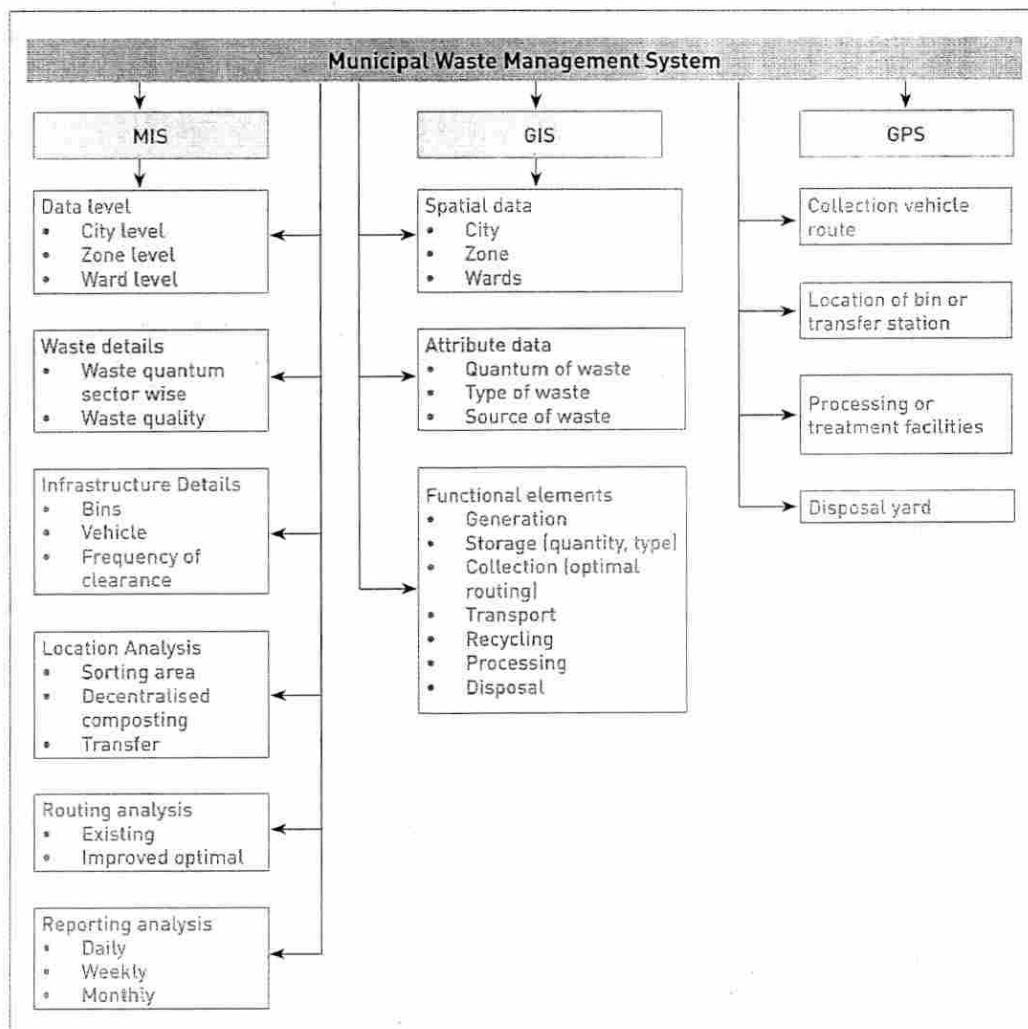


the general packet radio services (GPRS) technology can scan these tags and relay information to the GIS system, whereby all necessary information fed into the GPRS unit with regard to the equipment is updated automatically. GIS is then used to check the location.

Thus linked with GPRS or RFID systems, GIS provides real-time data on vehicles, collection of waste, bin pickup, and transportation of waste to treatment or disposal facilities.

These systems are now being suitably adopted by cities to improve service efficiency of MSWM. Minimum data requirements for an effective MIS-GIS-GPS system are shown in Figure 6.1.

Figure 6.1: Minimum Data Requirement for MIS, GIS and GPS Systems



Advanced communication tools enable reliable and efficient MSWM services:

- GIS
- GPS
- GPRS
- RFID

Benefits of these systems include the following:

- Data aggregation and process monitoring are managed electronically, avoiding daily human intervention, thereby increasing reliabil-

ity and transparency of information and helping in resolution of disputes among citizens, contractors, and officials.

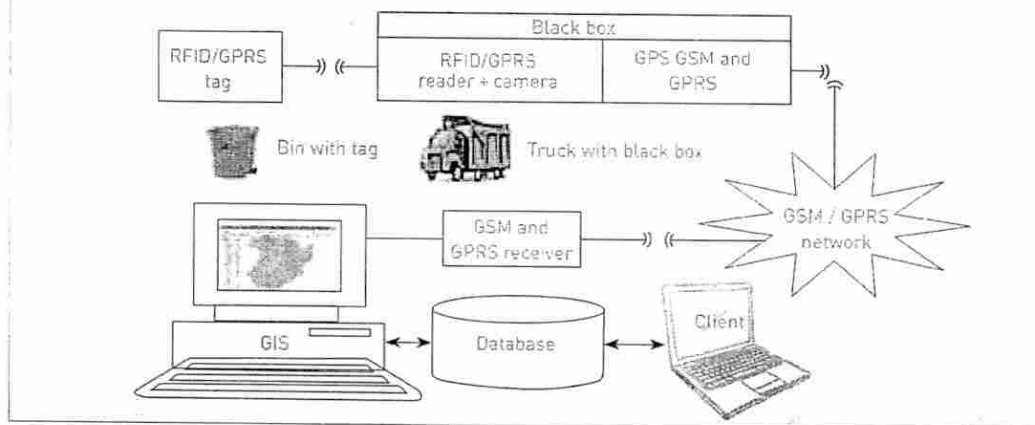
- Effective and timely complaint redressal of grievances is generated through online monitoring system.
- Movement of vehicles and tracking of average stoppage time may be monitored in real time by using a surveillance system based on GIS and GPS technologies, thereby reducing noncompliance and enhancing efficiency.
- Status of evacuation of bins on a daily basis can be monitored through RFID and GPRS, facilitating increase in service efficiency and decrease in customer complaints.

Integrated Technologies (MIS, GIS, GPS, RFID or GPRS) for Monitoring Municipal Solid Waste Management

Real-time monitoring of status of bin clearance, estimation of amount of waste in and around bins, surveillance of movement of vehicles, optimisation of routes, and reallocation of bins according to the estimated waste are possible through integration of several technologies, leading to transparency in civic administration.

As shown in the figure, each container is equipped with a radio frequency identification (RFID) or general packet radio services (GPRS) label having a unique identification code. Low frequency passive tags are proposed because they offer long-term low-cost solutions and are operational in extreme conditions and resistant to environmental hazards. Geo-coding of containers is done manually through field visits and by noting the locations using a global positioning system (GPS) receiver, which in turn is connected to the corporation database or management information system (MIS). When the container gets loaded onto the truck, the reader reads the serial number of the tag on the container. At the same time, the GPS receiver on the truck calculates its location using satellite data. The serial number of the tag, location, date, and time are transmitted in real time via the Global System for Mobile (GSM) network to the communication gateway of the control server. The same is repeated when the truck reaches its destination. After data processing, information is transferred to the geographic information system (GIS) terminal. Real-time information can be shared with clients via a web-based solution.

Municipal Solid Waste Monitoring and Management System³



3 'Solid Waste Truck Monitoring and Management using RFID, GIS AND GSM,' Hannan, M. A. et al. [2011]. *Journal of Applied Sciences Research*, 7[12].

Even though advanced application systems like GPS, GIS, RFID can add tremendous value to the MIS and the overall MSWM but the value and the need for strong baseline data cannot be underestimated. In addition, the cost implications of procuring, managing, and maintaining such systems should be understood by the ULB before deciding to adopt them. In order to maintain an efficient MSWM system, these technologies may be considered suitable aids but not a necessity due to their costs and specialised manpower requirements. Regular well-maintained records and coordination among field staff and supervisors will also produce the same level of efficiency in smaller ULBs, where the procurement of such systems may not be cost-effective.



Pimpri-Chinchwad Municipal Corporation Monitoring Municipal Solid Waste Management Services through Information and Communication Technologies

Pimpri-Chinchwad Municipal Corporation (PCMC) has initiated the task of monitoring its municipal solid waste management (MSWM) services through the use of information and communication technologies (ICT). By deploying Global Positioning System (GPS) based real time vehicle tracking system, PCMC is able to:

- monitor the actual movement and realtime position of the vehicle;
- monitor the movement of collection vehicles;
- improve the service delivery mechanism and achieve better information management;
- ensure citizens' participation in governance mechanism for overall improvements in collection efficiency;
- reduce unwanted trips, detours, or stoppages, thereby enhancing the productivity or utilisation of the fleet;
- generate management information system (MIS) report daily to take informed decision; and
- publish the "Bin Pickup Status" on their website to inform citizens and encourage them to monitor bin pickup status in their localities.

This endeavor resulted in improving PCMC's accountability and also offered a reliable tool to facilitate data provision under the Right to Information Act, 2005 where such information is sought.

Source: Pimpri-Chinchwad Municipal Corporation



Effective Monitoring of Collection and Transportation of Municipal Waste through Global Positioning System

Year of Start: 2011

Main Players: Nashik Municipal Corporation (NMC) – Health Department and Computer Department

Approach: Door to door collection of waste in the city was established through *ghantagadis* (designated waste collection vehicles) in 1998. With the start of the Jawaharlal Nehru National Urban Renewal Mission (JnNURM) project, NMC received central funds for strengthening the existing system resulting in the procurement of 124 *ghantagadis* and GPS systems under the project. GPS machines were fitted on each vehicle to improve the collection and transportation efficiency of the vehicles. An agency was appointed by NMC for installation of the GPS system (machines and software) and its operation and maintenance (O&M). A cell (centralised monitoring unit) was formed at the NMC office to manage and supervise the overall system: monitoring and tracking of vehicle movement on a regular basis, tracking of complaints and inefficiencies, and generating daily and weekly reports. The redressal of complaints was done with the support of the sanitary inspectors at ward level.

Outcome:

- Installations of GPS systems on all 124 *ghantagadis* owned by NMC, and centralised monitoring unit was created at NMC headquarter.
- Skill development and capacity building of the ground staff and contractors engaged in collection of municipal solid waste was undertaken when the system was introduced.
- Ensuring that the time delay and average stoppage time (4–5 minutes) for each vehicle was tracked.
- Effective and timely redressal of complaints was generated through the GPS monitoring system by the ward level sanitary staff.
- Generation of daily and weekly reports by vehicles to ensure adherence to the timing and collection of waste at the respective collection points.
- Information, transparency and data availability on the public domain for citizens and public representatives with respect to the routing and timings of the vehicles increased confidence in the system.

Success Factor:

- Proactive role of NMC to streamline and monitor the collection and transportation system.
- Capacity building of the NMC staff, contractors, vehicle drivers, and workers was developed prior to the installation of the system.
- Collection of waste at a stipulated time by the contractors.
- Real time report generation through GPS helped in resolution of disputes among citizens, officials, and contractor, thereby creating a transparency between the consumers and service providers.



- Regular monitoring of the reports by the commissioner and the health officer resulted in the improvement in the collection and transportation efficiency.

Overall Sustainability:

By appointing an operator for regular O&M of the GPS system, NMC has ensured that the GPS machines and the monitoring system is functional and the initial teething troubles faced by NMC, because of dysfunctional or destruction of GPS machines installed in the ghantagadis, was overcome. The proactiveness of the commissioner and the Health Department of NMC towards transparency in municipal solid waste management ensured the sustainability of the system in the city.

Source: Nashik Municipal Corporation (NMC)

6.1.3.1 RECORD KEEPING

Based on the monitoring requirements specified in Table 6.1 and Table 6.2, ULBs need to maintain reports for all elements that need to be monitored. The Head of the MSWM department should review all reports along with the monitoring and evaluation (M&E) team. Monitoring and reporting proves to be extremely beneficial when the data generated are analysed effectively to improve performance.

Appropriate training and strengthening of capacities of existing staff is required to ensure accurate collection and reporting of data. Capacity building is required for all levels of staff; external support from experts may be sought to streamline and integrate M&E of all functions.

As stipulated by the Solid Waste Management (SWM) Rules, 2016, ULBs should report to the SPCB annually

6.2 OPERATION AND MAINTENANCE PLAN FOR MUNICIPAL SOLID WASTE MANAGEMENT SERVICES

As per SWM Rules, 2016:

Clause 15: Duties and responsibilities of local authorities:-

- (v) facilitate construction, operation and maintenance of solid waste processing facilities and associated infrastructure on their own or with private sector participation or through any agency for optimum utilisation of various components of solid waste adopting suitable technology including the following technologies and adhering to the guidelines issued by the Ministry of Urban Development
- (w) undertake on their own or through any other agency construction, operation and maintenance of sanitary landfill and associated infrastructure as per Schedule 1 for disposal of residual wastes in a manner prescribed under these rules;
- (x) make adequate provision of funds for capital investments as well as operation and maintenance of solid waste management services



in the annual budget ensuring that funds for discretionary functions of the local body have been allocated only after meeting the requirement of necessary funds for solid waste management and other obligatory functions of the local body as per these rules;

Irrespective of whether the provision of services is by the ULB or private contractor, an operation and maintenance (O&M) plan should be prepared and followed. The O&M plan should be drafted by the authority responsible for procurement and management of equipment or facilities; this authority could be either the ULB or the private operator, depending on the contractual conditions for the equipment or facility. O&M plans developed by private operators should be ratified by ULB's MSWM department.

The O&M plan should include preventive maintenance schedules, responsibilities and also guidance for breakdown maintenance. It should be the responsibility of the supervisor from the ULB and the operator to regularly maintain and update the O&M plan and use it as an instrument for monitoring. The plan should also indicate procedures for recording, reporting, analysis, and further action.

Preventive O&M of equipment, vehicles, and facilities ensures the long term sustainability of MSWM service provision. All contracts to private sector players, irrespective of the mode of contracting, should include a provision for O&M of all vehicles, equipment, and installations during the period of the contract. The term of the contract should be co-terminus with the expected life of the vehicles and equipment, particularly where the contractor is expected to invest in the procurement of vehicle and equipment.



Operation and Maintenance of Municipal Solid Waste Management Services

- Regular operation and maintenance (O&M) of vehicles and equipment used for MSWM services ensures reduction in downtimes, thereby ensuring continual operation.
- Timely availability of required spares (including high wear and tear components, and critical components with long lead times for procurement) can be done easily through regular monitoring and maintenance.
- Preventive O&M provides financial planners with necessary timely budget and information to finance additional spares, equipment, and vehicles as maybe required.
- Preventive maintenance of equipment and fleet required for different activities (such as primary collection, secondary collection and transportation, transfer station, processing site, and landfill) ensures their continuous utility at full capacity throughout their design life.

Key Components of an Operation and Management Plan:

- O&M plan should address critical components subject to high wear and tear, avoiding potential cost implications of breakdown maintenance.

- The O&M plan should be prepared at the time of procurement by the authority, and schedule of preventive maintenance should be determined and strictly observed.
- O&M records should be maintained for all equipment. An analysis of this information will indicate critical issues of frequent breakdowns and components undergoing regular wear and tear. Supervisors could use this information to identify incorrect operating practices leading to frequent breakdowns. This analysis could also lead to the identification of equipment which is ill-suited to perform the requisite tasks and which needs replacement.
- The O&M plan should include contact information of concerned staff responsible for maintenance of specific equipment.
- Management personnel should periodically review this information to refine maintenance plans for individual vehicles and to identify improvements to the overall maintenance program.
- The effectiveness of the O&M plan can be measured by observing plant or machinery downtimes and the working conditions of the vehicle fleet.



Good Operating Principles for Waste Processing, Treatment, and Disposal Facilities

- Adequate and appropriate human resource available for operating the waste management facility with due consideration to minimum qualification of key employees, supervisor, and operators.
- Regular capacity building and hands-on training of staff.
- Regular inspection of facility by superior staff and ensuring timely corrective measures.
- Mechanism for reporting unacceptable or prohibited activities on sites.
- Mechanism for reporting accidents and mishaps, with recorded investigative processes, follow-up actions, and periodic analysis of mishaps to identify danger areas or weaknesses in the process, system, or equipment.
- Scheduled environmental monitoring as per Solid Waste Management (SWM) Rules, 2016 and other applicable norms.



Standard operating procedures (SOP) and manuals for all technical processes, procedures, and equipment should be made available with the MSWM department

6.3 PREVENTIVE MAINTENANCE

Preventive maintenance is an essential part of the operation of collection equipment, machinery, and transportation vehicles to ensure their maximum life. However, there is a need to make a clear distinction between preventive maintenance and crisis maintenance. Preventive maintenance is carried out at a pre-defined time and on the basis of a disciplined schedule for maintenance, while crisis (or breakdown) maintenance is carried out when a fault develops.

Good preventive maintenance starts with the selection and specification of appropriate vehicles and equipment. Vehicles should be well-suited to predefined requirements and localised conditions, and should be



Preventive maintenance helps in identifying mechanical problems at an early stage and hence saves expenditure and minimises downtime



procured only after ascertaining ease of availability of spare parts (cost of spares should also be considered). Local availability of spare parts is often associated with reliability. Preventive maintenance schedule must be notified well in advance to all concerned parties and should be strictly enforced.

6.3.1 BENEFITS OF PREVENTIVE MAINTENANCE

An important aspect of a planned preventive maintenance programme is that it helps to take corrective measures well in advance, anticipates faults, and prevents a major breakdown which could endanger the safety of the personnel and entail huge cost. A preventive maintenance programme ensures that an advance notice is available for any requirement for spare parts, ensuring that equipment or vehicles are not out of service while the parts are being obtained. A planned preventive maintenance programme will not only help in keeping existing equipment operating at its maximum efficiency with minimum downtime but will also provide requisite information to financial planners, enabling them to include accurate forecasts of required expenditure for repairs, maintenance, and replacement of vehicles and equipment. Preventive maintenance programmes can change the institutional culture of the municipal administration, where breakdowns will no longer be seen as a regular routine.

Accountability and Responsibility for Preventive Maintenance

Preventive maintenance imposes responsibility and accountability at various levels (drivers, store in-charge, mechanics, workshop managers, etc.) for breakdowns and delays in repairs after a breakdown. Delays in procuring spares may also be due to a lack of funds, for which the financial controller or officer may be accountable.

Example of a Preventive Maintenance Schedule for Vehicles

- Daily checks carried out by drivers.
- Weekly servicing checks by a junior mechanic highlights issues which a driver may not be able to identify or indicate if the daily checks are not effective.
- Monthly service check by a senior mechanic reveal any inadequacies in the weekly checks.
- The six monthly checks identify issues which have not been identified or addressed by the monthly checks.

The success of a preventive maintenance programme is indicated by fleet and equipment availability on any day. It can be indicated by calculating the number of vehicles (perhaps of a particular type) that are ready for service on any particular day, divided by the total number

Preventive maintenance programmes tend to change the institutional culture of municipal administration: breakdowns are no longer seen as a regular matter

Preventive maintenance instills a sense of ownership and accountability within all tiers of administration

of vehicles in the current fleet. The numbers could indicate the condition of the vehicles and whether the maintenance programme is improving or weakening. Availability levels can be used to show the number of standby vehicles that are needed (for each type of vehicle) and which types of vehicle are more reliable.

Management personnel should periodically review this information to refine maintenance plans for particular vehicles and to identify improvements to the overall maintenance program.

Similar systems should be in place for monitoring the downtimes and availability of other equipment and machinery used for all MSWM activities. MSWM processing, treatment, and disposal facilities should be encouraged to maintain records to ensure minimum downtime.

6.4 COMPLAINT REDRESSAL SYSTEM

A complaint redressal system creates a platform for citizens to voice their complaints and grievances regarding provision of MSWM services and also helps in promoting efficiency and transparency at the ULB level. The ULB, through an analysis of the complaints or grievances it receives, is able to identify lacunae and bridge gaps in service delivery. The time taken for resolution of grievances and the action taken are also monitored and recorded through this system. Typically, ULBs have a common complaint redressal system for all municipal services.

A complaint redressal system is effectively supported through the introduction of a citizen charter. The citizen's charter is a written voluntary declaration by a ULB with the basic objective to empower the citizens to get public service in a given time frame.

The Citizen's Charter includes:

- information on municipal services and expected outcomes,
- municipal service delivery standards,
- response time for rendering services or redressing grievances,
- information dissemination process on the complaint redressal process, and
- contact details of officers responsible for provision of the various municipal services.

The citizen's charter should be prepared by the ULB and officially adopted by the municipal council or committee and widely publicised. Urban development or local government departments may prepare a model citizen's charter to be adopted by all ULBs in the state after preparing city-specific citizen's charters for their own city.

A complaint redressal system is an effective tool which facilitates effective complaint management and expedites the redressal process in a transparent manner

A citizen's charter is a commitment of the ULB toward a stated level of service delivery, thereby enhancing accountability



6.4.1 ELEMENTS OF A COMPLAINT REDRESSAL SYSTEM

Typical elements of a complaint redressal system include the following:

1. **Complaint management system:** A computerised central complaint management system should be networked to all the zonal or ward level complaint centers. In small ULBs, the complaints could be recorded through a register. A grievance redressal officer from the MSWM department or cell at senior level should be responsible for recording and monitoring the complaints and also for taking necessary actions for redressal.
2. **Medium of complaint registration:** Multiple channels or a combination of different channels may be adopted for receiving complaints, e.g., phone calls to a centralised customer service or complaint number, SMS messages to notified mobile numbers, automated generated complaints sent to commissioners for their records, walk-in complaint registration, and online complaint registration. Complaint registration through the postal service may be considered, if relevant, based on the demography and size of the ULB.
3. **Complaint registration and recording system:** This system should
 - assign a unique ID to each complaint generated;
 - record contact details of the complainant;
 - record details of the physical location (zone, ward, area) relevant to the complaint;
 - assign the complaint to the concerned official in the MSWM department or cell;
 - record the stipulated time within which the complaint shall be redressed;
 - provide an acknowledgement receipt to the complainant with all the above details, in case the complaint is registered manually or online; and
 - provide a complaint reference number with an SMS of registration to telephone-based complainants.
4. **Resolution certificate:** Field officers, after resolving the complaint, should take resolution certificate from the complainant and subsequently inform the complaint cell. The complaint shall thereafter be treated as resolved.
5. **Complaint resolution and feedback:** The designated official for complaint resolution in the MSWM department or cell shall be made aware of received complaints on a daily basis. Feedback could be taken through telephone, internet, SMS.
6. **Pending complaints:** Complaints which are not resolved in stipulated time shall be deemed pending. The reason for the pending complaint should be recorded and the designated officer and the



A complaint redressal system is enabled through the following:

- walk-in complaints
- phone calls
- SMS
- online complaints
- postal service



Due acknowledgement of all the registered complaints is necessary for future reference

complainant should be duly informed. Such pending complaints should automatically be escalated to higher officials for monitoring and directions.

7. **Reporting and complaint analysis:** A daily status report of complaint redressal should be prepared by an officer and submitted to the higher officer-in-charge for further directions. The complaint management system should generate periodic, area-wise reports on number of complaints received, nature of complaints, time taken for resolution, etc. The report should highlight the critical issues such as most frequently received complaints, frequently delayed responses, repetition of complaints (if any), time for resolution of complaints, etc. The weekly analysis of all complaints received should be reported to the chief executive officer or commissioner. Status of the complaints should be put in public domain and updated on a daily basis for ensuring transparency of the system.

6.5 ENVIRONMENTAL AND OCCUPATIONAL HEALTH MONITORING OF MUNICIPAL SOLID WASTE TREATMENT, PROCESSING AND DISPOSAL FACILITIES

Environmental and occupational health monitoring of waste processing and disposal facilities is one of the most important aspects of overall management. For monitoring, collection and transportation, a number of tools have been already described (MIS, GIS, GPS, RFID, GPRS, etc.). When it comes to processing and disposal issues, additional tools are required in the form of standard operating procedure (SOP), which would be combined with MIS for proper operation and maintenance (O&M). In this case MIS would be designed to check if SOP for processing and disposal (sanitary landfilling) is being followed.

Annual audits supplemented by quarterly audits would be of great value. The following four types of audit would be necessary:

1. **Compliance audit:** This audit checks the level and extent of compliance with the applicable regulations. In this case the applicable regulations are Solid Waste Management (SWM) Rules, 2016 (overall management including processing and sanitary landfill); and Fertilizer Control Order (FCO), 2009 (for compost quality standard) and 2013 (for quality standard of phosphate rich organic manure). There are other waste regulations which would also need to be audited for overall environmental compatibility of a city, such as Plastic Waste Management Rules, 2016; E-Waste Management Rules, 2016; Bio-Medical Waste Management Rules, 2016.

The prescribed authority, i.e., the State Pollution Control Board (SCPB) or Pollution Control Committee (PCC), is mandated to



carry out these compliances except FCO, 2009 and 2013, which are under the concerned state agriculture department.

However, it would be desirable that the concerned ULB and the build-operate-transfer (BOT) operator or any other concessionaire get these compliances audited through their respective internal audit mechanism. This would lead to better performance and voluntary improvements.

2. **Resource management audit:** This audit checks how efficiently the resources are deployed. Water, energy, material resources (e.g., diesel), and staffing are crucial factors for smooth operation and long-term sustainability.
3. **Operational risk audit:** This audit brings out the consequences of operational risks and frequency with which these risks may occur, including constraint in necessary supplies, environmental damage, and preventive measures.
4. **Occupational risk audit:** This audit checks the measures for occupational safety. It is best done as per Occupational Health and Safety Assessment Series (OHSAS 18001) norms, which are accepted as standard norms across the globe. These are based on hazard identification, risk assessment, and determination of applicable controls.

The above audits have a significant impact on performance of the tasks related to waste management and ensure long-term sustainability along with environmental compatibility. Training and awareness generation are important adjuncts to achieving these goals.

6.5.1 ENVIRONMENTAL MONITORING AS PER SOLID WASTE MANAGEMENT RULES, 2016



SWM Rules, 2016 indicate specific requirements for siting, operating and monitoring different MSWM technologies, such as composting and landfilling

SWM Rules, 2016 stipulate regular monitoring of soil, water, and air quality around the municipal waste processing, treatment, and disposal facility. Schedules I, II, III, and IV of SWM Rules stipulate environmental norms for treatment, processing, and disposal facilities. Operators of MSW treatment, processing, and disposal facilities are responsible for regular monitoring of these parameters. Monitoring data should be reported to the SPCB by the ULB on an annual basis, as part of the annual reporting of ULBs. The MSWM service monitoring framework of the ULB should capture this information on a regular basis. The SPCB should monitor the compliance of standards for groundwater, ambient air, leachate, compost quality, and incineration as specified under schedules I and II (refer Section 3.2, 3.3 and 4.1 of Part II).



The SWM Rules, 2016 also specify environmental monitoring requirements for designing, disposal, treatment and processing facilities, to ensure pollution prevention and environmentally sound operation of these facilities. These specifications are detailed out in Section 3.2.1, 3.2.12, 3.3.13, 3.5.9, 3.6 and 4.1 of Part II.

6.5.2 REPORTING REQUIREMENTS

SWM Rules, 2016 specify reporting requirements for the State Level Advisory Body and Local Authorities:

Clause 15(za) prepare and submit annual report in Form IV on or before the 30th April of the succeeding year to the Commissioner or Director, Municipal Administration or designated Officer;

(zb) the annual report shall then be sent to the Secretary-in-Charge of the State Urban Development Department or village panchayat or rural development department and to the respective State Pollution Control Board or Pollution Control Committee by the 31st May of every year;

Clause 23: State Level Advisory Body:-

(2) The State Level Advisory Body shall meet at least one in every six months to review the matters related to implementation of these rules, state policy and strategy on solid waste management and give advice to state government for taking measures that are necessary for expeditious and appropriate implementation of these rules.

(3) The copies of the review report shall be forwarded to the State Pollution Control Board or Pollution Control

Committee for necessary action.

Clause 24: Annual Report:-

(1) The operator of facility shall submit the annual report to the local body in Form-III on or before the 30th day of April every year.

(2) The local body shall submit its annual report in Form-IV to State Pollution Control Board or Pollution Committee and the Secretary-in-Charge of the Department of Urban Development of the concerned State or Union Territory in case of metropolitan city and to the Director of Municipal Administration or Commissioner of Municipal Administration or Officer in -Charge of Urban local bodies in the state in case of all other local bodies of state on or before the 30th day of June every year

(3) Each State Pollution Control Board or Pollution Control Committee as the case may be, shall prepare and submit the consolidated

annual report to the Central Pollution Control Board and Ministry of Urban Development on the implementation of these rules and action taken against non complying local body by the 31st day of July of each year in Form-V.

- (4) The Central Pollution Control Board shall prepare a consolidated annual review report on the status of implementation of these rules by local bodies in the country and forward the same to the Ministry of Urban Development and Ministry of Environment, Forest and Climate Change, along with its recommendations before the 31st day of August each year.
- (5) The annual report shall be reviewed by the Ministry of Environment, Forest and Climate Change during the meeting of Central Monitoring Committee.

Clause 25: Accident reporting-

In case of an accident at any solid waste processing or treatment or disposal facility or landfill site, the Officer- in- charge of the facility shall report to the local body in Form-VI and the local body shall review and issue instructions if any, to the in- charge of the facility.

6.6 TRAINING REQUIREMENTS FOR MONITORING MUNICIPAL SOLID WASTE SERVICE PROVISION

As per SWM Rules, 2016:

Clause 15(zc) educate workers including contract workers and supervisors for door to door collection of segregated waste and transporting the unmixed waste during primary and secondary transportation to processing or disposal facility;

Suitably qualified sanitary supervisors, sanitary inspectors, chief sanitary inspectors, and responsible officer-in-charge are to be trained in the basics of MSWM service provision. Their training requirements are listed below:

- They should be made aware of the data requirements for monitoring MSWM service provision. The importance of regular data collection and record keeping should be emphasised. They should also be made aware of the different sources of data required.
- They should be trained in data analysis to be able to effectively use data for monitoring the performance of the system.
- Skills of all staff of the MSWM department should be regularly upgraded for understanding of and effective use of the management information system (MIS).

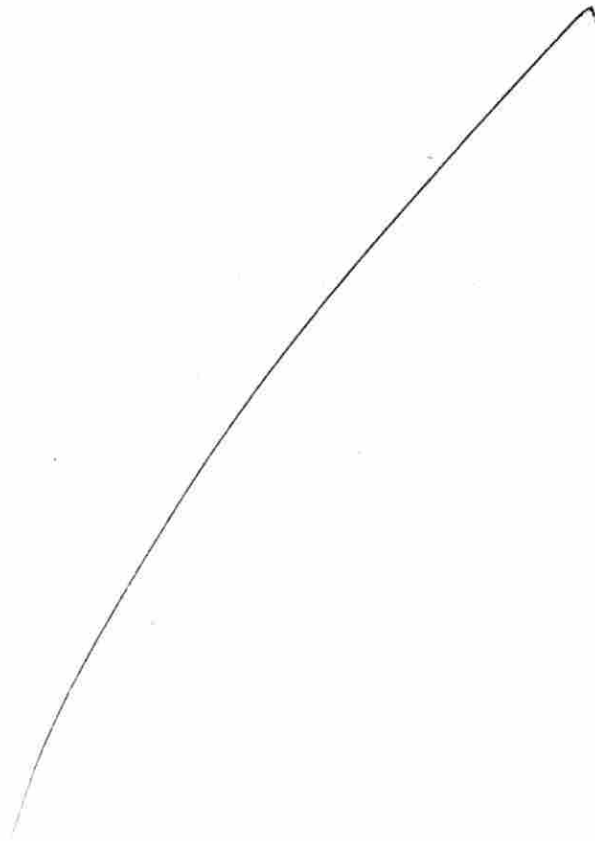


6.7 ACTION POINTS FOR AWARENESS GENERATION THROUGH INFORMATION, EDUCATION, AND COMMUNICATION ACTIVITIES FOR MONITORING MUNICIPAL SOLID WASTE SERVICE PROVISION

- Inform community of the scope and need for involvement in monitoring MSWM service provision.
- Publicise the citizen's charter for service provision to enhance accountability and details of the complaint redressal mechanism.
- Specify role of the ward committees in monitoring MSWM service provision and publicise contact details of ward committee members.
- Introduce local sanitary workers and supervisors to residents and owners of commercial establishments to enhance compliance from citizens and accountability of staff, which are a spin-off of increased interactions.
- Inform citizens about the institutionalisation of monitoring and reporting systems.
- Conduct quarterly community level meetings to discuss findings from the monitoring and reporting system and maintain a ward level service provision report card.

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7

**Management of
Special Waste**
Including Domestic
Hazardous Waste

IN THIS SECTION

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7. MANAGEMENT OF SPECIAL WASTE INCLUDING DOMESTIC HAZARDOUS WASTE

7.1 INTRODUCTION TO SPECIAL WASTE INCLUDING DOMESTIC HAZARDOUS WASTE

Special waste including domestic hazardous waste comprises of any solid waste or a combination of solid wastes that requires special handling and disposal because of its quantity, concentration, physical and chemical characteristics, or biological properties, in order to protect human health, as well as the environment and to exploit its potential for recycling.

In line with this definition, the following waste are defined as special waste:

1. Plastic waste
2. Bio-medical waste
3. Slaughterhouse waste
4. Electric and electronic waste (e-waste)
5. Waste tyres
6. Battery waste

Special waste including domestic hazardous waste should not enter the municipal solid waste (MSW) streams. But these wastes are also generated at the household and commercial level and, due to lack of segregation at source or improper collection systems, they frequently end up in the mixed MSW stream.

7.2 EXISTING RULES FOR MANAGEMENT OF SPECIAL WASTE INCLUDING DOMESTIC HAZARDOUS WASTE

The various rules notified for environmentally sound management of different types of special wastes including domestic hazardous waste are discussed briefly in Table 7.1. Copies of all the rules of the Ministry of Environment, Forests & Climate Change (MoEFCC), which govern the management of such wastes, are included in Annexure 9, 11, 12, 14 and 15 of the manual.

Special waste including domestic hazardous waste requires special handling and disposal due to its physical and chemical characteristics



Table 7.1: Existing Rules for Treatment of Special waste

LAWS AND REGULATIONS	MAJOR CONTENTS	TYPE OF WASTE
Plastic Waste Management Rules, 2016 ¹ Guidelines for Recycling of Plastics (Indian Standards [IS] 14534), 1998 ² Guidelines on Co-processing in Cement/Power/Steel Industry, February 2010 ³	The manufacture, importer stocking, distribution, sale, and use of carry bags, plastic sheets or like, or cover made of plastic sheet, and multilayered packaging is regulated by this rule. Requirements for management of plastic waste are also specified in this rule. Norms for labelling plastic bags and recycled plastic products (not less than 50 microns in thickness); and recycling, recovery, or disposal of plastic waste are to be carried out as per the rules and standards notified by the central government. Guidelines for co-processing has relevance for both hazardous and non-hazardous waste (plastic and tyres) and are therefore mentioned with special reference to utilisation of non-hazardous waste in cement or power industry.	Plastic wastes
Bio-Medical Waste (Management and Handling) Rules, 1998 ⁴ Draft Bio-Medical Waste (Management and Handling) Rules, 2011 ⁵ and The Bio-Medical Waste Management Rules, 2016 ⁶	According to these rules, the 'occupier' (a person who has control over the concerned institution or premises) of an institution generating bio-medical waste is responsible for ensuring that such waste is handled without any adverse effect to human health and the environment. The rules govern the categorisation, on-site, and off-site storage, transport, treatment, and disposal of bio-medical wastes. The Bio-Medical Management Rules, 2016 mandates every occupier to obtain authorisation irrespective of the number of patients being treated; Bio-medical waste has now been classified in to 4 categories instead 10 to improve the segregation of waste at source; and specifies colour coding for various categories of bio-medical waste to avoid overlapping; establish a Bar-Code System for bags or containers containing bio-medical waste for disposal. The new rules prescribe more stringent standards for incinerator and existing incinerators to achieve the standards for retention time in secondary chamber and Dioxin and Furans within two years;	Bio-medical wastes

- 1 Plastic Waste Management Rules, 2016. Available at: <http://www.moef.gov.in/sites/default/files/PWM%20Rules%2C%202016.pdf> [accessed on 20th April, 2016]
- 2 Guidance for Recycling of Plastics, 1998. Available at: <http://www.moef.nic.in/legis/hsm/plastic.html>
- 3 CPCB (2010), Guidelines on Co-processing in Cement/Power/Steel Industry. Available at: http://cpcb.nic.in/upload/Latest/Latest_51_GUIDELINES-ON_CO-ProcessinginCement.pdf
- 4 Bio-medical Waste (Management and Handling) Rules, 1998. Available at: <http://envfor.nic.in/legis/hsm/biomed.html>
- 5 Draft Bio-medical Waste (Management and Handling) Rules, 2011. Available at: [http://www.cpcb.nic.in/wast/bioimcdwast/DraftBio-medicalWaste\(M&H\)Rules,2011.pdf](http://www.cpcb.nic.in/wast/bioimcdwast/DraftBio-medicalWaste(M&H)Rules,2011.pdf)
- 6 The Bio-Medical Waste Management Rules, 2016. Available at: http://www.moef.gov.in/sites/default/files/BMW%20Rules%2C%202016_0.pdf [accessed on 20th April, 2016]
- 7 E-Waste (Management) Rules, 2016. Available at: <http://www.moef.gov.in/sites/default/files/EWM%20Rules%202016%20english%2023.03.2016.pdf> [accessed on 20th April, 2016]



Table 7.1: Existing Rules for Treatment of Special waste [contd.]

LAWS AND REGULATIONS	MAJOR CONTENTS	TYPE OF WASTE
E-Waste Management Rules, 2016 ⁷	These Rules are based on the principles of extended producer responsibility (EPR), wherein the producer engaged in the manufacture, sale, and purchase of electrical and electronic equipment is responsible for the end of life management of the electrical and electronic products listed in Schedule 1 of the rules. Procedures are provided for handling E-Waste as applicable to all stakeholders, such as collection centres, dismantlers, and recyclers of E-Waste. Stipulations for reducing the hazardous substances in electrical and electronic equipment are also prescribed. Procedures and formats for registration of facilities for recycling E-Waste are specified.	E-Wastes (electrical and electronic wastes)
Batteries (Management and Handling) Rules, 2001 ⁸	These rules are for regulating the recycling of lead acid batteries after use. The rules specify responsibilities of manufacturers, importers, assemblers, dealers, and re-conditioners of lead acid batteries, which are a source of electrical energy and contain lead. Requirements for registration of recyclers are prescribed under the rules. The rules also provide a control on the imports of substances by original equipment manufacturers and other equipment manufacturers.	Lead acid batteries
Hazardous Wastes (Management and Handling) Rules, 1998 and Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016 ⁹	The ambit of the Rules has been expanded by including 'Other Waste'. These rules are applicable to hazardous wastes and other waste as defined and listed in the rules; the rules specifies the procedure for management of hazardous and other waste, obligations of the occupier generating the hazardous and other waste, the process for grant of authorisation for handling such wastes from the State Pollution Control Board (SPCB) or Pollution Control Committees (PCC) and its procedure has been simplified to merge all the approvals as a single window clearance for setting up of hazardous and other waste disposal facility and import of other wastes; Requirements for packaging, labeling, and transport and strategy for import and export of hazardous and other wastes are also mentioned in the rules. The process for suspension or cancellation of licenses of generators and restrictions on the import of these wastes are also specified. The responsibility of the state government to inventorise all hazardous waste generators and the requirements for record keeping and reporting by the operator and the SPCB or PCC are mentioned. Co-processing as a preferential mechanism over disposal for use of waste as supplementary resource, or for recovery of energy has been provided and the approval process for co-processing for waste to energy recovery has been streamlined; the basic necessity of infrastructure to safeguard the health and environment from waste processing industry has been prescribed as Standard Operating Procedure (SOPs) specific to waste type.	Waste streams from process generating hazardous wastes as mentioned in Schedule I of the Amendment Rules, 2000
Note: Hazardous Waste is not commonly found in municipal waste streams and hence its management is not described in detail in this manual.		

7.3 SPECIAL WASTE MANAGEMENT INCLUDING DOMESTIC HAZARDOUS WASTE – GUIDANCE FROM THE INTEGRATED SOLID WASTE MANAGEMENT (ISWM) HIERARCHY

The integrated solid waste management (ISWM) hierarchy (Section 1.1 of Part II) indicates that the next preferred waste management method to waste minimisation or reduction is reuse and recycling. Waste that cannot be reduced or minimised should be reused (resource recovery) and recycled. Some special wastes including domestic hazardous waste like plastics waste, electrical and electronic waste (e-waste) can be reused or recycled; on the other hand, slaughterhouse waste and bio-medical waste should not be recycled and should be appropriately treated and disposed of to prevent hazardous impacts of undesirable dumping of these wastes.

Recycling of special wastes including domestic hazardous waste provides economic as well as environmental benefits and reduces reliance on virgin materials.

7.4 PLASTIC WASTE

The disposal of plastic waste is legislated under the Plastic Waste Management Rules, 2016. These rules specify the responsibilities of urban local bodies (ULBs) for managing plastic waste. However, most of the discarded plastics find their way into the municipal waste streams.

7.4.1 EXCERPTS FROM THE PLASTIC WASTE MANAGEMENT RULES, 2016

Clause 4: The manufacture, importer stocking, distribution, sale and use of carry bags, plastic sheets or like, or cover made of plastic sheet and multilayered packaging, shall be subject to the following conditions, namely:-

- a) carry bags and plastic packaging shall either be in natural shade which is without any added pigments or made using only those pigments and colourants which are in conformity with Indian Standard : IS 9833:1981 titled as “List of pigments and colourants for use in plastics in contact with foodstuffs, pharmaceuticals and drinking water”, as amended from time to time;

8 Batteries (Management and Handling) Rules, 2001. Available at: <http://www.moef.nic.in/legis/hsm/leadbat.html>
 9 Hazardous Wastes (Management and Handling) Amendment Rules, 2000 Available at: <http://envfor.nic.in/legis/hsm/hwamdr.html>
 Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016 <http://www.moef.gov.in/sites/default/files/Final%20HWM%20Rules%202016%20%28English%29.pdf>



- b) Carry bags made of recycled plastic or products made of recycled plastic shall not be used for storing, carrying, dispensing or packaging ready to eat or drink food stuff;
- c) carry bag made of virgin or recycled plastic, shall not be less than fifty microns in thickness;
- d) plastic sheet or like, which is not an integral part of multilayered packaging and cover made of plastic sheet used for packaging, wrapping the commodity shall not be less than fifty microns in thickness except where the thickness of such plastic sheets impair the functionality of the product;
- e) the manufacturer shall not sell or provide or arrange plastic to be used as raw material to a producer, not having valid registration from the concerned State Pollution Control Boards or Pollution Control Committee;
- f) sachets using plastic material shall not be used for storing, packing or selling gutkha, tobacco and pan masala;
- g) recycling of plastic waste shall conform to the Indian Standard: IS 14534:1998 titled as Guidelines for Recycling of Plastics, as amended from time to time;
- h) The provision of thickness shall not be applicable to carry bags made up of compostable plastic. Carry bags made from compostable plastics shall conform to the Indian Standard: IS 17088:2008 titled as Specifications for Compostable Plastics, as amended from time to time. The manufacturers or seller of compostable plastic carry bags shall obtain a certificate from the Central Pollution Control Board before marketing or selling; and
- i) plastic material, in any form including Vinyl Acetate - Maleic Acid - Vinyl Chloride Copolymer, shall not be used in any package for packaging gutkha, pan masala and tobacco in all forms.

Clause 5: The plastic waste management by the urban local bodies in their respective jurisdiction shall be as under:-

- (a) plastic waste, which can be recycled, shall be channelized to registered plastic waste recycler and recycling of plastic shall conform to the Indian Standard: IS 14534:1998 titled as Guidelines for Recycling of Plastics, as amended from time to time.
- (b) local bodies shall encourage the use of plastic waste (preferably the plastic waste which cannot be further recycled) for road construction as per Indian Road Congress guidelines or energy recovery or waste to oil etc. The standards and pollution control norms specified by the prescribed authority for these technologies shall be complied with.

- (c) Thermo set plastic waste shall be processed and disposed off as per the guidelines issued from time to time by the Central Pollution Control Board.
- (d) The inert from recycling or processing facilities of plastic waste shall be disposed of in compliance with the Solid Waste Management Rules, 2000 or as amended from time to time.

Clause 6: Responsibility of local body.-

- (1) Every local body shall be responsible for development and setting up of infrastructure for segregation, collection, storage, transportation, processing and disposal of the plastic waste either on its own or by engaging agencies or producers.
- (2) The local body shall be responsible for setting up, operationalisation and co-ordination of the waste management system and for performing the associated functions, namely:-
 - (a) Ensuring segregation, collection, storage, transportation, processing and disposal of plastic waste;
 - (b) ensuring that no damage is caused to the environment during this process;
 - (c) ensuring channelization of recyclable plastic waste fraction to recyclers;
 - (d) ensuring processing and disposal on non-recyclable fraction of plastic waste in accordance with the guidelines issued by the Central Pollution Control Board;
 - (e) creating awareness among all stakeholders about their responsibilities;
 - (f) engaging civil societies or groups working with waste pickers; and
 - (g) ensuring that open burning of plastic waste does not take place.
- (3) The local body for setting up of system for plastic waste management shall seek assistance of producers and such system shall be set up within one year from the date of final publication of these rules in the Official Gazette of India.
- (4) The local body to frame bye-laws incorporating the provisions of these rules.



**Clause 8: Responsibility of waste generator:-**

- (1) The waste generator shall.-
 - (a) take steps to minimize generation of plastic waste and segregate plastic waste at source in accordance with the Solid Waste Management Rules, 2000 or as amended from time to time.
 - (b) not litter the plastic waste and ensure segregated storage of waste at source and handover segregated waste to urban local body or gram panchayat or agencies appointed by them or registered waste pickers', registered recyclers or waste collection agencies;
- (2) All institutional generators of plastic waste, shall segregate and store the waste generated by them in accordance with the Municipal Solid Waste (Management and Handling) Rules, 2000 notified vide S.O. 908(E) dated the 25th September, 2000 under the Act or amendment from time to time and handover segregated wastes to authorized waste processing or disposal facilities or deposition centers either on its own or through the authorized waste collection agency.
- (3) All waste generators shall pay such user fee or charge as may be specified in the bye-laws of the local bodies for plastic waste management such as waste collection or operation of the facility thereof, etc.;
- (4) Every person responsible for organising an event in open space, which involves service of food stuff in plastic or multilayered packaging shall segregate and manage the waste generated during such events in accordance with the Municipal Solid Waste (Management and Handling) Rules, 2000 notified vide S.O. 908(E) dated the 25th September, 2000 under the Act or amendment from time to time.

**Clause 9: Responsibility of producers:-**

- (1) The producers, within a period of six months from the date of publication of these rules, shall work out modalities for waste collection system based on Extended Producers Responsibility and involving State Urban Development Departments, either individually or collectively, through their own distribution channel or through the local body concerned.
- (2) Primary responsibility for collection of used multi-layered plastic sachet or pouches or packaging is of Producers, Importers and Brand Owners who introduce the products in the market. They need to establish a system for collecting back the plastic waste generated due to their products. This plan of collection to be submitted to the State Pollution Control Boards while applying for Consent to Establish or Operate or Renewal. The Brand Owners whose consent has been renewed before the notification of these rules shall submit



such plan within one year from the date of notification of these rules and implement with two years thereafter.

- (3) manufacture and use of non- recyclable multilayered plastic if any should be phased out in Two years time.
- (4) The producer, within a period of three months from the date of final publication of these rules in the Official Gazette shall apply to the Pollution Control Board or the Pollution Control Committee, as the case may be, of the States or the Union Territories administration concerned, for grant of registration.
- (5) No producer shall on and after the expiry of a period of Six Months from the date of final publication of these rules in the Official Gazette manufacture or use any plastic or multilayered packaging for packaging of commodities without registration from the concerned State Pollution Control Board or the Pollution Control Committees.
- (6) Every producer shall maintain a record of details of the person engaged in supply of plastic used as raw material to manufacture carry bags or plastic sheet or like or cover made of plastic sheet or multilayered packaging.

7.4.2 COMPOSITION OF PLASTICS

Plastics comprise of polymers which are distinct for each product. The most common are polyethylene terephthalate (PET), high-density polyethylene (HDPE), and low-density polyethylene (LDPE) as classified by Bureau of Indian Standards (BIS) and others mentioned in the box below. The Society of the Plastics Industry (SPI) has established the SPI resin identification coding system as a set of symbols placed on plastics to identify the polymer type. The code is used internationally and its primary purpose is to allow efficient separation of different polymer types for recycling.



Classification of Plastics – Bureau of Indian Standards

Bureau of Indian Standards (BIS) classifies plastic into seven types.

SYMBOL	SHORT NAME	SCIENTIFIC NAME	USE IN
	PET	Polyethylene terephthalate	Water bottles, PET bottles etc.
	HDPE	High density polyethylene	Milk or detergent bags, Carry bags, Container etc.
	PVC	Polyvinyl chloride	Cables, Pipes, Floorings etc.
	LDPE	Low density polyethylene	Carry bags, Films
	PP	Polypropylene	Medicine bottles, Cereal liners, Packaging films etc.
	PS	Polystyrene	Foam packaging, Tea cups, Ice cream cups, etc.
	O	Others	Thermoset plastics, Multilayer and Laminated Plastics, PUF, Bakelite, Polycarbonate, Melamine, Nylon etc.

Source: BIS, CPCB

- Recyclable plastics (thermoplastics): PET, HDPE, LDPE, PP, PVC, PS, etc.
- Non-recyclable plastics (thermoset and others): Multilayer and laminated plastics, polyurethane foam (PUF), bakelite, polycarbonate, melamine, nylon, etc.

Extensive use of plastic leads to the generation of huge quantities of plastic wastes that may account for 1%–10% (by volume) of the total municipal solid wastes (MSW). India produces approximately 8 million tonnes of plastic products every year (2008).¹⁰ Plastic is used for several purposes (wrapping material, shopping and garbage bags, fluid containers, clothing, toys, household and industrial products, building materials, etc.). Plastic cannot be recycled indefinitely and, eventually, all plastic products end up as waste since virgin plastic material can be recycled 2–3 times only and the plastic material deteriorates due to thermal pressure after each recycling. Plastics are also highly resistant to biodegradation.

7.4.3 PLASTIC WASTE MANAGEMENT

Following the integrated solid waste management (ISWM) hierarchy, reuse and recycling of plastic waste are the preferred methods for managing plastic wastes after reduction. However, as mentioned, plastics cannot be recycled indefinitely; each recycling cycle reduces the strength and utility of the plastic. Energy recovery from plastics

Plastic waste choke the urban drainage system, causing urban flooding in many instances. Immediate action on appropriate management (focusing on minimisation) and disposal of these wastes is required

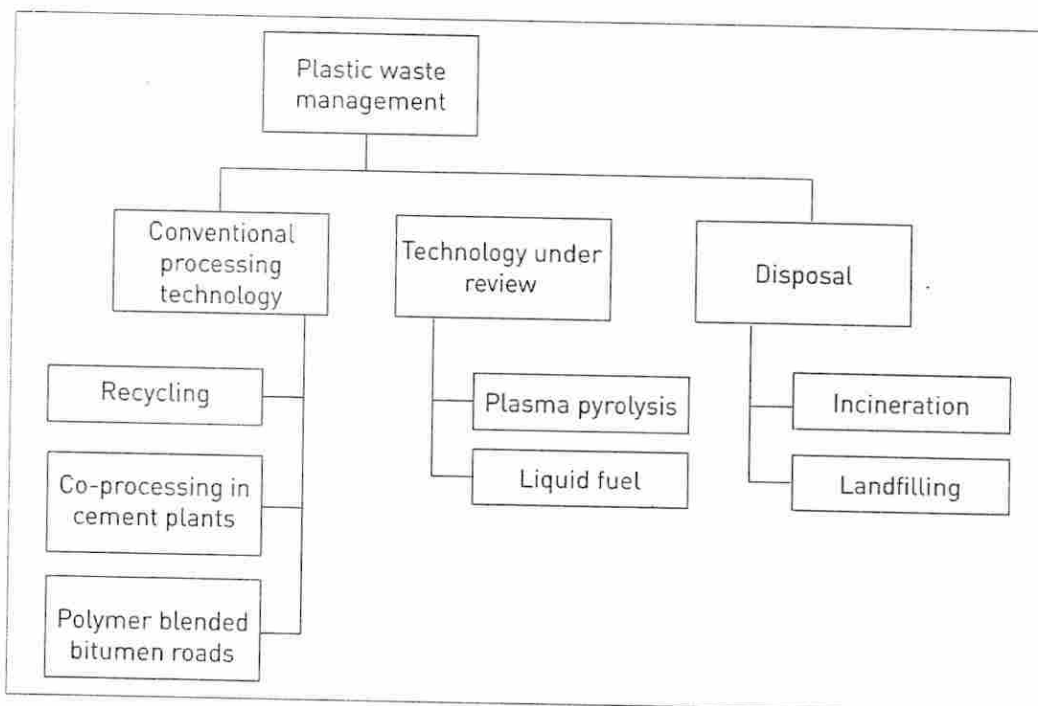
¹⁰ Material on Plastic Waste Management. Chapter – 1: Annual Report (2011–12) on Implementation of PWM. CPCB (2013). http://www.cpcb.nic.in/divisionsofheadoffice/pcp/management_plasticwaste.pdf



shall be considered when recycling is no longer possible. Plastic waste is accepted as fuel in cement kilns; residence times and temperatures are adequate to preempt the production of dioxins and furans. Incineration of plastic wastes for energy recovery may also be considered under strictly controlled and monitored conditions (for further details, refer to Section 3.3.2 of Part II). Reusing plastic waste to form polymer blended bitumen roads is an accepted method for final disposal of plastics in India. Landfilling of plastics should be avoided.

Plasma pyrolysis and production of liquid fuel from plastic waste are technologies being tested; however, commercial viability of such technologies is yet to be proven. The flowchart in Figure 7.1 depicts available options for plastic waste management, in order of their preference. Conventional technologies are more reliable than technologies still under development.

Figure 7.1: Options for Plastic Waste Management¹¹



Plastic recycling processes which produce end products with a higher order of reuse (eg. reuse as a virgin material substitute) coupled with a longer product life should be preferred

Recycling processes should seek to minimise pollution and maximise efficiency including energy efficiency of the process for recycling these wastes

7.4.4 RECYCLING OF PLASTIC WASTES

To a large extent, plastics are recyclable. Recycled polymers exhibit lower properties and performance than virgin polymers, and are useful only for lower value applications. Recycling of plastics without prior separation by resin produces a material with mechanical properties similar to timber. Hence, it is often used as a replacement for timber in certain applications. A higher quality of recycled plastics is achieved when separation by resin is carried out prior to the remoulding step.

11 Central Pollution Control Board. Available at: http://www.cpcb.nic.in/wast/plasticwast/Plastic_waste-1.pdf



7.4.4.1 STEPS INVOLVED IN THE RECYCLING PROCESS

Collection: Plastic waste should be collected from the door step from all MSW generators along with other reusable and recyclable non-biodegradable wastes and should be sorted out at intermediate sorting facilities or at the MSW processing facility.

Segregation: Plastic waste should be segregated from the rest of the recyclable waste based on different types of plastic, requiring different recycling processes.

Processing: After collection and segregation, post-consumer waste (used plastic waste) should be given away to recycling industry at a pre-negotiated price by the municipality. In cases where the municipal authority has already given the contract to a private operator to process MSW, plastic waste may be allowed to be processed or sold to the recycling industry by the operator following good industrial practices.

7.4.5 SUSTAINABLE DISPOSAL OF PLASTIC WASTE

At a stage where further recycling is not possible, the plastic material or product should be disposed of by suitable methods. Safe disposal of plastics is possible through various technologies such as co-processing of plastic waste in cement kilns and utilisation of plastic waste in road construction.

7.4.6 CO-PROCESSING AND CO-INCINERATION OF PLASTIC WASTE AS ALTERNATIVE FUEL AND RAW MATERIAL (AFR) IN CEMENT KILNS

Co-processing refers to the use of waste materials in the industrial process such as cement and power stations or any other large combustion plants. Co-processing indicates substitution of primary fuel and raw material by waste. Waste material such as plastic waste, multilayered packaging waste, etc. used for co-processing are referred to as alternative fuels and raw material. Co-incineration refers to utilisation of waste material for energy recovery.

Co-processing of plastic waste and multilayered packaging waste offers advantages for cement industry as well as for local authorities responsible for waste management. Producers save on fossil fuel and raw material consumption in co-processing, resulting in the adoption of eco-efficient production methods. Substituting fossil fuel and virgin raw material by alternative fuels and raw materials reduces overall carbon dioxide (CO₂) emissions of the process (assuming that the waste material being used would instead have been burned or disposed of without energy recovery). So far its application has been successful in



Co-processing and co-incineration of plastic waste in cement industries are proven methods for substitution of raw material as well as for energy recovery



the cement industry, and municipal authorities are also benefitted since co-processing of plastic wastes is an efficient and environmentally safe method to manage a sizeable quantity of non-recyclable plastic waste in MSW.

The Central Pollution Control Board (CPCB) has prescribed guidelines on co-processing of plastic waste as an alternative fuel.¹² The defined protocol is summarised below in Table 7.2.

Table 7.2: Central Pollution Control Board Guidance on Protocol for Co-processing of Plastic Waste¹³

SR. NO.	ITEM	DESCRIPTION	ACTION TO BE TAKEN BY
1	Collection of plastic waste	Concerned municipal authority should create a system for collection of plastic wastes from dustbins or dhalaos through PPP mode or any other feasible method.	Municipal corporation, municipality, municipal council, and cantonment board
2	Segregation & pre-processing of plastic waste	Collected plastics can be reprocessed or sorted into recyclable and non-recyclable fractions. The non-recyclable plastic wastes will be transported to nearest cement kilns and power plant for co-processing by concerned municipal authority in consultation with SPCB or PCC.	Municipal corporation, municipality, municipal council, and cantonment board
3	Identification of cement factory	Mapping of cement kilns and power plant for accepting co-processing of plastic waste in the same state or neighbouring state. An agreement shall be signed between municipal corporations and cement kilns.	SPCB, PCC, and municipal authorities
4	Modification for feeding plastic waste in cement kilns or power plants	Cement industry or power plant is to set up storage facility, shredder, conveyor belt, one hopper, one winch machine, and one double-flap damper.	Concerned cement industries or power plant
5	Setting-up of laboratory for plastics waste analysis	Cement industry or power plant shall set up a minimum laboratory facility to analyse plastic wastes before co-processing. The instrumentation includes thermogravimetric analyser; bomb calorimeter; and C, H, N, S analyser.	Concerned cement industry or power plant
6	Monitoring of emission by cement industry or SPCBs	Cement industry or power plant shall monitor the stack emission with respect to routine parameters and hazardous air pollutants.	Concerned cement industry, power plant, and SPCB or PCC

12 Material on Plastic Waste Management. Chapter - 1: Annual Report (2011-12) on Implementation of PWM. CPCB. (2013). http://www.cpcb.nic.in/divisionsofheadoffice/pcp/management_plasticwaste.pdf

13 Material on Plastic Waste Management. Chapter - 1: Annual Report (2011-12) on Implementation of PWM. CPCB. (2013). http://www.cpcb.nic.in/divisionsofheadoffice/pcp/management_plasticwaste.pdf



Table 7.2: Central Pollution Control Board Guidance on Protocol for Co-processing of Plastic Waste [contd.]

SR. NO.	ITEM	DESCRIPTION	ACTION TO BE TAKEN BY
7	Forwarding progress report to CPCB	Cement industry or power plant shall forward quarterly progress report of co-processing of plastic waste to CPCB.	Concerned cement industry, power plant, and SPCB or PCC

7.4.7 OTHER PLASTIC WASTE DISPOSAL OPTIONS

7.4.7.1 USE OF WASTE PLASTIC IN CONSTRUCTION OF BITUMINOUS ROADS

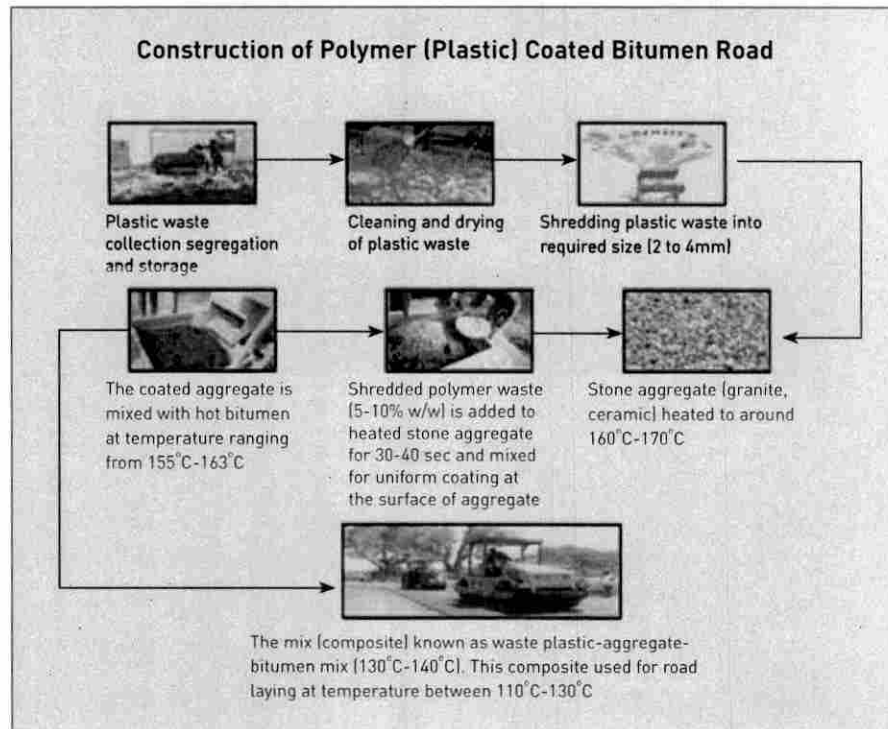
The use of plastic waste in bitumen roads (Figure 7.2) has been found to have several advantages including decreasing the susceptibility of the road to infiltration. There are also no observed deleterious impacts on the strength or properties of the road.¹⁴

Process Description:

- Waste plastic bags collected from roads, garbage trucks, dumpsites, compost plants, waste pickers, waste buyers, and households can be utilised in this process. Here plastic waste is sorted as per its thickness and type. Polyethylene with a thickness greater than 60 microns is sent for recycling; polyethylene below 60 microns is to be used in this process. Plastic waste should be cleaned by de-dusting or washing if required.
- Collected plastic is cut and sized into fine pieces.
- Lower micron plastic mixes easily with bitumen at higher temperatures (160°C–170°C). Bitumen is heated up to its melting temperature (160°C–170°C). Finely sized plastic pieces are added slowly to the hot bitumen, and the mixture is stirred for about 20–30 minutes at the same temperature. Polymer-bitumen mixtures of different compositions are prepared and tested for their application in road construction.

14 Plastic Waste Management. CPCB (2013). Available at: http://www.cpcb.nic.in/wast/plasticwast/Plastic_waste-1.pdf



Figure 7.2: Use of Plastic Waste in Construction of Bituminous Road¹⁵

7.4.7.2 CONVERSION OF PLASTIC WASTE INTO LIQUID FUEL

The conversion of plastic waste into liquid fuel has been considered as a possible solution for the disposal of plastic waste, however, it is still at its nascent stage. A research-cum-demonstration plant in Nagpur, Maharashtra converts waste plastics into liquid fuel. The process adopted is based on random de-polymerisation of waste plastics into liquid fuel in presence of a catalyst. The entire process is undertaken in closed reactor vessels followed by condensation. Waste plastics while heating up to 270°C to 300°C convert into liquid-vapour state, which is collected in condensation chambers in the form of liquid fuel while the tarry liquid waste is topped-down from the heating reactor vessel. Organic gas is generated, which is vented due to lack of storage facility. However, the gas can be used in dual fuel diesel-generator set for generation of electricity. This technology is at an experimental stage and may be considered only after it is well established as a technically, financially, and environmentally viable option of plastic waste processing or disposal.

ULBs should not experiment with non-proven technologies

¹⁵ Material on Plastic Waste Management, CPCB (2012). Available at: http://www.cpcb.nic.in/divisionsofheadoffice/pcp/management_plasticwaste.pdf



Plastic to Liquid Fuel: Initiative in New Moti Bagh, New Delhi

Under a 'zero waste' project at the 'General Pool Residential Accommodation Complex (GPRA)' of the Ministry of Urban Development in New Moti Bagh, a small facility to convert plastic waste into liquid fuel has been installed. The facility handles 50 kilograms of plastic waste per batch. The plastic waste, collected from the staff quarters, is segregated and put through a pyrolytic conversion process at about 400°C in the presence of a catalyst. The large polymeric molecules break down into smaller fractions yielding liquid fuel (in the range of light diesel oil or furnace oil), gaseous fuel, and char, all of which can be further used for different purposes. The light diesel oil or furnace oil is of key interest for commercial purposes. However, environmental implications of the process in terms of emissions, as well as its commercial viability, need to be further established.

7.4.7.3 INCINERATION OF PLASTIC WASTE

In cases where material recovery is not feasible, incineration with energy recovery is an accepted technology internationally for plastic waste disposal, with provision for adequate pollution abatement safeguards. Inappropriate operating conditions can cause the release of several harmful gases including dioxins and furans from chlorinated and brominated plastic waste. However, it is to be noted that achieving the requisite temperature and retention time in incinerators, coupled with an appropriate flue gas scrubbing or treatment system will ensure the safety of such technologies. For incineration technology, please refer to Section 3.3.3 of Part II.

7.5 BIO-MEDICAL WASTE

"Bio-Medical Waste" means any waste, which is generated during the diagnosis, treatment or immunisation of human beings or animals or research activities pertaining thereto or in the production or testing of biological or in health camps, including the categories mentioned in Schedule I appended to these rules.

Waste from kitchen, store, residential facilities, and gardens of health care establishments that are free from bio-medical waste contamination can enter the municipal waste stream.

7.5.1 SOLID WASTE MANAGEMENT RULES, 2016 - REQUIREMENTS ON BIO-MEDICAL WASTE



SWM Rules, 2016 prescribes that bio-medical wastes, industrial wastes, e-waste and domestic hazardous wastes shall be handled as specified in specific rules framed for management of such wastes and domestic hazardous waste may be handled as directed by the state pollution control board or pollution control committee.



As per the criteria for site selection given in Schedule I (x) of SWM Rules, 2016, the biomedical waste shall be disposed of in accordance with the Bio-medical Waste Management Rules, 2016, as amended from time to time.

The Schedule III of the Bio-medical Wastes Management Rules, 2016 mandates local authorities such as gram panchayats, municipalities or corporations to provide or allocate suitable land for setting up of Common Bio-Medical Waste Treatment Facility in their respective jurisdictions as per the guidelines of CPCB.

Collect other solid waste (other than the bio-medical waste) from the health care facilities as per the SWM Rules, 2016 or as amended time to time.



Clause 17 Site for common bio-medical waste treatment and disposal facility.-

- (1) Without prejudice to rule 5 of these rules, the department in the business allocation of land assignment shall be responsible for providing suitable site for setting up of common biomedical waste treatment and disposal facility in the State Government or Union territory Administration.
- (2) The selection of site for setting up of such facility shall be made in consultation with the prescribed authority, other stakeholders and in accordance with guidelines published by the Ministry of Environment, Forest and Climate Change or Central Pollution Control Board.

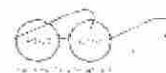
7.5.2 COLLECTION AND SEGREGATION OF WASTE IN HEALTH CARE ESTABLISHMENTS



Schedule I Part II of Bio-Medical Waste Management Rules, 2016:

Bio-medical waste generated in households during healthcare activities shall be segregated as per these rules and handed over in separate bags or containers to municipal waste collectors. Urban Local Bodies shall have tie up with the common bio-medical waste treatment and disposal facility to pickup this waste from the Material Recovery Facility (MRF) or from the house hold directly, for final disposal in the manner as prescribed in this Schedule.

Due to its infectious and hazardous characteristics, bio-medical waste should be segregated from other municipal wastes at source and handled appropriately at collection and storage points in the health care establishments. Bio-medical waste has been classified into four categories as per the rule (2016), and different treatment or disposal systems have been indicated for them. Health care establishments such as hospitals, nursing homes, pathological laboratories etc., generate bio-medical waste as well



as MSW (especially from their kitchen, garden, recreational area, etc.). These wastes should be segregated at the point of generation and stored in the colour coded containers separately following the provisions of Bio-medical Waste (M&H) Rules, 1998 and as amended in 2011 and 2016. This way the load on the bio-medical waste treatment facility would be much less because, normally, this category of waste is hardly 25%–30% of the total waste generated by health care facilities. The bio-medical waste should be sent for further treatment and disposal as per Bio-medical Waste (M&H) Rules, 1998 and as amended in 2011 and 2016; other solid wastes should be handled in accordance with the SWM Rules, 2016. This is essential to ensure that MSW generated from health care establishments is not contaminated, and does not pose any health and environmental risks to the waste handlers, processing plants, and users of end products of MSW at processing facilities.



ULBs should collect MSW generated by hospitals and other health care establishments after ensuring that such waste streams are not contaminated with bio-medical wastes

7.6 SLAUGHTERHOUSE WASTE

Slaughterhouse waste is predominantly disposed in dump sites or processed along with other organic waste in compost plants which are not scientifically and properly managed. Scientific processing and disposal of slaughterhouse waste is essential to recover useful fractions and for safe disposal of residual pathogenic biological wastes.

Processes undertaken in a modern slaughterhouse include slaughtering, dressing, cutting, and inspection of meats, and refrigeration, curing, and manufacturing of by-products. In the absence of a proper slaughterhouse waste processing or disposal facility, urban local bodies (ULBs) can practice deep burial of carcasses and animals killed in accidents with adequate precaution. However, ULBs should regularly monitor sites where deep burial is practiced for potential environmental and public health impacts.

Based on scale of operations, slaughterhouses have been classified into three categories: large, medium, and small (Table 7.3).

Large slaughterhouses are mostly in cities. They generate substantial quantity of solid wastes that have to be processed in an environmentally acceptable manner.

Table 7.3: Classification of Slaughterhouses¹⁶

CATEGORY	SLAUGHTERING CAPACITY (TONNES OF LIVE WEIGHT KILLED PER DAY)
Large	Above 70
Medium	15-70
Small	Below 15

¹⁶ Central Pollution Control Board, 2004



Waste materials produced in these establishments are of three types: solid, liquid, and gas. Solid waste is generated from manure, intestinal contents, hair, horns, hooves, gallbladders, trimmings, internal organs, condemned carcasses or body parts, carton, and plastics. Solid wastes from slaughterhouses are varied depending on the kind and scale of operations. Liquid wastes of slaughterhouses come from urine, blood, and wastewater from the slaughter processes. Odours and emissions are also produced in the operations.

These waste materials if not handled and managed properly pose a hazard to the environment. High concentration of animal blood and fat, dirt, and other pollutants in slaughterhouse effluent renders it very toxic to the receiving water bodies.

Usually the quantity of wastes per animal is large in small scale operations, where the recovery of offal is ineffective. Its main products are fresh meat in the form of whole, half, or quarter carcasses, or in smaller meat cuts. By-product processing is usually absent. In modern slaughterhouses, there is extensive processing of by-products. In such plants at least three additional operations are conducted: (i) rendering, paunch, and viscera handling; (ii) blood processing; and (iii) hide and hair processing. By these operations, maximum recovery of edible and inedible materials from the offal is achieved, and this results in lower production of wastes per animal.

7.6.1 PROCESSING SLAUGHTERHOUSE WASTE

The solid waste of slaughterhouses can be broadly classified into two categories: (i) vegetative matter (type I) such as rumen, stomach and intestine contents, dung, agriculture residues, etc., and (ii) animal matter (type II) like inedible offals, tissues, meat trimmings, waste and condemned meat, bones, etc. These waste streams can be segregated and treated separately.



For large and medium slaughterhouses, biomethanation of type-I waste and rendering for type-II waste are suggested. Biomethanation requires less space, which is advantageous for the slaughterhouses with land constraints. In-vessel high rate composting of type I waste may also be considered, but these systems are quite expensive.

In small slaughterhouses, sophisticated and capital-intensive technologies are unviable due to low volume of wastes and non-availability of other infrastructure facilities. For small slaughterhouses, a viable approach would be biomethanation or deep burial facility provided by the municipal authority.

The best practicable methods currently available for processing and disposal of different wastes from slaughterhouses are detailed in Table 7.4.

For large and medium slaughterhouses, biomethanation of type-I waste and rendering for type-II waste are suggested

For small slaughterhouses, biomethanation or deep burial facility is suggested



Table 7.4: Methods for Processing, Utilisation and Disposal of Solid Wastes from Slaughterhouse¹⁷

WASTE	CONSTITUENTS OF WASTES	SH CATEGORY	METHOD(S)
Type I	Vegetable matter such as rumen, stomach and intestinal contents, dung, agriculture residues, etc.	Large	Biomethanation or in-vessel composting
		Medium	Biomethanation or in-vessel composting
		Small	Biomethanation or pooling to a centralised facility
Type II	Animal matter such as inedible offal, tissues, meat trimmings, waste and condemned meat, bones, etc.	Large	Rendering or CPU
		Medium	Rendering or CPU
		Small	Deep burial facility provided by municipality

Composting: Composting is an aerobic biological decomposition of organic material, resulting in a stable humus-like product. This is a common practice of waste stabilisation but requires proper understanding of the method (for more details, refer to Section 3.2 of Part II).

Both type I and type II slaughterhouse wastes can be stabilised through composting. The compost stack is prepared by adding alternate layers of type I waste and type II waste, to build a 4 to 5 feet high heap. The heap should be laid directly on the ground. It is advisable to put a layer of about 6 -inches of coarse material underneath, such as maize or millet stalks, banana stumps, straw, grass, small twigs, etc., to achieve proper ventilation.

Large- sized matter (organs such as kidneys and lungs, or other similar wastes) in type II wastes should be minced to 2 to 3-inch pieces before composting. For better results, it is advised to mix these pieces with earth and evenly spread out in the centre of the heap where the temperature is high.

The ruminal and intestinal contents provide sufficient moisture for initiating and sustaining bacterial activity. As such, under normal circumstances, no additional water is required.

Biomethanation: Slaughterhouse waste is anaerobically stabilised in biomethanation. The success of the process, especially the effective removal of biochemical oxygen demand (BOD), has led to the acceptance of biogas plants for processing slaughterhouse wastes.

¹⁷ Sanitation in Slaughter House, CPCB (2004). Available at: <http://www.cpcb.nic.in/divisionsofheadoffice/pci3/pci3divslaughter.pdf>.



High Rate Biomethanation: The essential elements of a high rate biomethanation process are: size reduction and slurry making, operation at thermophilic temperature range, and complete mixing to achieve a uniform temperature with more or less uniform feeding of the waste. Pre-thickening or dilution of the digester contents are optional features of a high rate digestion system. The benefits of high rate biomethanation are reduced digester volume and increased pathogen kill. Wastes consisting of rumen and paunch contents, dung, agriculture residue, fat, and blood may be processed in the high rate biomethanation plant.

Rendering: Rendering plants are set up for the recovery of fats and bone and meat meal. This is a useful method for the recovery of by-products from slaughterhouse waste.

All animal matter such as inedible offal, tissues, meat trimmings, waste and condemned meat, bones, etc. can be processed in a rendering system, since the main constituents of animal matter are fat, water, and solids. Rendering is effected by heating; heat ruptures the connective tissue of individual fat and muscle cells so that raw fat and other material bound within is released. Wet and dry rendering plants may be adopted. Wet rendering plants yield animal fat and bone meal. Dry rendering enables 20% higher yield than wet rendering.¹⁸

Fat recovered during rendering is used for industrial purposes, and making soap and greases. Fat recovered from flesh of healthy parts can be edible. Meat meal or bone meal is utilised for the manufacture of stock feed and fertilizers. Sludge bio-solids from dry rendering plants should be appropriately treated and disposed.

Incineration is also an option for the treatment of slaughterhouse waste.



**Clean Technology and Modernisation for Slaughterhouse Waste
Treatment: Initiative of Municipal Corporation of Delhi in Ghazipur**

Location: Ghazipur, New Delhi

Year of Start: 2009

Main Players: Erstwhile Municipal Corporation of Delhi (MCD), East Delhi Municipal Corporation (EDMC), Haarslev Industries, Frigorifico Ala Anna Pvt Ltd.

Approach: The oldest slaughterhouse in Idgah, Delhi posed a major public health and environmental hazard due to indiscriminate disposal of waste, inadequate water supply, and discharge of effluents in open drains. Concerns raised by local residents, non-government organisations (NGOs) and MCD prompted the Supreme Court, in 2004, to direct the MCD

18 Sanitation in Slaughter House, CPCB (2004). Available at: <http://www.cpcb.nic.in/divisionsofheadoffice/pci3/pci3divslaughter.pdf>.



to relocate the Idgah slaughterhouse to a modernised slaughterhouse in Ghazipur. This led to the establishment of a modernised facility spread across 30 acres of land having slaughterhouse, livestock markets, rendering plant, roads, etc. and an effluent treatment plant (ETP) to ensure wastewater treatment and processing of waste as per the standards prescribed by Central Pollution Control Board (CPCB). The slaughterhouse plant has been established as a turnkey project. The funding for the project was from National Capital Region Planning Board (Rs. 60 crore loan), Ministry of Urban Development (Rs. 20 crore grant + Rs. 20 crore loan), Government of National Capital Territory of Delhi (Rs. 70 crore loan), and Ministry of Food Processing Industries (Rs 4 crore grant). The plant operation and maintenance has been handed over to the private operator named Frigorifico Allana, on annual royalty in 2009 for 10 years. The approach that was adopted for installation and operationalisation of the slaughterhouse plant is detailed below.

Institutional:

- Head of Veterinary Department of erstwhile MCD (now EDMC) and project in-charge of the private operator work closely and coordinate on a daily basis for smooth execution and functioning of the plant.
- Adequate health and safety measures (uniforms, gumboots, gloves, masks), as well as intensive trainings on regular basis, were provided to the workers to maintain cleanliness and hygiene during operation.
- Intensive trainings and capacity building on regular basis were provided to the workers for them to operate the rendering plant.

Managerial:

- The plant operates in three shifts. The morning and evening shifts are reserved for general traders and the middle shift for the operator of the facility.
- Token systems for the general traders were introduced to maintain transparency and discipline during peak shifts.

Stakeholder Consultations:

- Intensive meetings of MCD officials with the slaughterhouse association convinced the association about the necessity and urgency of the relocation.

Outcomes:

- Livestock market in Ghazipur is about 3–4 times larger than Idgah facility, thereby reducing the chances of insanitation and overcrowding. An ETP of 1,750 kiloliters per day capacity to treat the liquid waste and a rendering plant of 20 tonnes capacity including ETP of 250 kiloliters per day capacity have been established.
- Three separate lairages with adequate water, shed, and fodder facilities have been constructed to allow proper rest to the animals before slaughtering, facilitating proper examination of each animal by the veterinary department.
- The entire process in the slaughterhouse is carried out under hygienic conditions, and effluents discharged are treated and disposed of safely.

- Utilisation of the by-products obtained after the rendering process for industrial use.
- Capacity of slaughtering 5,500 animals per day (1,500 buffaloes and 4,500 sheep and goats).
- Treatment capacity of 60 tonnes of paunch waste in the plant.
- Carcasses were taken back by the shopkeeper to their shop for retail distribution.
- There was gradual acceptance of the general shopkeepers and traders for centralised and modern slaughterhouse facility, as it provided them a better market price owing to the quality of the slaughtered product.

Success Factor:

- Intensive training was provided to the workers to handle the waste scientifically.
- Modern and sophisticated technology was used for slaughtering.

Overall Sustainability:

The total cost of the plant was Rs. 183 crore. The cost comprises the construction and installation of the plant as well as the procurement of machinery for the rendering plant. The operational agreement is such that the concessionaire has to pay erstwhile MCD (now EDMC) Rs. 1.5 crore quarterly as a royalty for the plant. In order to sustain and optimised operation of the plant, the concessionaire, in consultation with erstwhile MCD, has introduced user charges against general traders at Rs. 45 for sheep and goats and Rs. 300 for buffalo. The concessionaire has been given the liberty to run one shift for their own export. Apart from this, the by-products (bone meal, oils) obtained from the rendering plant act as value-added material for the concessionaire.

Source: East Delhi Municipal Corporation

7.7 ELECTRIC AND ELECTRONIC WASTE

E-waste means any waste from electrical or electronic equipment, whole or in parts, or rejects from their manufacturing and repair processes, which are intended to be discarded.

7.7.1 E-WASTE MANAGEMENT RULES, 2016

E-waste is regulated under the E-Waste Management Rules, 2016.

According to Schedule IV of the E-Waste Management Rules, 2016, the responsibilities of the Urban Local Bodies are:

- To ensure that e-waste if found to be mixed with MSW is properly segregated, collected and is channelised to either authorised dismantler or recycler.



- To ensure that e-waste pertaining to orphan products is collected and channelised to either an authorised dismantler or recycler.

Municipal authorities must therefore give basic education to their staff on identification of e-waste and on measures to be taken when they find such a waste mixed with municipal solid waste.

These rules are based largely on the principle of Extended Producer Responsibility (EPR), which assigns the producer with the responsibility of 'end-of-life' management of the electrical and electronic equipment (for details refer to Section 2.1.2 of Part II). The objective of the rules is to put in place an effective mechanism to regulate the generation, collection, storage, transportation, environmentally sound recycling, treatment and disposal of the e-waste. It is mandatory that e-wastes be managed in accordance with provisions under these rules.

As per E-Waste Management Rules, 2016, the ULB should channelise e-waste found mixed with MSW to authorised e-waste recyclers



Bruhat Bengaluru Mahanagara Palike (BBMP) is adopting a three-bin system for collection of wet, dry, and e-waste. More than 10 collection bins for e-waste disposed of by citizens have been set up in the city. Citizens are required to bring e-waste to these locations. E-waste collected from these bins is recycled by authorised recyclers in an environmentally sustainable manner.

7.7.2 CURRENT STATUS OF E-WASTE GENERATION AND ITS MANAGEMENT

Electronic waste is one of the fastest growing waste streams in the country with a growth rate of 10% per annum. An increase in the use of electrical and electronic products and their high rate of obsolescence leads to generation of huge amounts of electrical and electronic waste (e-waste). As per preliminary estimates of the Central Pollution Control Board (CPCB), e-waste generation in India was 0.8 million tonnes in 2012.

E-waste management practices in India are beset with numerous shortfalls, such as the difficulty in maintaining an inventory of generated e-waste, unhealthy conditions of informal recycling, inadequate capacities, and lack of awareness among generators and ULBs.

7.7.3 E-WASTE CATEGORIES

E-waste is classified into two categories according to their characteristics under Schedule I of E-Waste Management Rules, 2016 (Table 7.5).



Table 7.5: Categories of electronic wastes as per E- Waste Management Rules, 2016¹⁹

WASTE CATEGORY	WASTE STREAM	TYPE OF E-WASTE
Category I	Information technology and telecommunication equipment	Centralised data processing: Mainframes, Minicomputers; Personal Computing: Personal Computers (Central Processing Unit with input and output devices); Personal Computing: Laptop Computers (Central Processing Unit with input and output devices); Personal Computing: Notebook Computers, Notepad Computers; Printers including cartridges; Copying equipment; Electrical and electronic typewriters; User terminals and systems; Facsimile; Telex; Telephones; Pay telephones; Cordless telephones; Cellular telephones and Answering systems
Category II	Consumer electrical and electronics	Television sets (including sets based on (Liquid Crystal Display and Light Emitting Diode technology); Refrigerator; Washing Machine; Air-conditioners excluding centralised air conditioning plants; Fluorescent and other mercury containing lamps.

E-waste consists of more than 1000 different components which can be categorised as “hazardous” and “non-hazardous”. Typically, e-waste consists of:²⁰

- ferrous metals (approximately 50%);
- plastics (approximately 21%);
- non-ferrous metals like copper, aluminium, silver, gold, platinum, palladium etc. (approximately 13%); and
- other components like glass etc. (approximately 16%).

Most plastic components in e-waste include phthalate plasticiser and brominated flame retardants, which are hazardous. Therefore, even though the plastic recovery potential from e-waste can be quantified, presence of above mentioned chemicals limits the actual recycling potential.

¹⁹ E-Waste Management Rules, 2016

²⁰ Converting Waste Plastics Into a Resource, United Nations Environment Programme (2009). Available at: http://www.unep.or.jp/ietc/Publications/spc/WastePlasticsEST_AssessmentGuidelines.pdf



The following three E-Waste streams are not covered under the Schedule I of the E-Waste Management Rules, 2016:

- Batteries used in electrical and electronic equipment, such as Ni-Cd, Li-ion, Mercury etc.
- Dry cell batteries

It is very likely that these components are found in municipal solid waste (MSW) despite their inherent recycling potential (since no vendor pays for them). Local authorities (like Ahmedabad Municipal Corporation) has started an initiative of collecting these wastes separately or as part of the special waste stream or mixed with dry waste (where special waste is not collected separately). This special waste is disposed appropriately in a separate designated portion of the sanitary landfill.



Compact Fluorescent Lamps Recycling

There are two methods of recycling compact fluorescent lamps (CFLs): shredder method and end cut method. The shredder method involves crushing of CFLs and chemical treatment of the crushed material in dust-tight containers to avoid spillage of any harmful substances. The hazardous mercury and phosphor are removed by specialised processes, and the remaining material is sorted into glass, metals, and plastics. The end cut method involves removing of ends from the lamps. Ends of lamps consist of metal and plastic which further get segregated; the tube is chemically treated to recover mercury and phosphor. Phosphor powder and mercury can be used in new lamps or other industrial purposes, while glass can be processed further in the furnace for reuse. The aluminium end caps are sent for smelting and other metals are recycled. However, it should be noted that such recycling facilities are not yet commonly established in the country and establishment of such facilities should be encouraged by all state governments.

7.8 WASTE TYRES

The management of used tyres is a challenge for even the most modern MSWM systems, due to the physical properties and shape of tyres. Tyres are composed primarily of complex natural and synthetic rubber compounds, both of which have substantial heating value and various other materials.



The Government of Maharashtra has issued Draft Guidelines for Regulation of Tyre Retreading, Tyre Pyrolysis (Recycling) and Prohibition on Burning of Tyres (2014). The notification lays emphasis on life cycle approach while recycling tyres. It provides guidance for the approach to be adopted for tyre retreading, location of pyrolysis units, pollution control measures, safety arrangements and environmental compliances to be achieved by such units.

Source: Draft Guidelines for Regulation of Tyre Retreading Activities in the State of Maharashtra, Notification-Environment Department, Government of Maharashtra

7.8.1 STORAGE OF USED TYRES

Stockpiles of used tyres can create substantial land use problems, and serve as breeding grounds for insects and other small animals that harbour pathogens detrimental to human health and environment. Stockpiles can self-ignite; and when it does, the fire may be difficult to control, leading to negative human health and environmental impacts.

7.8.2 REUSE OF USED TYRES

Some of the more common reuse practices include the following:

- Reuse is done through retreading for extended service.
- Used tyres are utilised for building retaining walls for narrow hill roads, for controlling erosion along drainage channels, as barriers in coastal areas, as crash barriers, for earth filling in civil engineering works, etc. They are also used during landfill construction for weighing down the liner material.
- Cuttings from used tyres are used in shoe soles, gaskets, continuous conveyor belts, etc. They may also be used for low-grade products such as automobile floor mats, and rubber wheel handcarts and wheel barrows.

7.8.3 PROCESSING OF USED TYRES

The typical product yield from scrap tyres is tabulated in Table 7.6:

Table 7.6: Typical Product Yield from Scrap Tyres²¹

PRODUCT YIELD FROM SCRAP TYRES	TRUCK TYRES	EQUIPMENT MANUFACTURER (EM) TYRES	CAR TYRES
Crumb rubber	70%	78%	70%
Steel	27%	15%	15%
Fiber and scrap	3%	7%	15%

The recovery of rubber from used tyres can be very energy-intensive, and such processing may generate hazardous substances and many other types of process residues. Processing of tyre materials should be conducted under controlled conditions, as it generates dust and buffing, which may be carcinogenic to workers. Pulling out the steel wires followed by shredding are the main processes.

7.8.4 CO-PROCESSING OF WASTE TYRES

Co-processing of tyres as fuel in cement plants is approved as an environmentally safe and efficient method to dispose of used tyres.

²¹ Scrap Tire Recycling, Reschner, K (2008). Available at: http://entire-engineering.de/Scrap_Tire_Recycling.pdf



Co-processing with tyres is also known to improve the combustion characteristics of high ash coal.

The CPCB guidelines on co-processing in cement, power, or steel industry indicate specific requirements for the feeding of materials for co-processing, suitability of substances for co-processing, operating conditions for co-processing plants, air pollution control requirements, and emission standards.



Co-processing of tyres as a fuel in cement plants is a preferred environmentally safe method for disposing waste tyres in urban areas which are in proximity to cement factories

7.9 LEAD BATTERY WASTE

Once the lead acid battery is no longer capable of being recharged or cannot retain its charge, it is a waste and should be disposed. At the end of its life, the battery is classified as a hazardous waste and should be handled as prescribed in the Batteries (Management & Handling [M&H]) Rules, 2001 to prevent damage to human health and environment.

7.9.1 THE BATTERIES (MANAGEMENT & HANDLING) RULES, 2001

The Batteries (M&H) Rules, 2001 govern the management of lead acid batteries, which are a source of electrical energy and contain lead metal. Used lead acid batteries are not considered a part of MSW and should not be mixed while disposal.

These rules apply to every manufacturer, importer, re-conditioner, assembler, dealer, recycler, auctioneer, consumer, and bulk consumer involved in the manufacture, processing, sale, purchase, and use of batteries or components thereof.



Clause 7: Responsibilities of dealer:

"It shall be the responsibility of the dealer to:

- ensure that the used batteries are collected back as per the Schedule against new batteries sold;
- ensure safe transportation of collected batteries to the designated collection centres or to the registered recyclers; and
- ensure that no damage is caused to the environment during storage and transportation of used batteries."



Clause 10: Responsibilities of consumer or bulk consumer:

"It shall be the responsibility of the consumer to ensure that the used batteries are not disposed of in any manner other than depositing with the dealer, manufacturer, importer, assembler, registered recycler, re-conditioner or at the designated collection centres.



It shall be the responsibility of the bulk consumer to:

1. ensure that the used batteries are not disposed of in any manner other than by depositing with the dealer or manufacturer or registered recycler or importer or reconditioner or at the designated collection centres”

Clause 11: Responsibilities of auctioneer:

“The auctioneer shall ensure that used batteries are auctioned to the registered recyclers only.”

Municipal authorities should acquaint their SWM staff with the above provisions. When disposed lead acid batteries are found mixed with MSW, ULB staff should be trained to report the identified defaulters to the concerned authority for taking appropriate action.

7.10 ACTION POINTS FOR AWARENESS GENERATION THROUGH INFORMATION, EDUCATION, AND COMMUNICATION ACTIVITIES FOR SPECIAL WASTE INCLUDING DOMESTIC HAZARDOUS WASTE

- Provide information to the community on different types of special wastes including domestic hazardous waste and their related impacts on human life and environment.
- Generate awareness in the community about segregating special waste at household level to prevent its mixing with MSW. Equally important is to provide information on collection and disposal systems for special waste and related initiatives taken up by the ULB.
- Encourage usage of sustainable material such as jute or cloth bags, energy efficient lighting and electronic appliances, and multi-use consumables as an effective strategy to minimise special waste generation.
- Provide and communicate incentives to the community for making use of dry waste and domestic hazardous waste collection centres.
- Inform public about economic and environmental benefits of reducing, reusing, and recycling special waste.
- Engage with local businesses or electronic suppliers and create awareness on EPR initiatives around special waste. Promote incentives to encourage such initiatives.
- Educate public about prevalent EPR initiatives.

Glossary

Acid gas	Gases produced during the combustion process containing significant quantities of acidic components such as sulphides and chlorides.
Active gas collection	A technique that forcibly removes gas from a landfill by attaching a vacuum or pump to a network of pipelines in the landfill or surrounding soils to remove the gases.
Aerated static pile	The process of exposing bulk material, like compost, to air. Forced aeration refers to the use of blowers in compost piles.
Aeration	The process by which air is circulated through, mixed with or dissolved water for exposing bulk material, like compost.
Aerobic	A system / material where free oxygen is available so that aerobic reactions can take place.
Aerobic composting	A controlled process involving microbial decomposition of organic matter in the presence of oxygen.
Agricultural waste	Waste material generated from agricultural activity or agro industry residues, e.g., straw, husk, tree pruning etc.
Air classifier	A device used to separate materials by a combination of size, shape and density at a facility(such as a MRF). It is the column of rising air with an upward force act on the mixed material to be sorted. The mixed materials with differing physical characteristics can be separated quickly and efficiently.
Air Density Separator (ADS)	A device to separate sand, grit and other heavy particles from compost, by using floatation from a fluid bed condition. Compost is sucked up and heavy particles fall behind.
Anaerobic digestion	A controlled process involving microbial decomposition of organic matter in absence of oxygen.
Animal house	A place where animals are reared/kept for the purpose of experimenting or texting.
Aquifer	Aquifers are underground layers of rock that are saturated with water that can be brought to the surface through natural springs or by pumping.
Ash	The non-combustible, solid by-product of incineration or other combustion process.



Ash residues	The left-over material from a combustion process. They may take the form of fly ash or bottom ash.
Assembler	A person who manufactures lead acid batteries by assembling various components.
Attenuation	A process of converting and destroying a chemical compound as it passes through layers of soil or rock.
Auction	Bulk sale of used lead acid batteries or component (s) thereof by invitation of tenders or auction, contract or negotiation by individual(s), companies or Government Departments.
Auctioneer	A person(s) who auctions used lead acid batteries or components, thereof.
Authorisation	The permission given by the State Pollution Control Board or Pollution Control Committee as the case may be, to the "operator of a facility" or "urban local body", or any other agency responsible for processing and disposal of solid waste.
Authorised person	An occupier or operator authorised by the prescribed authority to generate, collect, receive, store, transport, treat, dispose or handle bio-medical waste in accordance with these rules and guidelines issued by the Central Pollution Control Board, Ministry of Environment, Forest and Climate Change, Ministry of Health and Family Welfare, Government of India.
Autoclaving	Sterilisation via a pressurised, high-temperature steam process.
Bag house	A combustion plant emission control device that consists of an array of fabric filters through which flue gases pass in an incinerator flue. Particles are trapped and thus prevented from passing into the atmosphere.
Bailing	A machine used to compress recyclables into bundles to reduce volume. Balers are often used for newspaper, plastics, and corrugated cardboard.
Battery	A battery is a device consisting of one or more electrochemical cells that convert stored chemical energy into electrical energy.



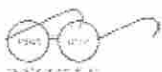
Bentonite	A type of soil that swells greatly in the presence of water. Since bentonite impedes the flow of water, it is used for liners, covers, and various other landfill applications.
Berm	An elongated pile of soil used to control and direct the flow of surface water runoff. Berms may also be used to block out noise and screen operations from public view.
Bio-degradable substances	Any organic material that can be degraded by micro-organisms into simpler stable compounds.
Biologicals	Any preparation made from organisms and micro-organisms or product of metabolism and biochemical reactions intended for the use in diagnosis, immunisation, or the treatment of human beings or animals, or in research activities pertaining thereto.
Bio-medical waste	Any waste, which is generated during the diagnosis, immunisation, treatment of human beings or animals, or in research activities pertaining thereto or in the production or testing of biologicals including the categories.
Bio-medical waste treatment and disposal facility	Any facility wherein treatment, disposal of bio-medical waste or processes incidental to such treatment and or disposal is carried out and includes common treatment facilities.
Biomethanation	A process which entails enzymatic decomposition of the organic matter by microbial action to produce methane rich biogas.
Bottle bill	A law requiring deposits on beverage containers.
Bottom ash	Bottom ash is primarily a toxic residue of incineration made from agglomerated ash particles that are too large to be carried in the flue gases and fall through open grates to an ash hopper at the bottom of the furnace.
Buffer zone	A zone of no-development which shall be maintained around landfills, processing and disposal facilities of solid waste demarcated.
Bulking agent	A material used to add volume to another material to make the second material more porous, which increases air flow. For example, municipal solid waste may act as a bulking agent when mixed with water treatment sludge.



Bulky waste	Large wastes (such as appliances, furniture, trees and branches, etc.) that cannot be handled by normal MSW processing methods.
Buy back centre	A facility to which individuals bring recyclables in exchange for payment.
Capacity building	Enabling people, organisations, and societies to develop, strengthen, and expand their abilities to meet their goals or fulfill their mandates is referred to capacity building. . It is a long-term and continuous process that focuses on developing human resources, organisational strength, technology know-how etc involving all stakeholders and is strengthened through the transfer of knowledge and skills that enhance individual and collective abilities to deliver services and carry out programs that address challenges in a sustainable way.
Cell	The basic unit by which a landfill is developed. It is the general area where incoming waste is tipped, spread, compacted, and covered.
Central Pollution Control Board	The Central Pollution Control Board constituted under sub-section (1) of Section 3 of the Water (Prevention and Control of Pollution) Act, 1974 (6 of 1974).
Cleaner production	Processes designed to reduce the wastes generated by production.
Co-disposal	The disposal of different types of waste together in one area of a landfill or dump. For instance, sewage sludge may be disposed of with regular solid wastes.
Cogeneration	Production of both electricity and steam from one facility, from the same fuel source.
Collection	Lifting and removal of municipal solid waste from collection points or any other location.
Collection centre	A centre established, independently or jointly or a registered society, or a designated agency, or a company or an association to collect e-waste.
Combustibles	Inflammable materials in the waste stream, including paper, plastics, wood, food and garden wastes.



Combustion	Combustion is a chemical process in which a substance reacts rapidly with oxygen and gives off heat. In MSWM, the combustion process is carried out in an incinerator.
Combustion Facility	Any unit and/or equipment dedicated to the thermal or oxidation treatment of municipal solid waste with or without recovery of heat generated.
Commercial waste	Waste materials originating in wholesale, retail, institutional, or service establishments, such as office buildings, stores, markets, theatres, hotels and warehouse.
Commingled	Mixed recyclables that are collected together after having been separated from mixed MSW.
Communication	An exchange or flow of information or ideas across the people through not as learners but as a target audience.
Compactor vehicle	A collection vehicle using high-power mechanical or hydraulic equipment to reduce the volume of solid waste.
Composite liner	A liner system for a landfill consisting of an engineered soil layer and a synthetic sheet of material.
Compost	The material resulting from decomposition of organic matter also called humus it act as is a soil conditioner.
Compost pad / platform	Hard impermeable surface, preferably concrete, on which composting is done.
Composting	A controlled process involving microbial decomposition of organic matter.
Construction	The process of erecting of buildings or built facility or other structure, or building of infrastructure including alteration in this entities.
Construction and demolition waste	The waste comprising of building materials debris and rubble resulting from construction, re-modelling, repair and demolition of any civil structure.
Consumer,	Any person using electrical and electronic equipment excluding the bulk consumers.
Contractors	A person or firm that undertakes a contract to provide materials or labour to perform a service or do a job for service providing authority.



Controlled dump	A planned landfill that incorporates, to some extent, some of the features of a sanitary landfill: siting with respect to hydro-geological suitability, grading, compaction in some cases, leachate control, partial gas management, regular (not usually daily) cover, access control, basic recordkeeping, and controlled scavenging.
Conveyor belt	A wide belt made of rubber, textile, nylon or more commonly composite material, which moves on wide rollers. In compost industry chain drive is popular as the belt moves in a guided manner, directed by the chain sprockets. Conveyor belts are used for material movement in different stages.
Co-processing	Co-processing is a secure form of waste management that fully recovers the energy and mineral content from waste for beneficial re-use as fuel for energy generation and product additives for manufacturing. Use of solid waste as raw material (plastics, tyres etc or as a source of energy or both to replace or supplement the natural mineral resources) and fossil fuels in industrial processes.
Cover material	Material, either natural soil or geosynthetic material, used in a landfill to impede water infiltration, landfill gas emissions, and bird and rodent congregation. It is also used to control odors and make the site more visually attractive. Landfills have three forms of cover: daily cover, intermediate cover, and final cover.
Curing	Allowing partially composted materials to reside in a pile for a specified period of time as part of the maturing process in composting.
Daily cell	In landfills, a portion of refuse that has been compacted and then surrounded with cover material. Daily cover is placed over the landfilled materials at the end of each day to complete the cell.
Daily cover material	Material, usually soil that is used in a landfill to cover the refuse after it has been compacted at the end of each day. The cover is placed mainly to ward off animals and for odor control.
Dealer	A person who sells and receives lead acid batteries or components thereof to and from the consumers or other dealers or retailers on behalf of the manufacturers, importers, assemblers and reconditioners or otherwise.



De-Construction	A planned selective demolition in which salvage, re-use and recycling of the demolished structure is maximised.
Demolition	Breaking down or tearing down buildings and other structures either manually or using mechanical force (by various equipment) or by implosion using explosives.
Designated collection centre	A collection centre established, individually or jointly by one or more manufacturers or importers, assemblers and re-conditioners in pursuance of their responsibilities under rule – 4 of these rules.
Detention basin	An excavated area of land that is used to collect surface water runoff for the purpose of creating a constant outflow from the basin.
Detinning	Recovering tin from “tin” cans by a chemical process that makes the remaining steel more easily recycled.
Dismantler	Any person, or registered society, or designated agency, or a company or an organisation engaged with dismantling the used electrical and electronic equipments into their components.
Disposal	The final and safe disposal of solid waste on as specified in schedule I to prevent contamination of ground-water, surface water, ambient air and attraction of animals and birds.
Domestic hazardous waste	Domestic hazardous wastes means waste contaminated with hazardous chemicals or infectious waste such as discarded paint drums, pesticide cans, CFL bulbs, tube lights, expired medicines, broken mercury thermometers, used batteries, used needles, gauge and syringes, etc. generated at the household level.
Drop-off centre	An area or facility for receiving compostable or recyclables that are dropped off by waste generators.
Drop-off collection	A method of collecting recyclable or compostable materials in which the materials are taken by individuals to collection sites, where they deposit the materials into designated containers.
Dry waste	Waste other than food waste and inert and includes recyclable waste, non-recyclable waste, combustible waste and sanitary waste.



Dump sites	A land utilised by urban local body for unscientific disposal of municipal solid waste without following the principles of sanitary landfilling.
E-waste	Means electrical and electronic equipment, whole or in part or rejects from their manufacturing and repair process, which are intended to be discarded as waste.
Electrical and electronic equipment	Means equipment which are dependent on electrical currents or electro-magnetic fields to be fully functional.
Electrostatic precipitator	Device for removing particulate matter from an incinerator facility's air emissions. It works by causing the particles to become electrostatically charged and then attracting them to an oppositely charged plate, where they are precipitated out of the flue gasses.
Emissions	Gases released into the atmosphere.
End use market	A company that purchases recycled materials for use as feedstock in manufacturing new products.
Energy recovery	The process of extracting useful energy from waste, typically from the heat produced by incineration or via methane gas from landfills.
Environmental Impact Assessment (EIA)	An evaluation designed to identify and predict the impact of an action or a project on the environment, human health and well-being. It can include risk assessment as a component, along with economic and land use assessment.
Environmental technologies	Means any technology approved by the Central Government from time to time.
Environmentally sound management of E-waste	Means taking all steps required to ensure that e-waste are managed in a manner which shall protect health and environment, against any adverse effects, which may result from hazardous substances contained in such wastes.
Environmentally sound management of hazardous waste	Means taking all steps required to ensure that the hazardous waste are managed in a manner which shall protect health and the environment against the adverse effects which may result from such waste.



Extended Producer Responsibility (EPR)	Means responsibility of any producer of electrical and electronic equipment, for their products beyond manufacturing until environmentally sound management of their end-of-life products.
Export	With its grammatical variations and cognatic expressions, means taking out of India to a place outside India.
Exporter	Means any person under the jurisdiction of the exporting country who exports hazardous waste including the country, which exports hazardous waste.
Facility	Any establishment wherein the solid waste management processes namely segregation, recovery, storage, collection, recycling, processing, treatment or safe disposal are carried out.
Ferrous metals	Metals derived from iron. They can be removed from commingled materials using large magnets at separation facilities.
Flaring	The burning of landfill gas/methane captured and emitted from collection pipes at a landfill.
Flood plain	A region of land around a body of water, usually a river or stream, that is flooded on a regular basis, usually annually.
Flue gas	All gasses and products of combustion that leave a furnace by way of a flue or duct.
Fluidised-bed incinerator	A type of incinerator in which the stoker grate is replaced by a bed of limestone or sand that can withstand high temperatures. The heating of the bed and the high air velocities used, causes the bed to bubble, which gives rise to the term "fluidised".
Fly ash	A highly toxic particulate matter captured from the flue gas of an incinerator by the air pollution control system.
Food stuff	Means ready to eat food products, fast foods, processed or cooked food in liquid, powder, solid or semi-solid form.
Garbage	It is the common term used for unwanted or discarded material which is not used anymore, is called refuse or garbage.



Gas control and recovery system	A series of vertical wells or horizontal trenches containing permeable materials and perforated piping. The systems are designed to collect landfill gases for treatment or for use as an energy source.
Gas monitoring probe	Probes placed in the soil surrounding a landfill above the groundwater table. The probes are used to determine if landfill gases are migrating away from the landfill.
Generation rate	The amount of waste that is produced over a given amount of time. For example, a district may have a generation rate of 100 tons per day.
Generator of waste	Persons or establishments generating municipal solid waste.
Geographic information system (GIS)	A system, usually computerised, that includes locations of all geographical characteristics of an area of land. Items may include elevation, houses, public utilities, or the location of bodies of water, aquifers, and flood plains.
Geotextile	A synthetic component that is used as a filter to prevent the passing of fine-grained material such as silt or clay. A geotextile may be placed on top of a drainage layer to prevent the layer from becoming clogged with fine material.
Goals	Specific, discrete aims that define accomplishment of the vision and mission.
Grain size distribution	A method of categorizing soils in which soil particles are separated according to size. A well-graded soil has a uniform grain size distribution while a poorly graded soil has a non-uniform grain size distribution.
Groundwater	Water beneath the earth's surface that fills underground pockets (known as aquifers), supplying wells and springs.
Groundwater monitoring well	A well placed at an appropriate location and depth for taking water samples to determine groundwater quality in the area surrounding a landfill or other site.
Hammermill	A type of crusher or shredder used to break materials up into smaller pieces.
Handling	Includes all activities relating to sorting, segregation, material recovery, collection, secondary storage, shredding, baling, crushing, loading, unloading, transportation, processing and disposal of solid waste.

Hazardous Waste (HW)	A waste that poses substantial or potential threats to public health or the environment generally exhibiting one or more of these characteristics: ignitable, oxidizing, corrosive, ecotoxic, radioactive, etc. Such wastes arising from industries are called as Industrial Hazardous Waste.
Heat value	Heat generated per unit weight or volume of combustible material completely burned.
Heavy metals	Metals of high atomic weight and density that are toxic to living organisms, such as mercury, lead, and cadmium.
HELP (hydrologic evaluation of landfill performance) model	A specialised computer program that performs the water balance equation and aids in modeling by predicting leachate generation. By selecting different covers and liners, an optimum combination can be achieved.
Household hazardous waste	Products used in residences that are toxic to living organisms and/or the environment, such as paints and some cleaning compounds.
Humus	The end product of composting which is a dark organic material forms after the decomposition of organic waste also called compost.
Hydraulic conductivity	The hydraulic conductivity of a soil is a measure of the soil's ability to transmit water when submitted to a hydraulic gradient. These properties determine the behavior of the soil fluid within the soil system under specified conditions.
Importer	A person who imports new lead acid batteries or components containing lead thereof for the purpose of sale.
Incineration	An engineered process involving burning or combustion of MSW to thermally degrade waste materials at high temperatures.
Industrial waste	Materials discarded from industrial operations or derived from manufacturing processes.
Inerts	Wastes which are not bio-degradable, recyclable or combustible and includes non recyclable fraction of construction and demolition waste, street sweeping or dust and silt removed from the surface drains.
Infiltration layer	A low hydraulic conductivity layer in a landfill, usually a component in the cover that is placed to minimise liquid infiltration to the waste layer.



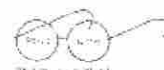
Informal sector	The part of an economy that is characterised by private, usually small-scale, labour-intensive, largely unregulated, and unregistered manufacturing or provision of services.
Inoculants	Microbial concoction or natural material containing microbes, e.g., stabilised sewage sludge, cattle manure, and commercially available proprietary material to boost composting, e.g., EM solution.
Inorganic waste	Waste composed of material other than plant or animal matter, such as sand, dust, glass, and many synthetics.
Institutional Generator	Includes occupier of the institutional buildings such as building occupied by central government departments, state government departments, public or private sector companies, hospitals, schools, colleges, universities or other places of education, organisation, academy, hotels and restaurants.
Institutional waste	Waste materials originating in schools, hospitals, prisons, research institutions, and other public buildings.
Integrated Solid Waste Management (ISWM)	ISWM refers to a strategic initiative for the sustained management of solid waste through the use of a comprehensive integrated format generated through sustained preventive and consultative approach to the complementary use of a variety of practices to handle solid waste in a safe and effective manner.
In-vessel composting	Composting in an enclosed vessel or drum with a controlled internal environment, mechanical mixing, and aeration.
Itinerant waste buyer	A person who moves around the streets buying (or bartering for) reusable and recyclable materials.
Kerbside collection	Collection of compostable, recyclables, or trash at the edge of a sidewalk in front of a residence or a shop.
Key Performance Indicators (KPIs)	Parameters that provide a meaningful, concise, overall picture of an organisation's performance or that of the project/programme, used to report progress that is chosen to reflect the critical success factors of a program or plan. The KPI's reflect long-term considerations.
Landfill gases	Gases arising from the decomposition of organic wastes; principally methane, carbon dioxide, and hydrogen sulphide. Such gases may cause explosions at landfills.



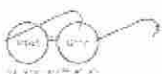
Landfill mining	A process of removing reusable resources from old landfills for recycling.
Landfilling	The disposal of residual municipal solid waste on land in a facility designed with protective measures against pollution of ground water, surface water and air fugitive dust, wind-blown litter, bad odour, fire hazard, bird menace, pests or rodents, greenhouse gas emissions, slope instability and erosion.
Leachate	The liquid that seeps through solid waste or other medium and has extracts of dissolved or suspended material from it.
Leachate collection system	Network of pipes or geotextiles/geonets placed at low areas of the landfill liner to collect leachate from a landfill for storage and treatment. Flow of leachate along the liner is facilitated by the use of a soil drainage blanket or geonet.
Leachate pond	A pond or tank constructed at a landfill to receive the leachate from the area. Usually the pond is designed to provide some treatment of the leachate, by allowing settlement of solids or by aeration to promote biological processes.
Liner	a protective layer, made of soil and/or synthetic materials, installed along the bottom and sides of a landfill to prevent or reduce the flow of leachate into the environment.
Magnetic band	Magnets fixed on a moving belt or band which moves close to a surface (e.g., a belt conveyor) and continuously picks up ferrous material and sheds them systematically into a hopper or another conveyor belt.
Magnetic separation	A system to remove ferrous metals from other materials in a mixed municipal waste stream. Magnets are used to collect the ferrous metals.
Manufacturer	In relation to any factory manufacturing lead acid batteries or components thereof means a person or Chief Executive Officer (CEO) of the company who has control over the affairs of the factory or the premises for sale and collection of lead acid batteries or components thereof.
Market waste	Primarily organic waste, such as leaves, skins, and unsold food, discarded at or near food markets.



Mass burn incinerator	A type of incinerator in which solid waste is burned without prior sorting or processing.
Material recovery facility (MRF)	A facility where non-combustible solid waste can be temporarily stored by the urban local body or any person authorised by the urban local body to facilitate segregation, sorting and recovery of various components of waste by informal sector of waste pickers or any other work force engaged for the purpose before the waste is delivered or taken up for its processing or disposal.
Mechanical separation	A system to remove ferrous metals from other materials in a mixed municipal waste stream. Magnets are used to collect ferrous metals.
Methane	An odourless, colourless, flammable, explosive gas, CH ₄ , produced by anaerobically decomposing MSW at landfills.
Moisture content	The fraction or percentage of a substance or soil that is water.
Municipal Authority	The Municipal Corporation, Nagar Nigam, Municipal council, Nagar Palika Nagar palika Parishad, Nagar Panchyat, Town panchayat, notified industrial township, notified area committee (NAC) and any other peri urban area declared as census town or urban centre during publication of 2011 census of India or any other urban local body constituted under the Acts for time being in force and, where the management and handling of municipal solid waste is entrusted to such agency.
Municipal Solid Waste (MSW)	Includes the domestic waste, commercial waste, institutional waste, market waste and other non residential wastes, street sweepings, silt removed/collected from the surface drains, horticulture waste, construction and demolition (C&D) waste and treated bio-medical waste excluding industrial hazardous waste, and e-waste generated in any municipal authority area in either solid or semi-solid form.
Municipal Solid Waste Management (MSWM)	Planning, implementation and enforcement of reduction, re-use, recovery and recycling of municipal solid waste in a scientific and hygienic manner, the storage of segregated municipal solid waste at source, primary collection from the source of waste generation, street sweeping, removal of silt from the surface drains, storage and collection of C&D waste, dairy waste, horticulture waste, secondary storage, transportation, processing and safe disposal of municipal solid waste.



Mulch	Ground up or mixed yard trimmings placed around plants to prevent evaporation of moisture and freezing of roots and to nourish the soil.
Municipal (project) revenue bond	A method of financing in which bonds are given on the basis of the worthiness, technological feasibility, and projected revenue of a project.
Non-biodegradable Waste	Any waste that cannot be degraded by micro organisms into simpler stable compounds.
Occupier	A person having the administrative control over the institution and the premises generating bio-medical waste which includes a hospital, nursing home, clinic, dispensary, veterinary institution, animal house, pathological laboratory, blood bank, health care facility, and clinical establishments by whatever name it may be called.
Operator of a common bio-medical waste treatment facility	A person who owns, or controls or operates, for the collection, reception, transport, storage, treatment, disposal or any other form of handling bio-medical wastes.
Operator of facility	A person or entity, who owns or operates a facility for handling solid waste which includes the urban local body and any other entity or agency appointed by the urban local body.
Organic compost	Compost made from raw materials, which may include materials of biological origin (plant, animal) such as food waste, horticultural waste, fruit / vegetable / meat / fish market waste, chemically unprocessed minerals etc. (such as, rock phosphate).
Organic material (Organic waste)	Composed of organic components containing carbon and other chemical compounds. The organic fraction of MSW includes paper, wood, food scraps, plastics, and yard trimmings.
Original equipment manufacturer	Manufacturer of equipment or product using lead acid batteries as a component.
Orphaned products	Non branded or assembled electrical and electronic equipment as specified in the Schedule I, or those products by a company, which has closed its operations or has stopped product support.



Particulate matter (pm)	Tiny pieces of matter resulting from the combustion process. PM can have harmful health effects when breathed. Pollution control at combustion facilities is designed to limit particulate emissions.
Passive venting	A venting technique using the natural pressure created in landfills to expel gases and control gas migration.
Pathogens	Disease-causing agents, especially microorganisms such as bacteria, viruses, and fungi.
Pelletisation	A process whereby small cubes or cylindrical pieces are made out of segregated combustible solid wastes.
Percolate	To filter gradually through a porous or a permeable substance. Groundwater may percolate into the bottom of an unlined landfill.
Permeability	A measure of how well a liquid moves through the pores of a solid. Expressed as a number applied to landfills in terms of how quickly water moves through soil; it is typically expressed as centimeters per second.
Permeable	Having pores or openings that permit liquids or gasses to pass through.
Phase diagram	A diagram (or a series of diagrams) used to show chronological order in a project. The diagram should show key transition points and contain enough detail to move smoothly from phase to phase.
Phasing	A system of running a project in more than one step (phase). Each phase is generally independent of the others, which offers more flexibility in management and operation.
Plastic	Material which contains as an essential ingredient a high polymer and which at some stage of its processing into its finished products can be shaped by flow.
Plastic waste	Any plastic product such as carry bags, pouches or multi-layered packages which have been discarded after use or after their intended life is over.
Platform	A type of transfer station that has a waste storage capacity of several days or more. While the waste is in temporary storage, recyclable materials may be removed.



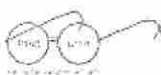
Post-closure care	A procedure of maintaining the environmental controls and appearance of a landfill after it has ceased to accept waste.
Post-consumer recycling	The reuse of materials generated from residential and commercial waste, excluding recycling of material from industrial processes that has not reached the consumer, such as glass broken in the manufacturing process.
Precycling	The decision-making process consumers use to judge a purchase based on its waste implications. Criteria include whether a product is reusable, durable, and repairable; made from renewable or non-renewable resources; over-packaged; or in a reusable container.
Prescribed Authority	The Authority declared as State Pollution Control Board or Pollution Control Committee for Union Territory under rule 4 and made responsible to perform the duties and undertake responsibilities as specified in rule 5.
Primary collection	Collecting, lifting and removal of segregated solid waste from source of its generation including households, shops, offices and any other non-residential premises or from any collection points or any other location specified by the urban local body.
Primary leachate	When waste enters a landfill, it contains some amount of liquid, which leaches out of the refuse as primary leachate.
Processing	The process by which municipal solid waste is transformed into new or recycled products.
Producer	Means any person who, irrespective of the selling technique used, 1. Manufacturers and offers to sell electrical and electronic equipment under his own brand; or 2. Offers to sell under his own brand, assembled electrical and electronic equipment produced by other manufacturers or suppliers; or 3. Offers to sell imported electrical and electronic equipment.
Reconditioner	A person involved in repairing of lead acid batteries for selling the same in the market.
Recycler	An occupier who processes used lead acid batteries or components thereof for recovering lead.
Recycling	The process of transforming segregated solid waste into a new product or a raw material for producing new products.



Redevelopment	Rebuilding of old residential or commercial buildings at the same site, where the existing buildings and other infrastructures have become dilapidated.
Refractory	A material that can withstand dramatic heat variations. Used in conventional combustion chambers in incinerators.
Refuse Derived Fuel (RDF)	Segregated combustible fraction of solid waste other than chlorinated plastics in the form of pellets or fluff produced by drying, shredding, dehydrating and compacting combustible components of solid waste that can be used as fuel.
Registered recycler	A recycler registered with the Ministry of Environment and Forests or an agency designated by it for reprocessing used lead acid batteries or components thereof.
Registration	The process of authentication of the facility run by an operator (NGO, CBO, private company), which would ensure standard operating procedure and produce material in compliance with applicable quality standards. This would be done in a time bound manner – initially for one year, to be renewed on yearly basis subject to appropriate inspection of the premises and sampling of the compost produced for quality check. Valid registration would be a pre-condition for consideration of any assistance from the Government or the Local Body.
Residual waste	Includes the waste and rejects from the solid waste processing facilities which are not suitable for recycling or further processing.
Resource recovery	A term describing the extraction and use of materials and energy from the waste stream. The term is sometimes used synonymously with energy recovery.
Reuse	The use of a product more than once in its same form for the same purpose; e.g., a soft drink bottle is reused when it is returned to the bottling company for refilling.
Rotary screen	A round screen which moves either on its axis or preferably moved from outside, so that the material inside goes through 'cascading' action. The feeding side is kept slightly higher than the discharge side.



Sanitary landfill	The final and safe disposal of residual solid waste and inert wastes on land in a facility designed with protective measures against pollution of ground water, surface water and fugitive air dust, wind-blown litter, bad odour, fire hazard, animal menace, bird menace, pests or rodents, greenhouse gas emissions, persistent organic pollutants slope instability and erosion.
Sanitary waste	Wastes comprising of used diapers, sanitary towels or napkins, tampons, condoms, incontinence sheets and any other similar waste.
Scavenging	At a landfill or material recovery facility, scavenging is the uncontrolled separation of recyclable and reusable materials. Uncontrolled means that the operator does not monitor the removal of materials, and in many cases prohibits it. Material scavenging of recyclables may also occur at the curb or at drop-off centres.
Scrap	Discarded or rejected industrial waste material often suitable for recycling.
Scrubber	Common anti-pollution device that uses a liquid or slurry spray to remove acid gases and particulates from municipal waste combustion facility flue gases.
Secondary collection	Collection of solid waste deposited at secondary waste storage depots or bins for onward transportation of the waste to the processing or disposal facility.
Secondary material	A material that is used in place of a primary or raw material in manufacturing a product.
Secondary storage	The temporary containment of solid waste at a public place in a covered bin or containers in a manner so as to prevent littering, vectors, stray animals and foul odour.
Segregation	Sorting and separate storage of various components of solid waste namely biodegradable wastes or wet waste, non biodegradable wastes or dry waste including recyclable waste, combustible waste sanitary waste and non recyclable inert waste, domestic hazardous wastes, E-waste and construction and demolition wastes.
Service Provider	An authority providing public utility services like water, sewerage, electricity, telephone, roads, drainage etc.



Settlement	As refuse decomposes and/or becomes compacted by the weight of overlaying layers, landfills experience a volume decrease and compaction of individual layers of waste in the landfill. Settlement refers to this volume decrease and compaction of layers.
Shredder	A mechanical device used to break waste materials into smaller pieces by tearing and impact action. Shredding solid waste is done to minimise its volume or make it more readily combustible.
Sludge	A semi-liquid residue remaining from the treatment of municipal and industrial water and wastewater.
Sorting	Separation of recyclables into various categories such as paper, plastic, metal, glass, etc including further separation of such material into varying grades as may be appropriate to facilitate cost effective recycling;
Source reduction	The design, manufacture, acquisition, and reuse of materials so as to minimise the quantity and/or toxicity of waste produced. Source reduction prevents waste either by redesigning products or by otherwise changing societal patterns of consumption, use, and waste generation. (See also, "waste reduction").
Source separation	The segregation of specific materials at the point of generation for separate collection. Residential generators source separate recyclables as part of curbside recycling programs.
Special waste	Refers to items that require special or separate handling, such as household hazardous wastes, bulky wastes, tires, and used oil.
Stabilizing	The biological decomposition of biodegradable wastes to a stable state where it generates no leachate or offensive odours and is fit for application to farm land ,soil erosion control and soil remediation.
Stacking	Arranging raw material in piles or heaps.
State Pollution Control Board or Pollution Control Committee	The State Pollution Control Board or the Pollution Control Committee, as the case may be, constituted under sub-section (1) of section 4 of the Water (Prevention and Control of Pollution) Act, 1974.



Static pile	A composting pile which is not turned for aeration. Instead, air is passed through the windrows by using perforated pipes and air blowers.
Storage	The temporary containment of municipal solid waste in a manner so as to prevent littering, attraction to vectors, stray animals and excessive foul odour.
Street Vendor	A person engaged in vending of articles, goods, wares, food items or merchandise of everyday use or offering services to the general public, in a street, lane, side walk, footpath, pavement, public park or any other public place or private area, from a temporary built up structure or by moving from place to place and includes hawker, peddler, squatter and all other synonymous terms which may be local or region specific; and the words "street vending" with their grammatical variations and cognate expressions, shall be construed accordingly.
Thermophilic microorganisms	Heat-loving microorganisms that thrive in and generate temperatures above 105 degrees Fahrenheit.
Tipping fee	A fee or support price determined by the urban local body or any state agency authorised by the state government to be paid to the concessionaire or operator for handling one or more components of solid waste.
Tipping floor/pit	Unloading area for vehicles that are delivering municipal solid waste to a transfer station or municipal waste combustion facility.
Transfer station	A permanent facility where waste materials are taken from smaller collection vehicles and placed in larger vehicles for transport, including truck trailers, railroad cars, or barges. Recycling and some processing may also take place at transfer stations.
Transportation	Conveyance of solid waste, either treated, partly treated or untreated from a location to another location in an environmentally sound manner through specially designed and covered transport system so as to prevent the foul odour, littering and unsightly conditions.
Treated Bio medical wastes	The wastes generated in hospitals and health care institutions which have been prescribed as treated in accordance with the Bio-medical Waste (Management and Handling) Rule 1998, as amended from time to time.



Treatment	The method, technique or process, designed to modify physical, chemical or biological characteristics or composition of any waste so as to reduce its potential to cause harm.
Trommel	An improved version of rotary screen, which is driven from outside, preferably using hydraulic power packs to keep the movement smooth, especially while starting after a power cut. The screen is covered from outside to control dust.
Turning	The material in a pile or windrow is moved in a manner that the material in the core area comes out on the surface so that the whole windrow gets exposed to air by turn.
Used batteries	Used, damaged and old lead acid batteries or components thereof.
Urban Local Body	The purpose of these rules means and includes the municipal corporation, nagar nigam, municipal council, nagar palika, nagar palika parishad, municipal board, nagar panchayat, town panchayat, notified area committee or any other local body constituted under the relevant statutes where management of solid waste is entrusted to such agency including the body in notified industrial township, notified area, villages declared outgrowth in urban agglomeration by the Registrar General and Census Commissioner of India from time to time.
User fee	A fee imposed through a bye-law by the urban local body on the waste generator.
Vector	An organism or insect which often carries diseases or parasites from one animal or plant to another, e.g., fly, mosquito etc.
Vermicast/ vermicompost	The excrement from earthworms, which is also called vermicompost.
Vermicomposting	A process of conversion of bio-degradable waste into compost using earthworms.
Viability Gap Funding	Financial support determined by the urban local body or authorised State Government or Central Government agency to be paid to the concessionaire or operator of a solid waste processing facility based on the output quantity of compost, biogas produced or energy or power generated so as to cover or partly cover the difference between market price of the output and its production cost plus reasonable profit margin



Vibro-screen	A screening arrangement, in which flat screens vibrate in a horizontal plane; less expensive than trommel but less efficient.
Virgin plastic	Plastic material which has not been subjected to use earlier and has also not been blended with scrap or waste.
Waste generators	Includes every person or group of persons or residential and commercial establishments including Indian Railways and Defense cantonments which generate solid waste.
Waste pickers	A person or groups of persons engaged in collection of reusable and recyclable solid waste from the source of waste generation as well as picking up of wastes from the streets, bins, processing and waste disposal facilities for sale to recyclers directly or through intermediaries to earn their livelihood.
Waste reduction	Waste reduction is a broad term encompassing all waste management methods—source reduction, recycling, composting—that result in reduction of waste going to a combustion facility or landfill.
Waste stream	A term describing the total flow of solid waste from homes, businesses, institutions and manufacturing plants that must be recycled, burned, or disposed of in landfills; or any segment thereof, such as the “residential waste stream” or the “recyclable waste stream.”
Waste-to-Energy system (WTE)	A method of converting MSW into a usable form of energy, usually through combustion.
Water balance	An equation that is used to model and predict the amounts of water that will go to various destinations. Typical destinations include evaporation, infiltration, and run-off. The sum of the amounts to the destinations must be equal to the source of the water (usually precipitation).
Water table	The level below the earth’s surface at which the ground becomes saturated with water. Landfills and composting facilities are designed with respect to the water table in order to minimise potential contamination.
Wet scrubber	Anti-pollution device in which a lime slurry (dry lime mixed with water) is injected into the flue gas stream to remove acid gases and particulates.



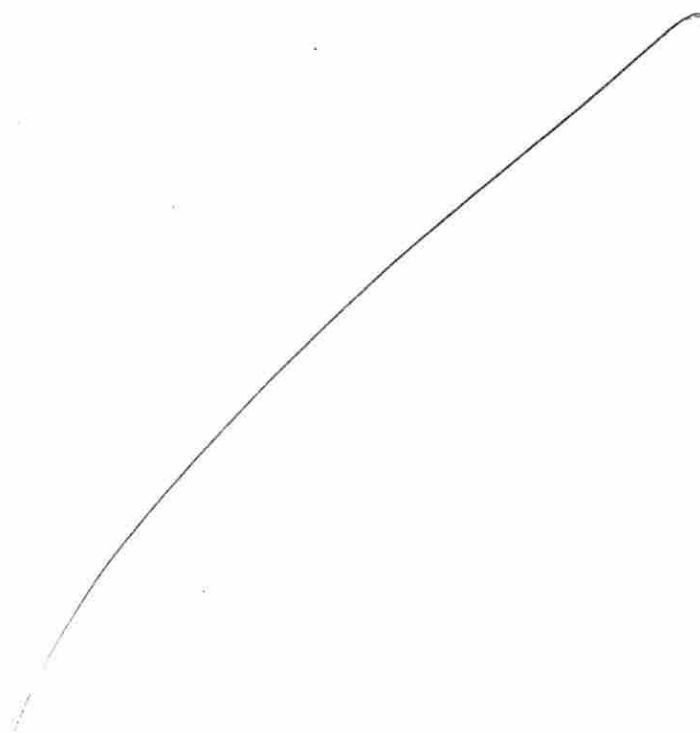
Wet/dry collection
systems

A collection system that allows wet organic materials to be separated by generators from dry wastes. Wet organic materials are suitable for composting, while dry materials are non-organics that may include recyclables.

Windrow

Long trapezoidal heaps or piles. Long composting heaps are referred to as 'windrow'. The base is wider and the top is narrower.

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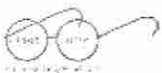


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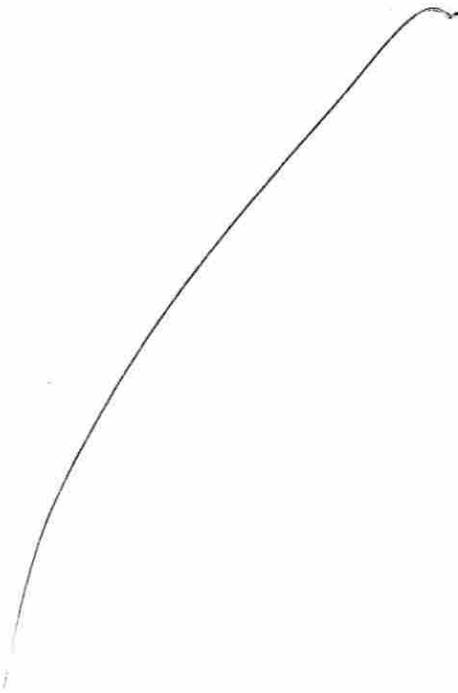
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GOVERNMENT OF INDIA



एक कदम स्वच्छता की ओर

CLEANLINESS PLEDGE

Mahatma Gandhi dreamt of an India which was not only free but also clean and developed. Mahatma Gandhi secured freedom for Mother India.

Now it is our duty to serve Mother India by keeping the country neat and clean.

I take this pledge that I will remain committed towards cleanliness and devote time for this.

I will devote 100 hours per year, that is two hours per week, to voluntarily work for cleanliness. I will neither litter nor let others litter.

I will initiate the quest for cleanliness with myself, my family, my locality, my village and my work place.

I believe that the countries of the world that appear clean are so because their citizens don't indulge in littering nor do they allow it to happen. With this firm belief, I will propagate the message of Swachh Bharat Mission in villages and towns.

I will encourage 100 other persons to take this pledge which I am taking today.

I will endeavour to make them devote their 100 hours for cleanliness.

I am confident that every step I take towards cleanliness will help in making my country clean.

Do's

- Start cleanliness from home
- Keep surroundings clean and green
- Keep work place neat and clean
- Devote 2 hours a week on sanitation
- Dispose garbage in designated places.

Don'ts

- Don't litter and don't let others litter
- Don't defecate and urinate in open
- Don't deface public properties
- Don't spit in public places
- Don't dump garbage in drains/water bodies

Eligible Components Under Swachh Bharat Mission in Urban Local Bodies

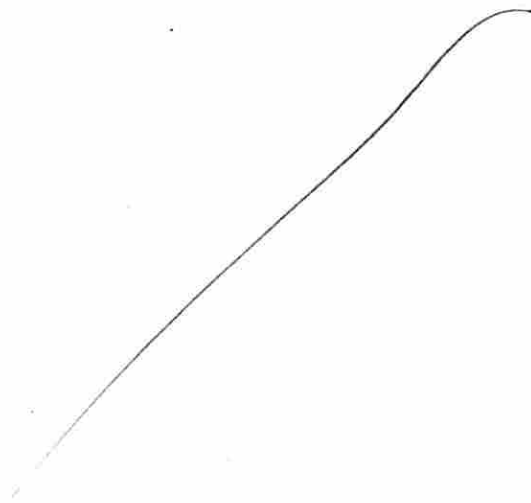
Individual Household Toilets | Community Toilets | Public Toilets | Solid Waste Management

MINISTRY OF URBAN DEVELOPMENT

Nirman Bhawan, New Delhi 110 011, India

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www.swachhbharaturban.gov.in



UTTAR PRADESH POLLUTION CONTROL BOARD

Letter No.-G-33305 SH-5/MSW-1/2020

Date:-27/07/2020

To,
Municipal Commissioner
Lucknow

That the solid waste processing plant established at Grag-Shiari in District-Sakhnau which is operated by M/s Eco Green Eni Padvet Limited, Shiari. In the inspection of the waste processing plant carried out earlier on 23.11.2019 by the authorized officers of Regional Office, Secunderabad Pollution Control Board, Lucknow, the waste processing operations in the solid waste processing plant were found to be closed and all the trams machines, compost plant and leathate treatment plant installed in the plant were found to be completely closed and due to accumulation of uncontrolled unsegregated solid waste of about 9 meter, 9.5 meter and 80 meter high on the compost pad, truggle machine/leathate treatment plant and open land around the compost plant, a large amount of leathate was found flowing out of the plant premises and ultimately collected in the low-sand area. Therefore, vide Board's letter no. M 25702/Chi-5/MSW-

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1/10 dated 30.12.2019, environmental compensation of Rs. 14,40,71000/- (Twenty crore rupees seventy one thousand) was awarded. A show cause notice was issued for imposing fine (Rupees only), in respect of which, as per the report of Regional Officer, Lucknow, no reply has been sent by the unit till date.

That further the unit was again inspected by the authorized officers of the regional office on 14.07.2020. As per the inspection report, during the inspection it was found that apart from inert material, a huge quantity of municipal solid waste, colored polythene bags and carcasses of about 7-8 dead animals were found stored in the concrete sandoffice area constructed for storing inert material in the unit. Limestone was found accumulated in the sandfill area. The main line network for disposal and treatment of the limestone was found closed.

That at the time of inspection, the housekeeping of the unit premises was found to be unsatisfactory. More than 2.50 lakh metric tonnes of untreated solid waste was found stored in the unit premises, which is stored in the shape of a mound in the premises. The points mentioned in the show cause notice dated 30.12.2019 issued by the State Board against the unit are not being complied with till now. By letter no. 115/Co-2245 A/20 dated 23.07.2020 of the Regional Office, Lucknow, it has been recommended to confirm the show cause notice dated 30.12.2019 issued for imposing environmental compensation.

In view of the above facts, after the approval of the Inspection Officer, the following instructions/orders are issued by the Municipal Corporation, Lucknow.

1. That a claim of Rs. 14,40,71,000/- (Rupees One Hundred Crore Pill Lakh Seventy One Thousand only) has been imposed against Nagar Nigam, Lucknow for a period of 107 days from 03.09.2019 to 18.12.2019.

In connection with the above, please ensure that environmental compensation of Rs. 14,40,71,000/- (fourteen crore forty lakh seventy one) is deposited in favour of YARD Headquarters, Uttar Pradesh, Lucknow within 01 month of receipt of this letter, otherwise, like land revenue, the process of recovery of environmental compensation will be started, for which the entire responsibility will be of Nagar Nigam, Lucknow and its responsible officers. This is for issuance of letter by the competent authority

Chief Environment Officer, Circle-5

Copy to: For information and necessary action.

1. Secretary, Urban Development Department, Government of Uttar Pradesh, Lucknow.

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2. \Private Secretary to the Chairman, Uttar Pradesh Pollution Control Board, Lucknow.
3. Submitted to the Member Secretary, Uttar Pradesh Pollution Control Board for information.
4. Sent to the District Magistrate, Lucknow for information.
5. Regional Officer, Uttar Pradesh Pollution Control Board, Lucknow with the direction to ensure receipt of this letter and deposit environmental compensation of Rs. 14,40,71000/- (Rupees Fourteen Crore Forty Lakh Seventy One Thousand only) in favour of the Board from Municipal Corporation, Lucknow within 01 month.

Chief Environment Officer, Circle-5

Municipal Commissioner Municipal Corporation Lucknow	To, Chief Environment Officer, Circle-5. Uttar Pradesh Pollution Control Board, TC-12th Vibhuti Block, Gomti Nagar Lucknow-226010
Letter No.: D/45/NA/PA/20	Date :- 06, August , 2020

Subject:- Regarding imposition of environmental compensation in view of non-operation of the solid waste processing plant of 1200 tonnes/day capacity authorized by the Municipal Corporation.

Sir,

Please take the trouble of referring to the letter number 30.12.2019 and letter number H-45702/C-5/MSW-1/19 dated G-33304/C-5/MSW-1/2020 dated 27.07.2020 of the office of Uttar Pradesh Pollution Control Board, Lucknow on the above subject. Through the Board's letter dated 30.12.2019, a notice was issued regarding imposition of environmental compensation of Rs. 14,40,71,000.00 for not operating the Shivri plant as per the standards, which has been confirmed by the letter dated 27.07.2020. In continuation of the above, it is to be informed that the Lucknow Municipal Corporation has selected M/s Ecogreen Energy Lucknow Pvt. Ltd. as the concessionaire for the Solid Waste Management Project, including the collection, transportation, processing, and disposal of household waste. All plant operations and maintenance work is being

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carried out by M/s Ecogreen Energy Lucknow Pvt. Ltd. The Uttar Pradesh Pollution Control Board has also issued a No Objection Certificate (NOC) to the firm for the plant's operation. From time to time, the Uttar Pradesh Pollution Control Board has issued direct instructions to the firm regarding the work, and the firm has submitted compliance reports directly to the Uttar Pradesh Pollution Control Board. This issue was also discussed in the Oversight Committee's video conference on 31.07.2020.

Therefore, it is requested that you kindly take action to get the environmental compensation imposed through the letter deposited directly from M/s Ecogreen Energy Lucknow Pvt. Ltd.

Yours truly

(Dr. Indramani Tripathi)

Municipal Commissioner

1. Secretary, Urban Development Department, Government of Uttar Pradesh, Lucknow.
2. District Magistrate Sir, Lucknow.
3. Member Secretary, U.P. Pollution Control Board, Lucknow.\
4. Regional Officer, Uttar Pradesh Pollution Control Board, Lucknow.
5. M/s Ecogreen Energy Lucknow Pvt. Ltd. with the direction that the Uttar Pradesh Pollution Control
6. Environmental compensation of Rs. 14,40,71,00,000 imposed by the Board, Lucknow in favour of the Board Make sure the deposit is made.

(Dr. Indramani Tripathi)

Municipal Commissioner

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UTTAR PRADESH POLLUTION CONTROL BOARD**Letter No. 55733 / C-5/MSW-1/2020****Date 20-11-2020**

To,

M/s Eco Green Energy Pvt. Ltd.,

Village-Shivri, Mohan Road,

Lucknow.

That the solid waste processing plant established in village Shivri of Lucknow district, which is operated by M/s Eco Green Energy Pvt Ltd, Shivri, Lucknow, was inspected by the authorized officers of Regional Office, Lucknow on 28.10.2020.

That under Solid Waste Management, a tripartite concessionaire agreement dated 21.03.2017 was executed through Municipal Corporation, Lucknow and M/s Eco Green Energy Private Pvt. Ltd. and Construction and Design Services (Unit of UP Jal Nigam) to ensure proper segregation, collection, storage, transportation, processing and disposal of solid waste generated in Lucknow city.

That at the time of inspection, all the waste processing units in the solid waste processing plant such as trammel, compost plant, leachate treatment plant were found completely closed and the plant was not operating due to power supply being disconnected. At the time of

inspection, unsegregated municipal solid waste was found stored all around the plant premises and municipal solid waste was also stored on the secure land field site, due to which the entry and exit routes to the plant were also blocked and leachate was collected at various places near the solid waste. The representative present informed that about 7.5 lakh metric tonnes of solid waste is stored in the plant.

It is stated that during the inspection, a sample of leachate collected within the plant premises was collected and submitted to the State Board's central laboratory for analysis. The analysis report showed the concentrations of effluents as pH 8.6, BOD 1030.0 mg/L, COD 7976.0 mg/L, suspended solids 680.0 mg/L, total coliform 220 million MPN/100 ml, and fecal coliform 26 million MPN/100 ml, which are above the prescribed standards. According to the inspection report, the representative present informed that the leachate is being discharged into the Narwa drain, which ultimately joins the Sai River near village Bhadohi.

That further, by the Board's letter no. G 33304/C-5/MMW-1/2020 dated 27.07.2020, environmental compensation of Rs. 14,40,71000/- (Rupees Fourteen Crore Forty Lakh Seventy One Thousand only) has been imposed against the waste processing plant for violation of total 107 days from 03.09.2019 to 18.12.2019. No representation or compensation has been submitted by the unit regarding compensation. By letter no. 635/Co-

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2240/20 dated 23.07.2020 of Regional Office, Lucknow, show cause notice and prosecution action has been recommended for imposition of environmental compensation.

Hence, in view of the above mentioned circumstances, in the interest of public health, to provide clean environment to the general public, under the powers conferred on the State Board under Section 5 of the Environment (Protection) Act, 1986 as amended and in the context of the above mentioned facts, after the approval of the competent authority, the following show cause notice is issued for imposing environmental compensation on M/s Eco Green Energy Private Limited, Shivri, Lucknow.

1. That as per the guidelines dated 08.02.2019 for assessment of environmental compensation prescribed by Central Pollution Control Board, environmental compensation of Rs. 25.3271 (Rupees Twenty Five Crore Thirty Two Lakh, Seventy Seven Thousand only) should not be imposed against M/s Eco Green Energy Private Limited, Shivri, Lucknow, a solid waste processing plant established in Lucknow district, for total default of 302 days from 01.01.2020 to 28.10.2020.
2. Why should prosecution proceedings not be initiated against the unit and its responsible persons under Sections 15 and 16 of the Environment (Protection) Act, 1986 as amended?

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In relation to the above, send a complete explanation to the Board Headquarters within 15 days of receiving this letter, otherwise further action will be taken as per the rules and by confirming the above mentioned show cause notice, for which the industry itself and the owner of the industry will be fully responsible.

Yours sincerely,

(Ashish Tiwari) Member Secretary

Copy to: For information and necessary action.

1. Secretary, Urban Development Department, Government of Uttar Pradesh, Lucknow.
2. Private Secretary to the Chairman, Uttar Pradesh Pollution Control Board, Lucknow.
3. Sent to the Municipal Commissioner, Municipal Corporation, Lucknow with the intention to ensure that the environmental compensation of Rs. 14,40,71000/- (Rupees Fourteen Crore Forty Lakh Seventy One Thousand only) imposed earlier by the Board's letter No. G 33304/C-5/MMW-1/2020 dated 27.07.2020 is recovered from the unit and deposited in the Board.
4. Forwarded to the District Magistrate, Lucknow for information.

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5. Sent to the Regional Officer, Uttar Pradesh Pollution Control Board, Lucknow with the intention that he should ensure that a copy of the show cause notice issued to the organization is obtained from his level also and the inspection report with clear recommendations is sent to the Board Headquarters within 15 days.

Yours sincerely,

(Ashish Tiwari) Member Secretary

From, Environmental engineer, Municipal Corporation, Lucknow	To Mr. Sanjay Sharma, (CEC) (India Group) Mr. Rajesh Kurup, Lucknow Operational Head Mr. Parud Choudhary. HR Head (Gurgaon & Lucknow) Mr. PSN Reddy, COO of Company & Lucknow Head Mr. Abhimanyu Chauhan, Accounts Manager Lko. Mr. Kailash Chauhan, Plant Manager Lucknow Chief Executive Officer, M/S Ecogreen Energy Lucknow Pvt. Ltd.
Letter No.: D/372/N.A./PA/22	Date :- 26, March , 2022

Subject:- Regarding recovery of environmental compensation imposed on M/s Ecogreen Energy Lucknow Pvt. Ltd. under the Solid Waste Management works within the limits of Lucknow Municipal Corporation.

Sir,

Please take the trouble of taking reference of letter no. ECO/LLKO/21-22/268 dated 14.06.2022 ECOLKO 21-22-276 dated 21.05.2022 and ECOTKO/21-22/277 dated 23.05.2022 sent by M/s Ecogreen Energy Lucknow Pvt. Ltd. through which the benefit of revised tipping fee, processing plant related works, garbage collection and transportation related works and No. 33.37.46,60063/ has been given by the

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organization including the dues of last month March and April 2022.

Details are as follows: Demand has been submitted

S.No.	Description	Amount
1.	To provide the benefit of revised tipping fees from April 19-20	12,38,13504
2.	for plant related work	3,00,00,000
3.	For processing of 4,12,107,00 metric tonnes of garbage by the processing plant.	732.66.057 63
4.	For payment of bill for the month of April 2022	10,00,43,327
5.	For payment of bill due on 02nd day of March	66,23,712
	Amount in the order of demand by the institution (1+2+3+4+5)	33,37,46,600.63

Regarding blood, it is to be informed that a contract was signed with 20 Ecogreen Energy Pvt. Ltd. (currently M/s Ecogreen Energy Lucknow Pvt. Ltd.) on March 21, 2017, for the implementation of the Solid Waste Management Project in Lucknow City. M/s Ecogreen Energy Lucknow Pvt. Ltd. has been carrying out work under Solid Waste Management in the city for the past five years. On 23.11.2019, during the inspection of the plant located at Shivri by the authorized officials of the Regional Office, Uttar Pradesh Pollution Control Board, Lucknow, the waste processing operations and the Ratbhi plant were found to be closed, and uncontrolled unsegregated solid waste was collected in the form of high mounds, the collected water mixed leachate was found to be not as per the prescribed

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standards after analysis, and the HDPE sheet from the side slope of the landfill site was found to be in a damaged condition. Taking cognizance of the deficiencies found by the Regional Office, environmental compensation of Rs. 14,40,71,000/- was imposed for a total period of 107 days from 03.09.2019 to 18.12.2019, which has not been deposited by the organization till now. In such a situation, due to non-deposit of the imposed environmental compensation, it is not possible to make payment to the organization in response to the demand of the said payment by M/s Ecogreen organization.

Therefore, in view of the environmental compensation of Rs. 14,40,71,000 imposed by the Uttar Pradesh Pollution Control Board not being deposited by M/s Ecopin, the payment is withheld as per the demand submitted by M/s Ecogreen Energy Lucknow Pvt. Ltd. The payment of future dues will be considered only after M/s Ecogreen deposits the above-imposed compensation with the concerned department.

Yours truly
Environmental engineer

Copy

Municipal Commissioner.

Additional Municipal Commissioner for information.

Yours truly
Environmental engineer

Municipal Commissioner Municipal Corporation Lucknow	To, Chief Executive Officer, Marara Ecogreen Energy Lucknow Pvt. Ltd.
Letter No.: D/976/N.A/P.A/22	Date :- 18, March , 2023

Subject: Regarding deposit of environmental compensation imposed against the solid waste processing plant operated by M/s Ecogreen Energy Lucknow Pvt. Ltd.

Sir,

Please refer to the letter no. H45702/C-5/MSW-1/19 dated 30.12.2019 of Uttar Pradesh Pollution Control Board, by which, in the course of inspection conducted on 01.12.2019 by the authorized officers of the regional office, a show cause notice was issued against Nagar Nigam Lucknow for imposing environmental compensation of Rs. 1440.71 lakh for violations for a total of 107 days from 03.09.2019 to 18.12.2019. In continuation of the above, again by letter no. G33304/C-5/MSW-1/2020 dated 27.07.2020, confirming the earlier issued show cause notice, orders were issued for depositing environmental compensation of Rs. 1440.71 lakh. In this regard, the environmental compensation imposed by the

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Uttar Pradesh Pollution Control Board has not yet been deposited by the Ecogreen organization.

In connection with the above, it is to inform you that, as per the contract dated March 21, 2017, M/s Ecogreen Energy Lucknow Pvt. Ltd. was contracted to undertake the comprehensive work of door-to-door collection, transportation, processing, and disposal of garbage within the Municipal Corporation area under the Lucknow City Solid Waste Project. According to the contract, your firm, M/s Ecogreen Energy Lucknow Pvt. Ltd., was to process the daily collected garbage. However, due to Ecogreen not disposing of the unprocessed waste collected at the processing plant in Shivri, the Pollution Control Board has imposed the above environmental compensation based on the amount of garbage collected at the plant, for which your organization is fully responsible. Furthermore, you have not renewed the Consent to Operate at the Shivri plant for several years, which is a violation of environmental rules and orders.

Therefore, in continuation of the above, please immediately deposit the amount of Rs. 1440.71 lakh (Rupees fourteen crore forty lakh seventy one thousand only) as environmental compensation imposed by the Uttar Pradesh Pollution Control Board on the Municipal Corporation of Lucknow

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and settle the related case. Otherwise, action will be proposed against you as per rules for recovery of the said amount.

Yours truly
(Indrajeet Singh)
Municipal Commissioner

Copy to:- For information and necessary action to:-

1. Principal Secretary, Urban Development Department, Government of Uttar Pradesh, Lucknow.
2. Divisional Commissioner, Lucknow Division, Lucknow.
3. District Magistrate, Lucknow.
4. Chief Environment Officer, Circle-5, Uttar Pradesh Pollution Control Board, Lucknow.
5. Additional Municipal Commissioner, Municipal Corporation, Lucknow.
6. Environmental Engineer, Municipal Corporation, Lucknow.

Yours truly
(Inderjeet Singh)
Municipal Commissioner

Municipal Commissioner Municipal Corporation Lucknow	To, Chief Executive Officer, Marara Ecogreen Energy Lucknow Pvt. Ltd.
Letter No.: D/975/N.A./PA/22	Date :- 18, March , 2023

Subject: Regarding deposit of environmental compensation imposed against the solid waste processing plant operated by M/s Ecogreen Energy Lucknow Pvt. Ltd.

Sir,

Please refer to letter number H87869/C-5/MSW-01/2023, dated 27.01.2023, issued by the Uttar Pradesh Pollution Control Board to M/s Ecogreen Energy Lucknow Pvt. Ltd., which inspected the solid waste processing plant located in village Shivri, Lucknow district, operated by M/s Ecogreen Energy Lucknow Pvt. Ltd., by authorized officials from the Regional Office, Lucknow, on 25.01.2023. At the time of the inspection, only one trommel was found to be operational among the waste processing units at the plant, including a trommel, compost plant, and leachate treatment plant. Furthermore, a mound of solid waste

approximately 8 to 12 meters high was found accumulated at the secure landfill facility site, and leachate generated from the solid waste was found stored here and there within the premises. Analysis of the report revealed that the quantity of effluents exceeded the standards. At the time of inspection by the organization, the leachate treatment plant was not even found to be under construction.

In light of the facts mentioned above, the State Board has recommended issuance of a show cause notice against M/s Ecogreen Energy Lucknow Pvt Ltd for imposing environmental compensation of Rs. 17,20,71,000/- (Rupees seventeen crore twenty lakh seventy one thousand only) for the violation of the Solid Waste Management Rules-2016 imposed by Ecogreen Sanstha for a total of 157 days from 22.08.2022 to 25.01.2023, for which your organization is fully responsible. In this regard, Ecogreen Sanstha has neither submitted an explanation nor deposited the amount imposed by the Uttar Pradesh Pollution Control Board regarding the environmental compensation imposed by it. Apart from the above, you have also not renewed the Consent to Operate at Shivri Plant for many years, which is a violation of environmental rules and orders.

Therefore, in continuation of the above, please immediately deposit the amount of Rs. 17,20,71,000/- as environmental compensation imposed by the Uttar Pradesh Pollution Control Board on M/s Ecogreen Energy

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Lucknow Pvt. Ltd. and settle the related case. Otherwise, action will be proposed against you as per rules for recovery of the said amount.

Yours truly
(Indrajeet Singh)
Municipal Commissioner

Copy to:- For information and necessary action to:-

1. Principal Secretary, Urban Development Department, Government of Uttar Pradesh, Lucknow.
2. Divisional Commissioner, Lucknow Division, Lucknow.
3. District Magistrate, Lucknow.
4. Chief Environment Officer, Circle-5, Uttar Pradesh Pollution Control Board, Lucknow.
5. Additional Municipal Commissioner, Municipal Corporation, Lucknow.
6. Environmental Engineer, Municipal Corporation, Lucknow.

Yours truly
(Inderjeet Singh)
Municipal Commissioner

Municipal Commissioner Municipal Corporation Lucknow	To, Chief Executive Officer, Marara Ecogreen Energy Lucknow Pvt. Ltd.
Letter No.: D/987/0A/50A/22	Date :- 21, March , 2023

Subject: Regarding deposit of environmental compensation imposed against the solid waste processing plant operated by M/s Ecochin Energy Lucknow Pvt. Ltd.

Sir,

Please refer to the letter No. H55133/C-5/MSW-1/2020 dated 20.11.2020 sent by Uttar Pradesh Pollution Control Board to M/s Ecogreen Energy Lucknow Pvt. Ltd., in which, during the inspection conducted on 28.10.2020 by the authorized officers of Regional Office, Lucknow, mentioning the facts found during the inspection, a show cause notice was issued for imposing environmental compensation of Rs. 25.3271 crore for the total default of 302 days from 01.01.2020 to 28.10.2020 and for initiating prosecution proceedings against the responsible persons under Section 15 and 13 of the Environment (Protection) Act, 1966 as amended. Thereafter, due to M/s Ecogreen not carrying out the work of proper

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segregation, collection, storage, transportation and disposal of solid waste generated from Lucknow city as per the Solid Waste Management Rules-2018, as per the recommendation of the Regional Office, Lucknow, through letter no. H87842/C-5/L/MSW-1/2023 dated 27.01.2023 sent by the Uttar Pradesh Pollution Control Board, a total environmental compensation of Rs. 25.3271 crore has been imposed for the violation of total default of 302 days as above. In this regard, Ecogreen organization has not yet deposited the environmental compensation imposed by the Uttar Pradesh Pollution Control Board.

In connection with the above, it is to inform you that, as per the contract dated March 21, 2017, M/s Ecogreen Energy Lucknow Pvt. Ltd. was contracted to undertake the comprehensive work of door-to-door collection, transportation, processing, and disposal of garbage in the Municipal Corporation area under the Lucknow City Solid Waste Project. According to the contract, your firm, M/s Ecogreen Energy Lucknow Pvt. Ltd., was to process the daily collected garbage. However, due to Ecogreen not disposing of the unprocessed waste collected at the processing plant in Shivri, the Pollution Control Board has imposed the above environmental compensation based on the amount of garbage collected at the plant. Your organization is fully responsible for this. Furthermore, you have not renewed the Consent to Operate at the Shivri

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plant for several years, which is a violation of environmental rules and orders.

Therefore, in continuation of the above, please immediately deposit the amount of Rs. 25.3271 crore (Rupees twenty-five crore thirty-two lakh seventy-one thousand only) as environmental compensation imposed by the Uttar Pradesh Pollution Control Board on M/s Ecogreen Energy Lucknow Pvt. Ltd. and settle the related case. Otherwise, action will be proposed against you as per rules for recovery of the said amount.

Yours truly
July (Indrajit Singh)
Municipal Commissioner

Copy to:- For information and necessary action:-

1. Principal Secretary, Urban Development Department, Government of Uttar Pradesh, Lucknow.
2. Divisional Commissioner, Lucknow Division, Lucknow.
3. District Magistrate, Lucknow.
4. Chief Environment Officer, Circle-6, Uttar Pradesh Pollution Control Board, Lucknow.
5. Additional Municipal Commissioner, Municipal Corporation, Lucknow.
6. Environmental Engineer, Municipal Corporation, Lucknow.

Yours truly
July (Indrajit Singh)
Municipal Commissioner

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Municipal Commissioner Municipal Corporation Lucknow	To, Chief Executive Officer, Marara Ecogreen Energy Lucknow Pvt. Ltd.
Letter No.:- D/1003/N.A./P.A./23	Date :- 24, March , 2023

Subject: Regarding disposal of collected material at the processing plant located at Shivri.

Sir,

It is to inform you that the solid waste management work within the Lucknow Municipal Corporation limits has been carried out by M/s Ittichin Emergency Lucknow Pvt. Ltd. for the past six years, pursuant to a tripartite agreement dated March 21, 2017. Under this agreement, Ecogreen was to collect, transport, and process the waste, while also creating the infrastructure for the waste disposal. However, you have only partially covered the waste, collecting and transporting the waste to the plant, but have not disposed of it. As a result, a mountain of waste has formed at the solid waste processing plant in Shivri, and leachate is polluting the surrounding groundwater and land. The SSF at the plant is also overflowing with waste. This unprocessed waste was to be disposed of by Ecogreen as per the provisions of the agreement, and a waste-to-energy plant was also to be established for waste disposal. But despite your repeated assurances, the waste has not been disposed of, and dung

has accumulated in most of the plant's premises. Due to deficiencies found at the plant and the failure to dispose of solid waste, the Uttar Pradesh Pollution Control Board has imposed environmental compensation of ₹144,071 million, ₹253,271 million, and ₹172,071 million, respectively, from time to time.

The Municipal Corporation has got a DPR prepared from an organization selected through tender to estimate the amount of unprocessed waste collected at the plant, according to which approximately 18.50 lakh metric tonnes of unprocessed waste has been collected at the plant, for which an expenditure of approximately Rs 98.00 crore has been shown for disposal through bioremediation method. The DPR prepared by the organization has also been VATED by the Regional Centre for Urban and Environmental Studies, Lucknow (RCUES).

In continuation of the above, due to the unprocessed waste collected at Shivri plant not being processed within time, the Municipal Corporation will have to dispose of this waste in future, for which the Municipal Corporation will have to spend additional amount on the basis of the prevailing rates as per the DPR prepared for the said work, the liability for which becomes that of Ecogreen organization.

Therefore, in connection with the above, ensure that the amount of environmental compensation imposed along with the amount to be spent

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for garbage disposal work is deposited immediately, otherwise the Municipal Corporation will be forced to get the said amount deposited through RC from M/s Ecogreen Energy Lucknow Pvt. Ltd.

Yours truly

(Inderjeet Singh)

Municipal Commissioner

Copy :-

1. To inform the Divisional Commissioner, Lucknow Division.
2. District Magistrate, Lucknow
3. Additional Municipal Commissioner (P) for necessary action.
4. To the environmental engineer for necessary action.

Yours truly

(Inderjeet Singh)

Municipal Commissioner

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NOTICE

Municipal Commissioner Municipal Corporation Lucknow	To, Chief Executive Officer, Marara Ecogreen Energy Lucknow Pvt. Ltd.
Letter No.:- D/75/N.A./P.A./23	Date :- 28, November , 2023

Subject : Regarding the contract being given to Ecogreen Energy Lucknow Pvt. Ltd. for the solid waste management work of Lucknow city. After the contract was signed from March 2017, it was blacklisted for the future.

Sir,

Under the Solid Waste Project of Lucknow city, a substitute tripartite contract was executed on 21.03.2017 with M/s Ecogreen Energy Pvt Ltd (presently M/s Ecogreen Energy Lucknow Pvt Ltd) for collection, transportation, processing and disposal of garbage from door to door in the Municipal Corporation area. In the course of which, for the implementation of the Solid Waste Management Plan of Lucknow city, M/s Ecogreen organization did not fulfill the terms, conditions and prescribed obligations of the contract, caused harm to the environment and did not ensure compliance with the Solid Waste Rules-2016, due to which Ecogreen organization was terminated on 06.07.2023.

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Due to the above actions of Ecogreen organization, lakhs of tonnes of unprocessed waste has accumulated at the processing plant located in Shivri, due to which the organization has caused irreparable damage to the environment by increasing air, water and soil pollution in the surrounding area.

In addition to the above, Ecogreen was provided with machinery, vehicles, plants, sheds, and other infrastructure to facilitate the scientific disposal of solid waste arriving daily at the processing plant in Shivri. The Ecogreen organization was supposed to maintain it. However, all the resources provided by Ecogreen have been completely destroyed, completely disrupting the city's solid waste management system and placing a significant financial burden on the Municipal Corporation.

All the allegations you have made against the Municipal Corporation officials are completely baseless and fabricated, and the Corporation denies them. The reality is that M/s Ecogreen has completely failed in implementing all the tasks under the Lucknow City Solid Waste Management Act, such as garbage collection, segregation, transportation, and processing, and has failed to fulfill any of the tasks and targets set out in the concessionaire agreement signed in March 2017. As a result, the Lucknow Municipal Corporation has suffered the aforementioned

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problems and irreparable damage to the city's sanitation system and environment.

Therefore, in view of the above, a notice was sent to you on 27.10.2023 regarding the proposed legal and administrative action against you through letter number D/642/N.A./PA/23 dated 26.10.2023, but you did not provide a satisfactory reply and the Municipal Corporation does not agree with the claims made. In such a situation, in light of the circumstances described above, your organization, M/s Ecogreen Energy Lucknow Pvt. Ltd., is being blacklisted by the Lucknow Municipal Corporation for solid waste management work.

Yours truly
(Indai Jeet Singh)
Municipal Commissioner

Copy :-

1. For the respectful perusal of Hon'ble Mayor.
2. General Manager, C&DS, Uttar Pradesh Jal Nigam, Lucknow for information.
3. Additional Municipal Commissioner for necessary action.
4. Environmental Engineer for necessary action.

Yours truly
(Indai Jeet Singh)
Municipal Commissioner



LUCKNOW MUNICIPAL CORPORATION

From, Municipal Commissioner Nagar Nigam, Lucknow.	To, 1. Ecogreen Energy Lucknow Private Limited, 515/516, DLF My Pad, Vibhuti Khand, Gomti Nagar, Lucknow-226010. 2. Ecogreen Energy Private Limited Through it's Executive Director, 219, 2nd Floor, Vipul Trade Center, Sector 48, Sohna Road, Gurgaon-122001 3. Ecogreen Energy Private Limited, 228-236, 2nd Floor, Tower A, Spaze I-Tech Park, Sector 49, Sona Road, Gurgram 122018, Email-hrdlucknow@ecogreenwte.com Website : www.ecogreenwte.com Phone : +91-124-4410700
Letter No. : D/ 273 /MC/EE/23	Date : 06 July, 2023

Subject : **TERMINATION NOTICE of the Selectee Concessionaire Agreement dated 21st March, 2017 on account of Event of Default committed by the Selectee Concessionaire which is you and your kind office.**

Reference -

- Preliminary Notice dated NIL and mailed on 14-11-2022 addressed to you under the instructions of my office highlighting the Events of Default committed by you and your office.
- Your reply dated 11-12-2022.
- Second preliminary Notice dated 15.04.2023 and your reply dated 03.05.2023.
- All other correspondences between us.

Whereas, Construction & Design Services, UP Jal Nigam had invited proposals for **Development of Integrated Solid waste Management Facilities*

for Nine Urban Local Bodies in UP on Public Private Partnership (PPP) Basis" on 25.08.2009 and Lucknow was one among these Nine cities.

That, M/s Jyoti Build Tech Pvt. Ltd submitted its technical and financial proposal on 14.09.2009 including the subsequent clarifications submitted in response of the letter issued by C&DS, UPJN on October 3rd 2009. On completion of evaluation process, M/s Jyoti Build Tech Pvt. Ltd. was declared successful bidder and LOA for development of Integrated Solid Waste Management Facilities for LUCKNOW Municipal Corporation was released on 11.11.2009.

Pursuant to the terms and conditions of the Request for Proposal dated 25.8.2009 and C&DS award letter No.5111G-2-16/14 dated 11.11.2009, a tripartite Concession Agreement (No.19/CGM-1/2010-2011) was executed on 23.10.2010 among ULB Lucknow, C&DS UPJN and Concessionaire M/s Jyoti Enviro Tech Pvt. Ltd, defining detailed terms and conditions of concessions including to design, build and operate the Lucknow SWM Project wherein municipal solid waste is collected, transported, processed and remnant waste is disposed-off as per the provisions of applicable Municipal Solid Waste Rules. Brief scope and services of Concessionaire as defined in agreement are as listed below;

- A. Door-to-door collection of MSW
- B. The primary storage of collected door-to-door MSW
- C. Secondary collection and transportation of MSW, including street sweeping waste, drain silt
- D. Development, construction and operation and maintenance of the MSW processing Facility with composting as one of the main processes including segregation
- E. Development, construction and operation and maintenance of the landfill facility
- F. Post closure Activities of landfill facility
- G. Collection, transportation, processing and disposal of the MSW

littered within the Concession Area as on COD

- H. Assist ULB in public education / Awareness Campaign related to MSW
- I. Collection of the user Charges, on behalf of ULB as determined by the ULB from the time to time.
- J. Develop and implement a Complaint Redressal system.
- K. Development, financing, operation and maintenance of the Project.
- L. Augmentation of equipment/ vehicle, capacity enhancement and provision of ancillary facilities required to implement the Project during the Concession Period.
- M. Deployment of adequate and qualified manpower for construction, operation and maintenance management of the Project
- N. Procure and / or provide any other required support services and facilities required for the project and

That, M/s Jyoti Envirotech Private Limited, committed numerous defaults in completing the works as per proposed and agreed schedule, but unfortunately it never made any sincere efforts to complete the works, and, thus Lucknow Municipal Corporation had no option except to initiate termination process. Pursuant to the provisions of Article 2.2. of Substitution Agreement, the Preliminary Termination Notice No.994/GM-N-8/G-8-16/14 dated 21.10.2016 was served on the M/s Jyoti Enviro Tech Pvt. Ltd calling upon it to submit proposal for curing the defaults within a period of 30 (thirty) days from the date of receipt of the preliminary termination notice, however Concessionaire failed to submit any proposal, with reference to the notice, within the stipulated period of 30 (thirty) days of receipt of notice, however proposal(s) were submitted later without any intent of completing the works and on physical verifications, were found to be bogus i.e. Concessionaire failed to cure defect; thus Concessionaire breached the Article 2.3 of Substitution Agreement and Article 12.2 (a) (ii) and (iii) of the Concession Agreement.

Subyot

The intimation of issuance of preliminary termination notice was communicated to ICICI Bank vide C&DS Office letter No. 389/CGM-1/016/15 dated 2.11.2016. Subsequent to failure of the M/s Jyoti Enviro Tech Pvt. Ltd to rectify the Events of Defaults as provided in the Preliminary Termination Notice, the Lender, in exercise of its powers under Article 2.4 of Substitution Agreement as placed in *Schedule 'K'* of concession agreement, brought to the notice of the ULB Lucknow about its intent to substitute the Concessionaire with a new party i.e. Selectee for Residual Concession Period. The intimation to this effect was also communicated to the Concessionaire.

The ICICI Bank evaluated various potential third parties for substitution of the Concessionaire on the basis of selection criteria prescribed in Article 2.5(i) of Substitution Agreement and after due evaluation selected the Selectee Concessionaire for substitution, however the selection process was merely on nomination basis and no tender process was adopted by Lender bank.

The ICICI Bank, as per Article 3.1 (i) of Substitution Agreement submitted proposal (along with requisite documents including unconditional undertaking as provided in Article 3.1 (ii) of Substitution Agreement) with ULB Lucknow for approval of the Selectee Concessionaire, and, ULB Lucknow, after being empowered by Government of U P vide letter No. 915/Nau-5-2017-91sa/2017 dated 09.03.2017, has accorded its approval for substitution of Concessionaire with Selectee Concessionaire vide letter no. 217/P/Praya.Abhi./N.A. dated 10.03.2017.

As per the said Selectee Concessionaire Agreement dated 21.03.2017, the Eco Green Energy Pvt. Limited was substituted as Concessionaire and the object of the Agreement was to enable the selectee Concessionaire, to carry out its function including but not limited to collection, transportation, Processing of Municipal solid waste and disposal of remnant waste as per the provision of applicable rules and to operate and manage scientific Municipal waste Management system and carry out other duties, responsibilities and exercise such rights more fully described in Concession

Agreement for residual concession period.

It is pertinent to mention here that as per clause 14.3 of selectee Agreement, the selectee agreement and Concession Agreement are to be taken as mutually explanatory and, be read, construed, understood, severally and/or jointly, as the case may be and in the event of any conflict, difference or dispute between them, the priority shall be accorded to the Concession Agreement and the detailed terms and conditions, as specified in the Concession Agreement shall have over-riding effect.

That there have been numerous instances of non-compliances of terms and conditions of the Concessionaire Agreement which unambiguous and explicit Events of Default as per the Article 12 Sub-Article 12.1 of the said agreement from your side which are highlighted below and were brought your notice vide the Preliminary Notice dated NIL & mailed on 28-11-2022 and second Preliminary Notice dated 03.05.2023 also.

- In accordance to the clause 6.2 of concession agreement, "*The Concessionaire shall in respect of the Project, procure the Applicable Permits and be in compliance thereof at all times during the Concession Period*". However, consent to establish is not renewed and it is expired thereby causing breach of clause 6.2 of concession agreement
- In accordance to the clause 6.7 (a) of concession agreement, "*The Concessionaire shall undertake the Operation and Maintenance (O&M) of the Project by itself. However, the Concessionaire may sub-contract part of the O&M activities to a Contractor possessing requisite technical, financial and managerial expertise and capability;*". Whereas, Lucknow Municipal Corporation has found that you have sublated the O&M activities without divulging the technical, financial and managerial expertise and capability of selected Contractors to Lucknow Municipal Corporation thereby causing breach of clause 6.7 of concession agreement.

- That the clause 6.7 (c) of concession agreement necessitates, "The Concessionaire shall during the Operations Period in accordance with the Requirements:
 - undertake door to door collection of MSW from Persons generating such waste in the Concession Area.
 - collect MSW from Persons generating such waste within the Concession Area.
 - segregation and secondary collection of MSW.
 - transfer, transport and deliver the MSW collected at the MSW Processing Site.
 - process the MSW brought to the MSW Processing Site and dump the Landfill Waste at the Landfill Facility.

Your company has utterly failed in achieving the targets related to all above scope of work. Your company was responsible to collect the waste material from the houses and after segregation, you have to transport the solid waste material to the secondary collection centre and deploy sufficient manpower and primary collection vehicle for 100% Door to Door MSW collection but you have provided only 60% vehicles at ward / zone level, and as per the report of zonal officers you have collected Municipal Solid waste from only 35-50% of houses / commercial establishment. Due to lack of 100% primary collection from the houses, waste is being dumped at open points and drains. For cleaning of open points/drains Lucknow Municipal Corporation deployed own resources/ infrastructure resulting into extra expenditure upon Lucknow Municipal Corporation. We have given several directions in this connection to make you aware regarding solid waste management rule 2016 but you have not taken it seriously and since inception of selectee agreement you have not executed the work assigned to you seriously and violated the terms of the agreement and Rules of Solid Waste Management 2016.

You have also abandoned the Project Facilities at Shivri processing

plant resulting into accumulation of huge quantity of unprocessed waste and thereby causing event of default under provisions of clause 12.1 (a)-viii of concession agreement.

- As per Clause 1.8 of Section-1 of Schedule G (Operation & Maintenance Requirements-General) of concessionaire Agreement, it is concessionaire responsibility to ensure that the MSW processing facility shall remain operational 365 days a year subject to shut down due to planned maintenance. However, you have consistently failed in operating processing plant and even frequent shutdown/labour related strikes has been observed in Door-to-Door collection, Transportation services, resulting into breach of Clause 1.8 of Section-1 of Schedule G.
- As per Clause 5 (iii) of Schedule G-Section 3 (Operation & Maintenance Requirements-MSW Processing Facility) of concessionaire Agreement) "No untreated leachate, which does not meet the applicable code and standards, shall be let out from the processing site. Whereas, the leachate treatment system is found non-functional and regular flooding of leachate in all part of Shiveri site has been observed resulting into breach of Clause 5 (iii) of Schedule G-Section 3.
- As per Clause 9.2 of Selectee Concession Agreement concessionaire had to install a Waste-to-Energy plant Unfortunately, no effort has been taken by the you to process the MSW and to comply the environmental law of land.

Whereas, your company had already submitted a list of equipment's for setting up 15 MW power plant and Subsequently, your company had taken the various steps to establish the Power Plant and also obtained the following critical clearances for the development of Waste to Energy Project; (a) Consent to Establish (CTE) as received on 5th September 2018 (b) No objection Certificate (NOC) for ground water

withdrawal as obtained from Central Ground Water Authority on 19th June 2018 (c) Power evacuation & Connection Agreement with Uttar Pradesh Power Transmission Corporation Limited as done on 18th April 2018 (d) No objection Certificate (NOC) for Chimney height from Airport Authority of India (e) IBR approval for Boiler manufacturing was obtained (f) Custom Duty exemption for imports from the Ministry of New & Renewable Energy was also obtained and (g) Amended power purchase agreement as signed on 05.10.2019.

All the clearances involved time & resources of government bodies and at your end as well. In spite of putting so much efforts, for establishing the said power plant, your company failed in setting up the 15 MW Waste to Energy plant leading to non-processing of MSW, resulting into the over-accumulation of the MSW at Shiveri Plant. It seems that your company had deliberately stopped the work with malicious intentions to defame the image of Lucknow Municipal Corporation leading to breach of clause 9.2 of Selectee Concession Agreement.

- As per Clause 5 (iii) of Section III of Schedule G, "no untreated leachate, which does not meet the applicable code and standards, shall be let out from the processing site" But for your information, the Leachate can be seen overflowing over internal roads and other plant area indicating that the leachate management and treatment system is completely absent at processing plant site.
- In accordance to the clause 6.7 (d)-i of concession agreement, "*The Concessionaire shall during the Operations Period, collect User Charges, on behalf of the ULB as determined by ULB from time to time maintain and update the existing customer database of households available with ULB*". Also, as per clause 6.7 (e) concessionaire shall have ensured minimum collection efficiency of the total amount of user charges billable on a monthly basis at the user charges rates prescribed by ULB as per efficiency tabulated below

OPERATIONS PERIOD	THRESHOLD LIMITS AS PER REVISED AGREEMENT
1st Year	50% of the total amount of user charges billable on a monthly basis
2nd Year	60% of the total amount of user charges billable on a monthly basis.
3rd Year onwards	75% of the total amount of user charges billable on a monthly basis

Your company have never divulged and submitted any customer database of households and Consistent failure in service delivery from your part has resulted into short fall in User charge collection to the tune of Rs 116.60 Crore and has resulted into additional burden upon Lucknow Municipal corporation.

It is hereby conveyed the clause 6.7 (e) provides that "In case the Concessionaire is unable to collect the user charges in accordance with this sub-clause (e), the **ULB** shall withheld such shortfall from the tipping fee payable to the Concessionaire for the particular month" and therefore Lucknow Municipal Corporation is entitled to recover all such short fall in User charge collection i.e equivalent to Rs 116.60 Crore from your company.

Repair and Replacement

- Clause 6.9 of concession agreement necessitated as under
 - (a) The Concessionaire shall at its cost, plan for replacement, replenishment and renewal as the case may be of the Project Facilities (including equipment/vehicles) well ahead of the time when the Project Facilities thereof is reasonably expected to expire its operating life or its impending obsolescence and replace the Project Facilities in accordance with Good Industry Practice so as

- to ensure that the Project commensurate with the requirements of this Agreement, at all times during the Concession Period.
- (b) In case an irreparable damage to a vehicle and/or equipment, due to any reason (including but not limited to Force Majeure), the Concessionaire shall at its cost, within a maximum period of 30 (thirty) days, replace the **damaged** vehicle and/or equipment.
- (c) The Concessionaire shall not remove from the Project Facilities, any equipment, materials, consumable and non-consumable items that are required for the Project, without the prior written consent of ULB.
- (d) The Concessionaire shall maintain and complete accurate records of all equipment, materials, consumables and spare parts procured and shall provide copies of such records to ULB upon request.

Similarly, as per **Clause (7.1) of concession agreement**, All the transport vehicles and other movable equipment shall be replaced Concessionaire at its own cost with equipment of similar or better after the expiry of its useful life or 7 years whichever is earlier.

The inspection reports indicates that many of vehicles are beyond repairable condition but you have never taken steps for replacement of such vehicles. In wake of your reluctance to provide sufficient number of vehicle/equipment, LMC have purchased/arranged the vehicle/equipment worth Rs. 32.16 crore from your outstanding O&M payments and additional vehicle/equipment worth Rs 55.00 Crore from own fund for smooth operation.

Project facilities at Shiveri like shed, roads and drains are highly damaged and you have neither repaired the same nor have submitted your plan for the replacement, replenishment and renewal of these project facilities which was expected to be submitted ahead of the time from your end, it was not submitted even after the expiry of the

operating life of the machinery and equipment. Lucknow Municipal Corporation have prepared an estimate for repair of the damaged shed and it worths Rs 7.34 Crores. This is clearly evident that the Good Industry Practices were not followed since commencement of the project thereby breaching the concession agreement clause 6.9.

Many equipment and machineries at the processing facilities are found missing and may have been removed deliberately from the processing plant without the consent of the ULB causing material adverse effect on project and breach of the Clause 6.9 of concession agreement

- **Clause 6.10** i.e. Operation And Maintenance Plan and Operation And Maintenance Manual necessitated you to finalize

(a) an O&M Plan ("O&M Plan") prepared in line with the Scope of Work of the Project, Statutory Requirement, Development Plan and compliance with the requirements of this Agreement.

(b) a manual for the operations, regular and preventive maintenance of the Project Facilities ("O&M Manual") and shall ensure and procure that at all times during the Concession Period, the Project Facilities are operated and maintained in accordance with the provisions hereof.

You have never submitted your O&M Plan and O&M Manual thereby breaching of the Clause 6.10 of concession agreement

- Clause 6.12 of concession agreement necessitated you to install a Vehicle Tracking and Monitoring System in all the vehicles at your own cost and expenses. You failed to provide the access of Vehicle Tracking and Monitoring System to Lucknow Municipal corporation and in turn preventing authority to access of real time data related to the time, position and route taken by the vehicles to Lucknow

Municipal corporation and thereby breaching of the Clause 6.12 of concession agreement.

- Clause 6.14.1 of concession agreement necessitated you to purchase and maintain all insurances in respect of the project facility in accordance with the Good Industry Practice at your own cost and expense. However, you have neither divulged the detail of insurances purchased to LMC nor had taken approved of terms from LMC thereby breaching of the Clause 6.14.1 of concession agreement.
- **Clause 6.15** of concession agreement necessitated that "the Concessionaire shall, at all times, ensure that all aspects of the Project and the processes employed in the construction, operation and maintenance of the Project Facilities shall conform to the laws pertaining to environment, health and safety aspects including rules such as MSW Rules, policies and guidelines related thereto". However, the manner you have utilised project site and made the entire processing site into uncontrolled/unprotected dump area, reflects your apathy towards maintenance of environmental standards and laws.
- **Clause 6.19** of concession agreement necessitated that "The Concessionaire may adopt such processes and methods as it considers necessary or expedient for Processing of MSW and Landfilling at the Project Facilities, subject to meeting the Construction Requirements and O&M Requirements and Landfill Waste is not more than 20% of Incoming Waste". Similarly, the **Clause 6.21** of concession agreement necessitated that "The Concessionaire shall carry out Landfilling, including carrying out of relevant Tests, maintenance of records and ensure certification by Independent Engineer, in accordance with O&M Requirements. The Concessionaire shall weigh the Landfill Waste prior to disposal of the same in the Landfill Facility And it shall not be more than 20% (twenty per cent) of the Incoming Waste".

However, you have dumped almost 100% of incoming waste into Landfill and other area of processing plant. Dumping of unprocessed waste is clear violation of Clause 6.19, Clause 6.21, Clause 10.5 (a) and Clause 1.1 (b) of Section III of Schedule G of concession agreement which attracts penalty of 2% of the amount payable to you in tipping fee invoice for every 1% increase in Landfill waste. Moreover, the indiscriminate dumping has resulted into accumulation of 18 -19 lacs MT unprocessed MSW at Shiveri. The cost of Bio-remediation of unprocessed waste dumped at Shiveri is estimated at around 96.53 Cr.

Lucknow Municipal Corporation under the provisions of clause 6.31.1 of concession agreement has decided to recover all such penalty/damages and also terminate the agreement as per clause 6.31.4 and Article 12.1 of concession agreement.

- **Clause 6.29.1** of concession agreement necessitated that "The Concessionaire shall provide 2 (two) copies of its Balance Sheet, Cash Flow Statement and Profit and Loss Account along with the report thereon by its Statutory Auditors within 6 (six) months of the close of the Accounting Year to which they pertain. In addition, the Concessionaire shall also submit a statement of fixed assets forming the part of the Project Facility, as on the end of the Accounting Year, duly certified by Statutory Auditor. The statement of fixed assets shall provide the inventory of fixed assets as on the end of Accounting Year along with a list of additions and deletions during the period".

You have never provided the copies of Balance Sheet, Cash Flow Statement and Profit and Loss Account along with the report thereon by its Statutory Auditors and statement of fixed assets to Lucknow Municipal Corporation since the commencement of the project thereby breaching the concession agreement clause 6.9.

Collection, Transfer & Transportation

- That as per Clause 2.1 of Section 2 of Schedule G (Operation & Maintenance Requirements-collection & transportation) of concessionaire Agreement you should have made efforts for primary segregation of MSW from households, commercial establishments and other collection points but no efforts have been made by you for segregated collection of waste.
- That as per Clouse 8 (a) of Section 2 of Schedule G (Operation & Maintenance Requirements-collection & Transportation) of concessionaire Agreement the maintenance of the transport vehicles should be undertaken so that at least 90% of the vehicles are available at any point of time for operations. It has been found that the breakdown is consistently more than the threshold limit of 90%.
- That as per Clause 6.4 of (Concessionaire Obligations) of concessionaire Agreement the concessionaire have, within 15 days of the appointed date, submit to the construction supervisor a plan (development plan) on conformity with the construction requirements, *O&M requirements and business plan* submitted by the selected bidder along with the financial proposals.
- That providing sufficient infrastructure for segregation, transportation of waste was part of your job but you have not executed the same.
- We have given direction to you to submit the work plan for effective processing of solid waste and in pursuance of that you have given a proposal vide letter No. ECO/Lko/21-22/2123 Dated 21.10.2021 along with affidavit and given the work plan. You have not executed the work as per the submitted work plan with the time frame given by you therefore, it is clear that you have deliberately and wilfully gave a false affidavit and not started the waste processing work. ✓

- Again, we gave direction to submit fresh work plan to you and in pursuance of that vide letter No. ECO/LKO /22-23/OP/23, dated 20.07.2022 you have again submitted the fresh work plan, but again not executed the same.
- Due to negligence and to non-maintenance on your part and non-execution of work / job assigned to you, many vehicle engaged in the secondary waste collection are now not in working conditions and as a result , the cleanliness of the area is badly affected.
- That as per the terms and condition of the Agreement, Lucknow Municipal corporation has appointed an independent engineer (IE) and as per various reports submitted by independent engineer, serious shortcomings have been observed in operation and maintenance of project facilities.
- You have made no effort to achieve the target of segregation at source, segregated transportation, and segregated processing & disposal of the waste by involving scientific technics and merely indulged in transportation of mixed waste and dumping the waste at Shiveri plant resulting into mountains of solid waste at Shiveri plant.
- That you have violated the terms and conditions of the agreement and solid waste management Rules, 2016 as you have not operated the plant as per the norms, which is not only highly objectionable, but also directly affecting the environment also.
- That we are making payment for your services regarding solid waste management but you are not performing as per the performance standards as defined under the agreements dated 23.10.2010 and 21.03.2017.
- That Government reply on **"Performance Audit on Solid Waste"**

Management in Urban Areas" raised several queries where you are availing all the facilities and funds from Lucknow Municipal Corporation, however the services are found to be below the standards and the approach of work is clearly at fault.

- That your conduct is against the Rules, Conditions and directions issued by Hon'ble National Green Tribunal, U.P. Pollution control Board and Central Pollution Board. Even after many directions issued by Lucknow Municipal Corporation for proper execution of work, you have not successfully delivered the work as assigned under the agreements, due to which there are huge amount of solid waste is accumulated on the plant causing environmental issues.
- Clause 1.3 and Clause 1.8 of Section 1 of Schedule G (Operation & Maintenance Requirements-general) necessitated project facilities remain operational for all 365 days in a year. However, there are numerous instances of deliberate stoppage of C&T work and almost 100% stoppage of processing work.
- As per Clause 1.3 and Clause 7 of Section 1 of Schedule G, you were also supposed to implement a public complaint system operational for at least 8 hours a day. The undersigned have received Regular complains about faulty operation at personal number which reflects non-functional complaint registration & redressal system.
- Clause 1.7 (ii) of Section 1 of Schedule G (Operation & Maintenance Requirements-general) necessitated that *"During the Operations Period, the Concessionaire shall, in respect of the Project Facilities, ensure that adverse effects on the environment and to the owners and occupiers of property and/or land in the vicinity of the Project Facilities, due to any of its actions, is minimized and is limited to standard as per MSW Rules"*

- In contrary to this you have continuously caused environmental damages at Shivri processing site by dumping unprocessed waste and disposal of untreated leachate resulting into *adverse effects on the environment and to the owners and occupiers of property and/or land in the vicinity of the Project Facilities.*
- Similarly, you were supposed to construct the Transfer station at Purania (Priyadarshini Nagar Colony) in scientific manner in closed premises so as to avoid accumulation of waste and minimise the adverse effects on the environment. You did not construct the Transfer Station inspite of taking Rs. 1.00 Crore and kept on dumping waste on ground that resulted into public unrest and subsequent filing of a case against Lucknow Municipal Corporation in National Green Tribunal.
- Clause 2.2 of Section 1 of Schedule G (Operation & Maintenance Requirements-general) requires that "Six weeks prior to the anniversary of COD each year, the Concessionaire shall in consultation with the Independent Engineer / ULB finalise an annual O&M Plan for the next year of operations". You have willingly not submitted O&M Plan to deceive the operational facts with LMC. Moreover, you have not submitted any O&M Manual making you liable for concessionaire event of default.
- As per Clause 3 of Section 1 of Schedule G you supposed to adopt MSW Rules and Central Public Health & Environmental Engineering Organisation (CPHEEO) guidelines/standards. But your work never reflected adherence to MSW rules and CPHEEO manuals.
- Clause 4.1 of Section 1 of Schedule G i.e. Routine Maintenance Standards, necessitates for routine maintenance of the Project Facilities that include but not be limited to:

- (i) prompt repairs of the weigh-bridge, windrow platforms, leachate collection drainage and treatment system, electrical items, drains, internal roads, sieving machinery, lighting and fencing;
- (ii) replacement of equipment/consumables, horticultural maintenance and repairs to equipment, structures and other civil works which are part of the Project Facilities;
- (iii) maintaining the shape, scope, full cross-section of the storm water drainage system and leachate collection and drainage system;
- (iv) keeping the Project Facilities in a clean, tidy and orderly condition and taking all practical measures to prevent damage to the Project Facilities or any other property on or near the Site;
- (v) undertaking maintenance works in accordance with the O&M plan and O&M Manual;
- (vi) preventing, with the assistance of law enforcement agencies, where necessary, any unauthorised entry to and exit from and any encroachments including any encroachments on the Site; *
- (vii) taking all reasonable measures for the safety of all the workmen, material, supplies and equipment brought to the Site. Explosives, if any, shall be stored, transported and disposed of by the Concessionaire in accordance with Applicable Laws/Applicable Permits.

- Your utter failure in achieving the minimum standards is clearly evident from non-functional project assets related to collection, transfer, transportation and processing of waste.
- Clause 8 of Section 1 of Schedule G (Operation & Maintenance Requirements-general) mandates you to submit to the ULB the following reports.

- (i) Ward wise quantity of MSW received and its characterization
- (ii) Leachate generation
- (iii) Test reports
- (iv) Monthly Tipping Fee invoice in accordance with Article 8 of the Agreement.
- (v) Annual compilation of Monthly tipping fee invoice.
- (vi) Monthly compilation of MSW processed and Residual Inert Matter landfilled.
- (vii) Monthly compilation of capital expenditure
- (viii) Monthly compilation of complaint redressal performance
- (ix) Annual fitness certificate of the transport vehicles and loading equipment
- (X) Disagreements/ disputes, if any and proposed measures to be taken
- (xi) Brief report of any accident/ incident related to the Project, injury/fatality, property damage, cause of accident and actions taken to avoid recurrence
- (xii) copies of any reports submitted for purposes of regulatory compliance and of notices received or reports or notices submitted to any Competent Authority or otherwise
- (xiii) Any other report that may be reasonably required by ULB for itself or to fulfil any regulatory compliance.

It has been observed that your company has not complied with any of the above responsibilities and no report has been submitted in sufficient detail in spite of giving several opportunities.

- Under Clause 1, of Section II of Schedule G Collection and Transportation Service Requirements, you were supposed to Organise door to door collection of Municipal Solid Wastes through organized door to door collection system by collecting waste daily on pre-

informed timings and scheduling. Nevertheless, you are able to achieve only 50 to 55% DTDC targets.

- The said Clause required that the Horticultural and construction or demolition wastes or debris or dairy waste shall be separately collected and disposed-off after treatment in a proper way but you have not even started the procedure for separate collection and processing of Horticultural, construction or demolition wastes or dairy waste. Because of your inaction, the Lucknow Municipal Corporation was forced to install a 100 TPD C&D waste processing plant with a cost of 1.82 Cr.
- The said Clause mandates you that at any Stage the MSW shall not be burnt. However, the Lucknow Municipal Corporation has found numerous incidents of garbage burning and incidents of fire in city leading to gross environmental damages.
- Under Clause 4, of Section II of Schedule G you should have operated and maintained the waste bins as follows:
 - a) The clearing schedule of waste bins should ensure that the waste bins (Biodegradable Waste and Non-Biodegradable Waste) are lifted at least once every 24 hrs.
 - b) There should be no overflow of MSW from the waste bins.
 - c) Cleanliness of surrounding area: The Concessionaire should ensure that the area around the waste bins is kept clean at all times.
 - d) Waste bins needs to be maintained so that there are
 - (i) No breakages
 - (ii) No cracks
 - (iii) There are no leakages
 - (iv) There is no toppling of bins
 - (v) No dislocation of covers



We found you in breach of all above requirements in all the wards of cities.

- Under Clause 5, of Section II of Schedule G, you were required to ensure that there is no spillage of Municipal Solid Waste around the Transfer Station at any point of time or within the Transfer Station area, All Municipal Solid Waste at the Transfer Station shall be handled mechanically and the leachate shall be collected and treated as per the Applicable Laws. In contrary to meeting above compliance, your inaction has led to dumping of waste on ground resulting into public unrest at Purania. Dayal Chouraha transfer station is also found filled with leachate and filth.
- Under Clause 8, of Section II of Schedule G, you were required to operate and maintain the transport vehicles as follows:
 - a) The maintenance of the transport vehicles should be undertaken so that at least 90% of the vehicles are available at any point of time for operations.
 - b) All the vehicles and the drivers shall always be in compliance with the Applicable Laws.
 - c) The maintenance of the transport vehicles should be good so as to prevent breakdown of the vehicles.
 - d) All transport vehicles employed should contain
 - (i) Vehicle controls and dashboard displays
 - (ii) Lamps and lighting, blinker systems
 - (iii) Reflective devices at the back and sides
 - (iv) Rear view Mirrors
 - (v) Occupant protection
 - (vi) seat belts
 - (vii) Windshield mounting, wiping, and washing
 - e) Vehicle Tracking and Monitoring System (VTM):

- f) A fitness certificate for each transport vehicle should be obtained by the Concessionaire by the end of first month of every calendar year and given to the Independent Engineer for verification.

Field reports conducted by Lucknow Municipal corporation reveals that the breakdown percentage is always more than 10 %. Moreover, Fitness certificate of most of vehicles are also found lapsed.

- Under Clause 8, of Section III of Schedule G The main objective divided into (a) Segregation of mixed MSW into biodegradable and non-biodegradable with normal efficiency of 30% (i.e., 30% non-biodegradable is removed from the mixed MSW) by upfront segregation or pre-processing. (b) Composting of biodegradable MSW and use of other MSW processing methods technologies to reduce the Landfill Waste to less than 20% of the Incoming Waste.

It very much evident that you have achieved neither of the two objectives of processing as mentioned above.

- Clause 5, of Section III of Schedule G pertaining to Leachate Collection and Removal System ("LCRS") you should have *"ensured no overflow of leachate from the LCRS, all leachate drains are free from clogging and allows unobstructed flow of leachate and no untreated leachate, which does not meet the applicable Code and Standards, shall be let out from the MSW Processing Site"*.

We have found filthy situation and overflow of leachate all time at Shiveri Processing plant putting you in gross breach of environmental standards.

- Clause 1, of Section IV of Schedule G, mandate you that Landfilling shall be restricted to non-biodegradable, inert waste and other Non-hazardous waste that are not suitable either for recycling or for biological processing. Land filling shall be restricted for only post-processing residues of Processing Facilities and pre-processing rejects.

However, you have dumped the entire incoming waste without processing into Landfill.

- Clause 6.30.5 (j) your company was supposed to make efforts to maintain harmony and good industrial relations among the personnel employed in connection with the performance of its obligations under this Agreement and shall be solely responsible for compliance with all labour laws and solely liable for all possible claims from any third party and employment related liabilities of its staff employed in relation with the Project and hereby indemnifies ULB against any claims, damages, expenses or losses in this regard and that in no case and shall for no purpose shall ULB be treated as employer in this regard;

Whereas, Lucknow Municipal Corporation has found your non-compliance related to payment of Provident Fund of personnel employed by you leading to notices from PF department and imposition of penalty.

- That, as per said selectee concessionaire agreement dated 21.03.2017, there are events of defaults and further, the non-commencement of work and deficiency in operation has continuously breached following terms and conditions of the concession agreement ((Clause 6.4)(i) of Article 6 (Concessionaire Obligations) of concessionaire Agreement), ((Clause 6.7)(e) of Article 6 (Concessionaire Obligations) of concessionaire Agreement), ((Clause 6.29)(6.29.1) of Article 6 (Concessionaire Obligations) of concessionaire Agreement), ((Clause 6.1)(6.1.1(i)) of Article 6 (Concessionaire Obligations) of concessionaire Agreement), ((Clause 6.1)(6.1.1(ii)) of Article 6 (Concessionaire Obligations) of concessionaire Agreement), ((Clause 10.5)(b) of Article 10 (Tipping fee) of concessionaire Agreement), ((Clause 10.5)(d) of Article 10 (Tipping fee) of concessionaire Agreement), ((Clause 1(1.3)(v) of Schedule G-Section 1 (Operation & Maintenance) of concessionaire Agreement).

Maintenance Requirements) of concessionaire Agreement), ((Clause 1(1.8) of Schedule G-Section 1 (Operation & Maintenance Requirements-General) of concessionaire Agreement), ((Clause 2(2.1) of Schedule G-Section 2 (Operation & Maintenance Requirements-collection & Transportation) of concessionaire Agreement), ((Clause 8 (a) of Schedule G-Section 2 (Operation & Maintenance Requirements-collection & Transportation) of concessionaire Agreement), ((Clause 5 (iii) of Schedule G-Section 3 (Operation & Maintenance Requirements-MSW Processing Facility) of concessionaire Agreement), (Article 2 of Selectee Concession Agreement), (Clause 9.2 of Selectee Concession Agreement). Thus, due to the unsatisfactory work only LMC have imposed damages upon your company and penalized time to time.

That vide the said Preliminary notice dated NIL, mailed on 14.11.2022, we expected that you will provide a proposal to rectify the Events of Default as per the Clause 12.2 (a) (ii) however, in your reply dated 11-12-2022 you have not submitted any such proposal to rectify/cure the short-comings (Events of Default) at your end.

With a view that another opportunity be provided to you, we gave you another preliminary notice dated 15.05.2023, hoping that you would rectify/cure the short comings, but instead of doing so or submitting any proposal for the same, you have sent us a reply dated 03.05.2023 which contains allegations and accusations which have been examined in detail by us and have been found to be incorrect and untrue.

Your company has been responsible for breach of various duties and obligations of the Concessionaire Agreement which has caused serious ramifications on the environment and health of the city of Lucknow. Further, as a consequence of the environmental damage caused due to your company's inadequacy and callous behaviour, UPPCB and Hon'ble NGT has imposed the compensation on Lucknow Municipal Corporation

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because of the non-compliance of MSW 2016 Rules from your side. The details of compensation imposed are as follows:

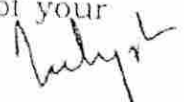
- Year 2019-20: UPPCB imposed INR 14,40,71,000/- compensation
- Year 2020-21: UPPCB imposed INR 25,32,71,000/- compensation
- Year 2021-22: UPPCB imposed INR 2,40,00,000/- compensation
- Year 2022-23: Hon'ble NGT imposed INR 10,00,00,000/- compensation

Apart from this UPPCB has sent the Show cause notice to LMC for DEFAULTER of 17,20,71,000/- because of the non-compliance of MSW 2016 rules by your end for which a demand notice has issued to you for recovery of all such penalties imposed on account of your event of default.

That, the print media (newspapers) have given wide coverage regarding the poor solid waste management in LMC thereby defaming the Lucknow Municipal Corporation due to your pathetic work and delayed salaries of employees there has been several strikes of employees and there is total breakdown of the MSW collection and transportation services were evident in the city. Municipal Corporation has imposed penalties and fine on you but you have not only failed to pay the fines and penalties but you have not improved your services at all.

That from the above-mentioned facts and circumstances, it is evident that you have not executed the responsibilities assigned to you by virtue of agreements dated 23.10.2010 and 21.03.2017 and you never intended to execute / perform the job / work assigned to you and never intended to even give response to the several directions given by us. Therefore, you dishonestly deceived and cheated Lucknow Municipal Corporation into believing that you would fulfil your obligations under the aforesaid agreements dated 23.10.2010 and 21.03.2017.

The ULB is further invoking its right under Clause 6.1.1 of the concession agreement and is asserting that you have been in material breach of your

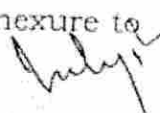


O&M obligations for which damages are liable to be levied upon you and also the agreement is liable to be terminated.

In lieu of the various instances of non-compliances of terms and condition of the Concessionaire Agreement by your company constituting into events of default as per the article 12, sub article 12.1 of the said agreement, Executive committee in the meeting held on 26.06.2023 authorised Hon'ble Mayor and Municipal Commissioner of Lucknow to decide the matter of Solid Waste Management in Lucknow city. In light of this order, the Municipal Commissioner under the direction of Hon'ble Mayor of Lucknow constituted the high-level committee. During the meeting of the said high level committee, detailed consideration of the above delineated events of default were made and the committee concluded and decided that the concessionaire agreement dated 21.03.2017 should be terminated forthwith.

In view of the above-mentioned facts and your company's unequivocal intention to not to abide by the terms of the Concessionaire Agreement as evident by your various replies and the correspondence exchanged between us, the Lucknow Municipal Corporation is constrained to terminate the said Concessionaire Agreement with your company as per all the relevant provisions of the agreement between us.

Therefore, the Selectee Concessionaire Agreement dated 21st March, 2017 is hereby terminated with effect from the termination date which shall be 06th September 2023 albeit Lucknow Municipal corporation reserve it's right to take appropriate action/decision for early take back of project assets, if situation demand so, and the performance security as subsisting is hereby directed to be appropriated. The Termination Payment payable as estimated under clause 12.2 (c) (iii), read with 12.2 (f) (ii) is Rs 12.62 Crore, the shortfall payments for the bills submitted and approved/ the bills not submitted by you are approximately 22.00 Crore whereas the damages to be recovered from you under clause 12.4 and calculated on account of various non performance is Rs. 309.97 Crore. The summary of calculations is tabulated below and the details of computation are attached as annexure to this notice.



Sr.No.	Description	Termination Payment (Rs. In Lacs)	Damages to be Recovered (Rs. In Lacs)
1.	Termination payment equal to 70% of Book value of Fixed assets to be paid to concessionaire.	1262.086	
2.	Shortfall payments to concessionaire for the bills submitted by concessionaire.	2200.00	
3.	Damages to be recovered by Lucknow Municipal Corporation from concessionaire.		30996.93
	Net amount to be recovered from concessionaire.	Rs. 27534.84 Lacs	

You are hereby called upon to henceforth abide by the Clause 12.2 (d)(i) of concession agreement which says until Termination the Parties shall to the fullest extent possible. Discharge their respective obligations so as to maintain the continued operation of the Project Facilities, failing which, keeping in view the interest of public at large Lucknow Municipal Corporation will be compelled to take back the fixed assets by adopting due processes of Law for smooth functioning of solid waste management in city and will also be compelled to take civil and / or Criminal Legal action against your company You are also directed to abide by clause 12.2 (d) (iii) of concession agreement and complete the formalities of handing over of project Facilities to Lucknow Municipal Corporation free from any Encumbrance and also ensure to make the payment due to Lucknow Municipal Corporation as mentioned in above Table ,Moreover it is made clear that LMC have replied and addressed all your previous correspondences. Letters and grievances through this Termination notice.

Lucknow,

Date 06.07.2023

Municipal Commissioner

Nagar Nigam Lucknow.

Copy to:-Copy to General Manager C&DS U P Jal Nigam Lucknow for kind information.

ANNEXURE P/4

From, Municipal Commissioner, Municipal Corporation, Lucknow.	To, Registrar, Hon'ble National Green Tribunal, Copernicus Road, New Delhi.
Letter No.:- D/308 / N.A./Environmental Act/23	July 22, 2023

Subject :Regarding the order passed in the review petition 15/2023 filed by the Municipal Corporation in pursuance of the order dated 13.02.2023 of OA No. 654/2022 of Hon'ble NGT filed by Priyadarshini Colony Welfare Society.

Sir,

Please take the trouble of referring to the letter No. D/42/N.A./Environmental Act/23 dated 18.04.2023 sent earlier on the above subject. In this regard, it is to be informed that in view of violation of Solid Waste Management Rules-2016 by M/s Ecogreen Energy Lucknow Pvt. Ltd. regarding the transfer station functioning for urban solid waste management of Lucknow city, Sthal Bandha Road, Faizullaganj Road, near Priyadarshini Colony D, Residence Welfare Society, Lucknow, the Honorable National Green Tribunal, New Delhi had ordered for the following action in paragraph-15 of the order dated 13.02.2023 passed in OA No. 654/2022 "Priyadarshini Colony D. Residence Welfare Society vs. State of Uttar Pradesh and others":-

"Accordingly, while directing expeditious compliance of norms in managing the waste for acknowledged violations for long time and which are serious, we fix the interim compensation of Rs. 10 corors against the Corporation on polluter pays principle which may be deposited with the State PCB within one month but positively before 31.03.2023, which will be the personal responsibility of Commissioner, Lucknow Municipal Corporation. The interim compensation will be over and above the compensation assessed by the State PCB. The amount may be utilized for restoration of environment in accordance with the District Environment Plan of the District associating the District Magistrate. If there is a failure in deposit, the Commissioner, Lucknow Municipal Corporation will not be entitled to draw salary after 01.04.2023". (संलग्नक-1)

In the above sequence, a review petition number 15/2023 was filed by the Municipal Corporation in the main bench for review of the order dated 31.03.2023 of Hon'ble Green Tribunal, in whose order dated 31.03.2023, page number 04, paragraph 08, the following order has been passed.

"Thus, even by way of showing indulgence, only modification which we can make is that instead of Corporation itself making separate deposit of ₹10 Crore, as directed, it will be free to use the funds allocated by the State, in terms of order dated 23.03.2023 in O.A. No. 606/2018, subject

to the Chief Secretary, Uttar Pradesh, allocating the said amount separately for the Lucknow Municipal Corporation within one month from today. The direction against drawl of salary by the Commissioner, Lucknow Municipal Corporation will also stand deferred on such condition. Let compliance report be filed as earlier directed by 15.05.2023 by email at judicial-ngt@gov.in preferably in the form of searchable PDF/OCR supported PDF and not in the form of image PDF". (संलग्नक-2)

compliance with the above orders, the Municipal Corporation sent a letter to the government with letter number D/56/N.A./Environmental Officer/23 dated 26.04.2023, seeking guidelines for further action (under legal process). In this regard, the Joint Secretary, Urban Development Section-5, Government of Uttar Pradesh has directed action on the following two points:

1. In view of the order dated 13.02.2023 passed by Hon'ble National Green Tribunal, New Delhi in OA No. 654/2022 "Priyadarshini Colony D, Residence Welfare Society, Lucknow vs. State of UP and others" and the order dated 31.03.2023 passed by Hon'ble National Green Tribunal, New Delhi in Review Petition No. 15/2023 filed by Municipal Corporation Lucknow against the said order and in compliance with the order dated 23.03.2023 passed by Hon'ble National Green Tribunal, New Delhi in OA

No. 606/2018 Compliance of Municipal Solid Waste Management Rules, 2016 and Other Environment Issues, a "Ring Fence Account" is to be opened on the retirement of District Magistrate, Lucknow and money is to be deposited therein for works related to environmental improvement such as Solid Waste Management and Liquid Waste Management and the said money is to be used only for works related to environmental improvement. For example, it has to be done only on solid waste management and liquid waste management etc.

2 Please, in view of the proposal made available by the Municipal Commissioner, Municipal Corporation Lucknow in the above referenced letter dated 26.04.2023, in compliance with the order of Hon'ble National Green Tribunal, New Delhi, a ring fence account should be opened and an amount of Rs. 63.94 crore should be deposited in it and the said amount should be used for the work of solid/liquid waste management for environmental improvement and a copy of the action taken should also be made available to the Government.

Regarding compliance of the direction given in the said review petition, further hearing has been fixed on 27.07.2023 in Hon'ble National Green Tribunal, New Delhi.

In compliance with the above orders, an amount of ₹63.95 crore (US\$1.95 billion) has been allocated for solid waste and liquid waste management in Lucknow city, transferred to a ring fence account. This includes the ₹10.00 crore (US\$1.95 billion) imposed on the Lucknow Municipal Corporation for environmental compensation. The transfer station located near Priyadarshini Colony at the site in question has been closed and a tender process has been initiated to construct new transfer stations at three locations. While work was initiated at two locations, it could not begin due to opposition from local residents. A site for the transfer station construction is being selected on the outskirts of the city. The said amount is being spent on waste collection, transportation, plant operation, transfer station, and other related activities under solid waste management. Enclosure: As above.

Yours truly

Inderjeet Singh

(In Municipal Commissioner)

Copy :-

1. The Principal Secretary, Government of Uttar Pradesh for kind perusal.
2. State Mission Director, Swachh Bharat Mission- Urban, State Mission Directorate, Uttar Pradesh for information.

(Indrajeet Singh)

Municipal Commissioner

Item No.10

Court No. 1

**BEFORE THE NATIONAL GREEN TRIBUNAL
PRINCIPAL BENCH, NEW DELHI**

Original Application No. 654/2022

Priyadarshini Colony Sector D
Residence Welfare Society

Applicant

Versus

State of Uttar Pradesh

Respondent

Date of hearing: 07.02.2024

**CORAM: HON'BLE MR. JUSTICE PRAKASH SHRIVASTAVA, CHAIRPERSON
HON'BLE MR. JUSTICE SUDHIR AGARWAL, JUDICIAL MEMBER
HON'BLE DR. A. SENTHIL VEL, EXPERT MEMBER**

Applicant: Mr. Rahul Khurana, Adv. for Applicant

Respondent: Mr. Indrajeet Singh, Municipal Commissioner, Lucknow Nagar Nigam
(Through VC) with Mr. Mukesh Verma, Adv.
Mr. Pradeep Misra & Mr. Daleep Dhyani, Advs. for UPPCB (Through VC)**ORDER**

1. This Original Application involves the issue of unscientific handling of garbage at various dumping sites at Lucknow and the steps being taken by Municipal Corporation for effective management of the waste.
2. In the previous proceedings dated 04.12.2023 Tribunal had taken note of the status report filed by the Municipal Corporation, Lucknow showing the position of treatment and management of the waste in tabulated form. Thereafter, Tribunal had directed the Municipal Commissioner, Lucknow to file fresh affidavit after two months indicating the action taken in compliance of the timelines disclosed in the affidavit dated 11.09.2023.

3. In terms of the order of the Tribunal dated 04.12.2023, fresh affidavit dated 05.02.2024 has been filed by the Municipal Corporation indicated the progress as under:-

Table-1: Ensure door to door collection of segregated waste				
Activity	Current Status as on 01.09.2023	Target Achieved on 31.10.2024	Target set by 31.01.2024	Current status 31.01.2024
Door-to-Door collection of segregated solid waste (Rule 15 (b) of SWM Rule 2016)	381000 HH	762604 HH/User (100%)	495690 HH/User (65%)	Lucknow Municipal Corporation (LMC) has initiated a door-to-door waste collection initiative, concluding a successful tender process for zones 1, 3, 4, 6, and 7. M/s Chennai MSW Private Limited has been awarded the contract, and the formal agreement has been signed. LMC successfully achieved its target within the Allocated timeframe, encompassing a total of 496371 households. Out of these, 157996 houses have been provided segregated waste.
Collect waste from vegetable, fruit, flower, meat, poultry and fish market on day-today basis and promote setting up of decentralised compost plant or bio-methanation plant (Rule 15 (m) of SWM Rule 2016)	Nil	8	1 (12.5%)	As part of an ongoing waste collection strategy covering diverse markets, a comprehensive waste management program has been implemented. Virat Khand, recognized as a Zero Waste colony in Lucknow, features 1600 households source-segregating organic waste, composted for park maintenance. Similarly, Parshu Nath Planet in Vibhuti Khand, with 542 households, actively manages organic waste through composting, contributing to decentralized municipal solid waste management.
Enforcing waste generators to pay user fee for solid waste management. (Rule 4 (3) & 15 (f) of SWM Rule 2016)	180000 Units (Rs 1.10 Crore)	762604 Units (Rs 4.60 Crore)	267000 units (35%)	Lucknow Municipal Corporation (LMC) has collected the Rs.37923220.00 amounts in December 2023 and January 2024. Demands have already been sent to all commercial and residential areas.
Integration of Rag Pickers/ Waste collectors/ Kabadis/ Volunteers/ CBOs/ N Gs (Rule 15(c) of SWM Rule 2016)	1050 no.	10463 no.	20% (2100 no.)	250 No. new rag pickers, waste collectors, and kabadiwalas have been identified and provided with training to enhance their efficiency and effectiveness in waste management practices. This initiative signifies a proactive approach to empower and improve the capabilities of these individuals, ultimately contributing to more organized and efficient waste collection, segregation, and management within the municipal area.

Facilitating formation of Self-Help Groups, provide identity cards and thereafter encourage integration in solid waste management including door to door collection of waste; (Rule 15 (d) of SWM Rule 2016)	110 Nos	220 Nos	132 Nos (60%)	Kalawati Chhata Istariya Samiti, under the leadership of Sangeeta Pal, consists of 800 women who have demonstrated a keen interest in participating in waste collection initiatives with Lucknow Municipal Corporation (LMC). Recognizing this commitment, the Chennai MSW company has been chosen for the door-to-door waste collection project, specifically focused on at least one zone.
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2. Setting up of Material Recovery Facilities or secondary storage facilities and transfer facility (Rule 15 (h) and Rule 22 at Sr.no. 7-8 of SWM Rule 2016)

Activity	Current Status as on 01.09.2023	Target Achieved on 31.10.2024	Target to be achieved by 31.01.2024	Current status 31.01.2024
Setting up of Material Recovery Facilities Cum PCTS (Rule 15 (h) and Rule 22 at Sr.no.7-8 of SWM Rule 2016)	8 Nos	25 Nos	10 (40 %)	The construction of 9 Material Recovery Facilities (MRFs) has been completed, and they are manually operational. Notably, a large size/capacity MRF is currently under construction near the RR Office Plant, signifying a commitment to expanding waste recovery infrastructure.
Setting up of Material Recovery Facilities Cum TS (Rule 22 at Sr.no.7-8 of SWM Rule 2016)	0 Nos	2 Nos	1 (50 %)	Specifically, work on 01 No. Transfer Station has started in Kesari Khara, Alambagh, under Zone-5. TPS Infrastructure Limited is managing this project. Key progress includes completing excavation and boring work at the TS site, laying the groundwork for construction, and successfully executing concrete work (PCC), a significant phase in structural development.
Setting up of Material Recovery Facilities Cum FCTS (Rule 22 at Sr.no. 7-8 of SWM Rule 2016)	0 Nos	4 Nos	1 (25 %)	In Zone-3 of Faizulla Ganj, Ghaila substantial progress has occurred in waste management infrastructure. Lucknow Municipal Corporation (LMC) has reclaimed land previously occupied by local bodies, enabling transformative developments. Construction is in full swing for the Transfer Station (TS) Cum Fixed Compactor Transfer Station (FCTS). The project hit key milestones, finalizing layout design and successfully completing excavation and boring tasks. Currently, Plain Cement Concrete (PCC) work is finished, while column work is ongoing.

1.9 Setting up Solid Waste Processing Facilities (Rule 22 at Sr.no.7-8 of SWM Rule 2016)

Activity	Current Status as on 01.09.2023	Target Achieved on 31.10.2024	Target to be achieved by 31.01.2024	Current status 31.01.2024
Setting up 2000 TPD Processing Plant (1000 TPD for Wet waste and 1000 TPD for dry waste)	664 MT/Day (600 MT at Shivari + 64 MT Decentralise)	2000 MT/Day	1250 MT/Day (63%)	Currently engaged in a short-term tender with M/S Horizons Solution Pvt.Ltd. the 1250 tons per day (TPD) of Fresh waste, with enhanced efficiency. Looking towards a sustainable future, a Request for Proposal (RFP) has been meticulously crafted, outlining plans for Biomethanation plant, waste-to-energy and compost plant facilities. The impending release of this tender marks a significant stride toward implementing advanced and scientifically grounded waste processing strategies at the selected location.

Setting up of Aerobic Composting pits in parks (Rule 22 at Sr.no. 7-8)	640 (Pits)/ 64 MT/day	1500 (Pits) 150 MT/day	1200 (Pits) 80%	Total 1315 compost pits have been constructed for effective waste management in parks. The utilization of mulching techniques further enhances waste management practices within these park areas.
Setting up 300 TPD Bio- CNG Plant	0	1	0	Initiated construction following the contract awarded to Ever Enviro Company through the Expression of Interest (EOI) process. Establishing a Bio CNG plant involves preparatory tasks like construction of the boundary wall is now 95% complete. The design for internal roads and administration/utility buildings has been finalized. Vendor onboarding is currently in progress, and construction work on some buildings is also underway.
Setting up of Waste to Energy Facilities (Rule 22 at Sr. no.7-8)	0	1	(0 %)	NTPC has expressed interest in the installation of a waste-to-energy plant (TORREFIED CHARCOAL PLANT) with a capacity of 1000 TPD.
Promotion of comarketing of compost with chemical fertilisers (Rule 7 of SWM Rule 2016)	LMC will ensure to apply and get approval forsale of city compost			A letter seeking approval has been sent to the District Agriculture Department.
Phase out the use of chemical fertilizer and use compost in all parks, gardens maintained by the local body and wherever possible in other places under its jurisdiction. (Rule 15 (u) of SWM Rule2016)	LMC will ensure to use the compost generated from pit			Compost preparation has commenced and has been utilized in parks. Excess compost has been sold to M/S Indian Agro Organic company.
Integration and Incentives to informal waste recycling sector for recycling initiatives. (Rule 15 (u) of SWM Rule2016)	Approximate 50 informal waste recycling center (Kabariwala) has been identified and LMC will provide training and integrate 20 such recycling center in next 3 months and balance will be integrated in next 6 months.			A total of 109 RRR Permanent and Temporary centers have been established in LMC areas, with over 53 kabadiwalas integrated into these centers. Additionally, 50 new kabadiwalas have been selected for training in these centers.
I.10 Setting up sanitary landfill facilities (SLFs) (Rule22 at Sr.no.9-10)				
Activity	Current Status as on 01.09.2023	Target Achieved on 31.10.2024	Target to be achieved by 31.01.2024	Current status 31.01.2024
Setting up sanitary landfill facilities (SLFs) (Rule22 at Sr.no. 9-10)	1	2	50%	Lucknow Municipal Corporation has acquired 55 acres of land in Shivari, freed from local occupation, and has prepared it for the sanitary landfill site in accordance with CPCB guidelines. The tender for this project will be floated shortly.
I.11 Bio-remediation of old and abandoned dump sites (Rule 22 and Key Indicator by NGT in OA 606/2018)				

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Activity	Current Status as on 01.09.2023	Target Achieved on 31.10.2024	Target to be achieved by 31.01.2024	Current status 31.01.2024
Bio-remediation of old and abandoned dump sites (Rule 22 and Key Indicator by NGT in OA 606/2018)	47,959 MT	18.5 Lac MT	150000 (8)%	The tender process for this pivotal waste management project has been successfully finalized, culminating in the issuance of the Letter of Award to M/S Bhumi Green Energy Private Limited. The current management of legacy waste within the short-term tender operated by Greenus Energy and Solutions Private Limited. recently, the company has effectively processed 86,272 metric tons (MT) of legacy waste.
1.12 prepare and submit annual report in Form IV on or before the 30th April of the succeeding year to the Commissioner or Director, Municipal Administration or designated Officer; (Rule 15 (za) of SWM Rule 2016) –				Form was submitted.
1.13 IEC & Citizen grievance redressal; (Rule 15 (zc) of SWM Rule 2016)				
Activity	Current Status as on 01.09.2023	Target Achieved on 31.10.2024	Target to be achieved by 31.01.2024	Current status 31.01.2024
Educate workers including contract workers and supervisors for door-to-door collection of segregated waste and transporting the unmixed waste; (Rule 15 (zc) of SWM Rule 2016)	More than 2000 Works trained so far	8000 workers	4000 workers (40%)	More than total 4500 workers have training provided by SBM workers and LMC for waste collection and segregation tasks.
Create public awareness through IEC campaign and educate the waste generators to practice home composting, vermi-composting, bio-gas generation or community level composting; (Rule 15 (zg(v)) of SWM Rule 2016) generation or community level composting; (Rule 15 (zg(v)) of SWM Rule 2016)	More than 200000 HH by engaging professional agency	762604 HH (For 100% coverage)	280000 HH (36% coverage)	More than 110,000 individuals have been educated and trained by SBM workers and LMC employees for waste collection, segregation, and composting activities
Citizen Grievance Redressal through Swachh App (Key Indicator by NGT in OA 606/2018)	91 %	100%	99%	The Citizen Grievance Redressal process facilitated by the Swachh Bharat Mission (SBM) app empowers citizens to efficiently address their concerns regarding cleanliness and sanitation. With a success rate of 98%, the app enables prompt resolution of reported issues, ensuring effective and timely actions are taken to uphold cleanliness and hygiene standards in communities.
B. COMPLIANCE OF CONSTRUCTION & DEMOLITION WASTE MANAGEMENT (C&D WM) RULES, 2016				

Activity	Current Status as on 01.09.2023	Target Achieved on 31.10.2024	Target to be achieved by 31.01.2024	Current status 31.01.2024
Commissioning and implementation of Processing / Recycling facility. (C&D WM) Rules 13 Schedule- III (3), 2016)	100 TPD	300 TPD	33.33%	Construction and Demolition (C&D) Waste generated in LMC's jurisdiction, a 100 TPD process plant was established in 2021, operated by Jagrati Infratech. Presently, the city generates approximately 250 to 300 TPD of C&D Waste. In response to the increased waste, a tender has been awarded to M/s Garg & Co and Rise Eleven Ready mix Product Pvt. Ltd., selected based on the lowest quoted Tipping Fee for the development/revamping of the existing processing plant on a PPP model. Old C&D waste plant has handover to the selected company and layout work is completed.
Notification of sites for collection and processing facility. (C&D Waste Rule 6(4& 5), 9(2) and 13- C&D WM Rules, 2016)	8 Collection centers	16 CC	10 collection centers (62.5%)	Lands for collection centers have been identified across all 8 zones, and the tender process has been successfully finalized in 03 places work is in progress.
Get the collected waste transported to appropriate sites for processing and disposal; (Rule 6 (5)- C&D WM Rules, 2016)	Approx 40 MT is being transported separately.	267 MT	50 MT/day (20%)	more than 50 metric tons per day C&D waste is collected by LMC vehicle are transported separately to the C&D waste plant.

C. COMPLIANCE OF PLASTIC WASTE MANAGEMENT (PWM) RULES, 2016

Activity	Current Status and Target to be achieved by 31.01.2024	Current status 31.01.2024
Local bodies shall encourage the use of plastic waste (preferably they cannot be further recycled) for road construction as per Indian Road Congress guidelines or energy recovery or waste to oil etc.	Lucknow Municipal Corporation within 3 months will ensure to use about 5% of generated non- recyclable plastic waste (2-to-3%-part replacement with bitumen) in road construction.	LMC utilized 9.66 MT of non-recyclable plastic in the construction of roads across 7 major locations in various zones. No new roads have been constructed using non-recyclable plastic in the last two months.
Plastic waste management rule 2016 5(b)		
Activity	Current Status and Target to be achieved by 31.01.2024	Current status 31.01.2024
The local body for setting up of system for plastic waste management shall seek assistance of producers. Plastic waste management rule 2016 6(3)	Lucknow Municipal Corporation within 3 months will ensure its registration as recycler and will ensure assistance of producers under EPR framework.	The registration remains pending as the State ID hasn't been generated yet. Upon issuance of the State ID, the city ID will be generated accordingly. The management of more than 18 lac MT of legacy waste has entered a pivotal stage as Bhumi Green Energy Private Limited, selected through the tender process, initiates the installation of a waste management plant. This aligns with the Extended Producer Responsibility (EPR) concept for plastic waste, reflecting a commitment to responsible product life cycle management.
Every retailer or street vendors selling or providing commodities in, plastic carry bags or multilayered packaging or plastic sheets or like or covers made of plastic sheets which are not manufactured or labelled or marked in accordance with these rules shall be liable to pay such fines as specified	Lucknow Municipal Corporation is putting a cumulative average monthly fine of Rs. 55650.00 per month and have targeted to increase the fine upto Rs. 100000.00 Lacs Per Month in next 3 months.	Lucknow Municipal Corporation has intensified its inspections targeting retailers and street vendors using non-compliant plastic carry bags, multilayered packaging, or similar items lacking proper manufacturing labels or markings. As a result, penalties totaling Rs. 525100.00 have been imposed for

under the bye-laws of the local bodies. Plastic waste management rule 2016 14(2)		the seizure of such non-compliant plastic materials	
D. COMPLIANCE OF BIO-MEDICAL WASTE MANAGEMENT (BWM) RULES, 2016			
The detail of current status and Targets of compliance to Bio-Medical waste Management Rules 2016 are summarize below in Table-9.			
Table-9: current status and Targets of compliance to Bio-medical waste Management Rules 2016			
Activity	Current Status and Target to be achieved by 31.01.2024	Current status 31.01.2024	
Provide or allocate suitable land for development of common bio-medical waste treatment facilities (Para 7 of Schedule 3 of BWM Rule 2016)	Lucknow Municipal Corporation have provided the land admeasuring 1.25 Acres for establishing the Bio-medical waste processing plant at Village- Bindova, Mohanlal Ganj. Plant is operational and receiving waste from 1030 HCF (9751 beds) and treating 3600 Kg/day (100% of collected waste). LMC collect all Municipal Solid waste from all HCFs in segregated form and dispose off accordingly.	Plant is operational and receiving waste from 1263 HCF (9751 beds)and treating 967160 Kg (100% of collected waste). Lucknow Municipal Corporation have provided the land admeasuring 1.25 Acres for establishing the Biomedical waste processing plant at Village- Bindova, Mohanlal Ganj by M/S SMS water grace Medi waste management pvt.ltd. Plant is operational and receiving waste from 1263 HCF(9751 beds) and treating 3600 Kg/day (100% of collected waste).Through 16 Vehicle LMC collect all Municipal Solid waste from all HCFs in segregated form anddispose off accordingly	
Facilitating construction, operation & maintenance of Carcass disposal facility.	Lucknow Municipal Corporation is operating Carcass pl a nt in 4 Acres of land at Shivari in scientific way and also going to install within 6 months a new incineration plant for incineration of dead stray animals in scientific way	At present, the incineration plantfor the scientific disposal of deceased stray animals RFP has prepared, and tender float shortly.	
E. COMPLIANCE OF E-WASTE MANAGEMENT E-WASTE RULES, 2016			
Activity	Current Status and Target to be achieved by 31.01.2024	Current status 31.01.2024	
Urban Local Bodies shall ensure that e-waste pertaining to orphan products is collected and channelised to authorised dismantler or recycler (Rule 24 E- Waste Management Rule 2016)	Lucknow Municipal Corporation have engaged a private partner for collection, transportation and processing of E-waste.	The door-to-door waste collecting company also separately collects e-waste and processes it according to the E-waste Rule of 2016. Karo Sambhav Private Limited has set up a collection center in Lucknow, accumulating e-waste from various zones. The total collection of e-waste last 2 months is approximately 25 kg.	
Responsibilities of the producer for implementing the Extended Producers Responsibility (Rule 5 of E-Waste Management Rule 2016)	Lucknow Municipal Corporation will ensure its registration will seek assistance of producers under EPR framework.	The registration remains pending as the State ID hasn't been generated yet. Upon issuance of the State ID, the city ID will be generated accordingly.	
F. OTHER INITIATIVES			
Sr.No	Points	Description	Current status 31.01.2024
1	Zero Waste Ward	Developing zero-waste gated colonies and wards.	Virat Khand and Parshu Nath have been developed as zero waste generators.
2	Efficient Waste Management	LMC took swift action to terminate the services of M/s Ecogreen, the company responsible for waste collection, due to their failure to fulfill their obligations. Subsequently, over 50% of malfunctioning primary and secondary waste collection vehicles were repaired to ensure prompt waste removal, benefiting the citizens of Lucknow.	The tender process for this project has successfully concluded for zones 1, 3, 4, 6, and 7. The letter of award has been formally issued to the selected company, M/s Chennai MSW Private Limited.

3	Solid Waste to Wealth	LMC adopted a "Waste to Wealth" strategy within its waste policy by implementing plans to recycle waste for biogas and electricity production. Additionally, the daily wages of approximately 8,500 sanitation workers were increased from ₹308 to ₹388, starting from September.	JBM Company has successfully installed a 20 Tons Per Day (TPD) compressed biogas facility. LMC supplies cow dung to the biogas plant, and, in return, the company provides a tipping charge of Rs. 200/- per Metric Ton (MT). This arrangement will generate approximately monthly revenue of Rs. 1,100,000 for LMC.
4	Eco-Friendly Initiatives	In line with environmental protection efforts, 90 new CNG vehicles were deployed for primary waste collection.	-
5	Waste Collection Expansion:	LMC provided 1,215 new rickshaw trailers, 300 garbage trolleys, 2,605 speed(sweeper) cycles, and 1,000 Hand Cart to facilitate primary waste collection.	Allocation aimed to enhance waste management efficiency, streamline collection processes, and ensure complete coverage for waste collection within each zone.
6	Employee Safety:	In the interest of employee safety, 4,132 safety helmets, 4,132 safety goggles, and 4,132 rubber gloves were distributed.	Distribution has been successfully completed, along with the procurement of 18 grab bucket desilting machines and super suckers.
7	Secondary Waste Collection	600 different capacity dustbins were procured to facilitate secondary waste collection.	
8	Greenery Enhancement	The green cover of Lucknow was expanded through tree planting and the development of various parks, including Amausi, Gram Saintha, Gram Rasulpur Kayasth, and green belts along various roads.	Approximately 14 hectares of new green cover areas are currently under development in Gram Rasulpur, using Miyawaki techniques for the creation of a Nagar Van. Additionally, more than 1 lakh plantations have been undertaken across various parks and vacant lands under the Municipal Corporation.
9	Drain Cleaning	A total of 414 drains were cleaned to address waterlogging issues during the monsoon.	All drains have been cleaned.
10	Tree Pruning	High trees that posed a risk were pruned using tree pruners and threader and chipper machines.	Work is currently in progress.
11	Sustainability and clean energy	LMC is transitioning its waste collection fleet to CNG vehicles and installing CNG pumps to reduce dependence on fossil fuels.	The work has been sanctioned by the committee.
12	Central Workshop Upgrade	The central workshop of LMC is being renovated and is expected to operate with modern facilities in the near future.	

4. A perusal of the above progress presented in tabulated form reveals that timeline in respect of certain works have been altered. For example- timeline to achieve 100% target for door to door collection, indicated in the previous affidavit was 30.09.2024 which has now been altered to 31.10.2024.

5. Municipal Corporation is expected to adhere to the timeline and complete the work as disclosed in the affidavit. The Commissioner is required to monitor the progress regularly and impediments, if any, need to be resolved including inter-departmental issues.

6. Learned Counsel for the Municipal Corporation, Lucknow as also the Commissioner, Municipal Corporation, Lucknow, present virtually have submitted that tenders have been floated to engage agencies for completing the work indicating in the timeline and that the entire process will be completed within 15 days and in this background, a prayer for adjournment of three months has been made so that progress under various heads can be indicated.

7. The fresh affidavit should point out clarity on activities targeted for achievement under Sr. No. 1.9, 1.10 and 1.11 in above table, relating to waste processing facilities, setting up of sanitary landfill site and remediation of old and abandoned site. The Commissioner should ensure that waste generated within Lucknow Nagar Nigam is processed in totality on day to day basis and no legacy waste is created on account of delay in setting up the adequate processing capacity.

8. Let a fresh affidavit reflecting the progress be filed by the Municipal Commissioner, Lucknow at least one week before the next date of hearing by e-mail at judicial-ngt@gov.in preferably in the form of searchable PDF/ OCR Support PDF and not in the form of Image PDF.

9. List on 20.05.2024.

Prakash Shrivastava, CP

Sudhir Agarwal, JM

Dr. A. Senthil Vel, EM

February 07, 2024
Original Application No. 654/2022
JG.

Annexure P-6

Item No. 07

Court No. 1

BEFORE THE NATIONAL GREEN TRIBUNAL
PRINCIPAL BENCH, NEW DELHI

Original Application No. 607/2024

News Item titled "In Lucknow, waste - side story plastic peril paints grim picture" appearing in The Hindustan Times dated 22.04.2024

Date of hearing: 11.09.2024

CORAM: HON'BLE MR. JUSTICE PRAKASH SHRIVASTAVA, CHAIRPERSON
HON'BLE MR. JUSTICE ARUN KUMAR TYAGI, JUDICIAL MEMBER
HON'BLE DR. A. SENTHIL VEL, EXPERT MEMBER

ORDER

Respondents: Ms. Sthavi Asthana, Adv. for UPPCB
Ms. Suman Arora, Adv. for CPCB (Through VC)

1. In this original application, registered *suo motu*, the Tribunal is examining the issue of generation of nearly 300 MT of plastic waste in Lucknow city every day as mentioned in the news item dated 22.04.2024. The news item also states that there was a fivefold jump from 59 tons in 2015 to 300 MT of plastic waste generation in the city in 2024. Vide order dated 27.05.2024 the Tribunal had impleaded respondent and issued notice.

2. Reply dated 10.09.2024 has been filed by Respondent No. 1 UPPCB. The reply is based upon some information provided by the Environmental Engineer Nagar Nigam Lucknow to the effect that the total waste generated in Lucknow city is approximately 99 tons per day. The reply does not reflect that the UPPCB made any attempt to crosscheck such information nor does it reflect how Nagar Nigam Lucknow assessed the quantity of waste generated in Lucknow city.

3. On the basis of the information so provided by the Nagar Nigam Lucknow a stand has been taken by the UPPCB that out of 99 tons per day, 86 tons per day is processed. It mentions that a penalty of Rs. 15.26 lakhs was imposed on the defaulters and recovered.

4. We find that the UPPCB has filed the reply mechanically without undertaking any exercise to ascertain the figures relating to the generation and processing of plastic waste in the city of Lucknow..

5. The news item, based on which suo motu cognizance has been taken, states about the disclosure made by the Environmentalist. It also refers to certain reports of CPCB and mentions the serious adverse effects of plastic waste on the soil quality and health of the residents. Therefore, before taking any stand and filing the reply the UPPCB was expected to carry out the groundwork meticulously and ascertain the correct position.

6. Learned Counsel for the UPPCB seeks three weeks to file a fresh report, keeping in view the observations made above.

7. Having regard to the above, we also implead additional respondent as under:

Respondent No. 5: Commissioner, Municipal Corporation,
Lucknow.

8. The office is directed to serve the newly added respondent.

9. Newly added respondent is directed to file a response/reply by way of affidavit before the Tribunal at least one week before the next date of hearing through e-filing. If any respondent directly files the reply without routing it through his advocate then the said respondent will remain virtually present to assist the Tribunal.

10. List on 12.12.2024.

Prakash Shrivastava, CP

Arun Kumar Tyagi JM

Dr. A. Senthil Vel, EM

September 11, 2024
O.A. No. 607/2024
HB..

CONCESSION AGREEMENT**Between****LUCKNOW MUNICIPAL CORPORATION****AND****BHUMI GREEN ENERGY****For**

"Supply, Installation, Commissioning of 1000TPD Municipal Solid waste (Wet & dry) extendable up to 2000 TPD processing plant at Shivari, Lucknow and its operation & maintenance for a period of 03 years"

(RFP NO-D/493/EE/24-25**Dated: 11/09/2024)****Issued on: 15/11/2024**



उत्तर प्रदेश UTTAR PRADESH

GP 707145

This Agreement is made on this 15th day of November 2024 at Lucknow, Uttar Pradesh.

BETWEEN

Lucknow Nagar Nigam, a body constituted under the Uttar Pradesh Municipalities act, 1959, having its office at Triloknath Road, Lalbagh Lucknow – 226 001 acting through its **Municipal Commissioner** (hereinafter referred "Authority/ Corporation/LMC" which expression shall unless excluded by or repugnant to the context, be deemed to include its successors and assigns); **OF THE FIRST PART** termed as **AUTHORITY**.

AND

On behalf of Bhumi Green Energy, a partnership firm having its registered office at B-14 Narayan-Bagh society Magarpatta Pune-411028 (here in after called to as "**Concessionaire**", which expression shall include its successors, administrators and permitted assigns) of the **SECOND PART**.

The Corporation and "**Concessionaire**", shall be individually referred to as Party and jointly as Parties.

Amish
LMC

अपर नगर आयुक्त
नगर निगम लखनऊ

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For Bhumi Green Energy
Kamlesh
Concessionaire
Director

RECITALS

A. The Corporation intends to substantially improve the quality-of-service delivery for mixed solid waste management activities and sought private sector participation for processing of Mixed Solid Waste (as defined below);

The Corporation floated an RFP no D/493/EE/2024 dated 11 September 2024 with respect to "Selection of Concessionaire for Supply, Installation, Commissioning of 1000TPD Municipal Solid waste (Wet & dry) extendable up to 2000 TPD processing plant at Shivari, Lucknow and its operation & maintenance for a period of minimum 03 years."

B. Concessionaire had submitted a lowest bid of Rs.988 Per M. Ton of waste to be processed to the Corporation for the Tender. This rate was further negotiated, and the Concessionaire has offered to work at the reduced rate of Rs.943 Per M. ton. The Corporation has agreed to award the Tender to Concessioner at the negotiated rate by taking proper approval by authorities and Hon. Tender committee vide resolution bearing No. dated 25 October 2024. The LMC has issued the Letter of Intent Numbered डी/667/पर्या0आभि0/24 dated 4th November 2024 (as attached herewith) and accordingly agreement has been executed on 15th day of November 2024 between the agreeing parties.

C. Therefore, the Parties have entered into this Contract Agreement to record in writing their understanding in this respect.

NOW THEREFORE, in consideration of the mutual covenants, undertakings and conditions set forth below, the receipt and sufficiency of which are hereby acknowledged, the Parties hereby agree as follows:

1. DEFINITIONS:

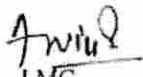
In this Agreement (including the recitals above and the schedules, annexures and exhibits hereto), except where the context otherwise requires, (i) capitalized terms defined by inclusion in quotations and/or parenthesis have the meanings so ascribed; and (ii) the following words and expressions shall have the following meanings respectively:

1.1. "Affected Party" means Party claiming to be affected by a Force Majeure Event (*hereinafter defined*) as described in this Agreement.

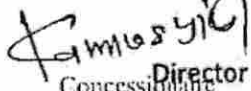
Anish
अपर नगरपालिका

For Bhumi Green Energy
Commissioner
Concession Director

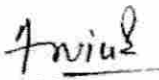
- 1.2. **"Agreement"** means this contract agreement and includes all schedules and/or exhibits annexed hereto and any amendments to this contract agreement executed by the Parties in writing.
- 1.3. **"Applicable Law"** means all laws in force and effect as of the date hereof and which may be promulgated or brought into force and effect and here in after in India, including judgments, decrees, injunctions, writs or orders of only court of record, as may be in force and effect during the subsistence of Term to be signed under this Agreement.
- 1.4. **"Applicable Permits"** shall mean all clearances, permits, authorizations, consents and approvals required to be obtained or maintained by Concessionaire under Applicable Law, in connection with the construction, operation and maintenance of the Solid Waste Processing Plant during the Term of this Agreement.
- 1.5. **"Authority"** means any agency, legislative, judicial or executive authority, department, ministry, public or statutory person, whether autonomous or not, of the Government of India or Government of Uttar Pradesh or any local authority including the Corporation or any other sub-division or instrumentality of any thereof.
- 1.6. **"By-Products"** means the products that would be derived from the processing of Mixed Solid Waste at the Solid Waste Processing Plant.
- 1.7. **"Coercive Practices"** means harming or threatening to harm, directly or indirectly, persons or their property to influence their participation in a procurement process or affect the execution of a contract.
- 1.8. **"Collusive Practices"** means a scheme or arrangement between Concessionaire, with or without the knowledge of the Authority, designed to establish prices at artificial, non- competitive levels.
- 1.9. **"Commencement Date of Phase-1"** means the date of the execution of this Agreement.
- 1.10. **"Commencement Date of Phase-2"** means the date of commencement of operations for 2000 TPD at the Solid Waste Processing Plant as and when intimated in writing by Concessionaire to the Corporation and verified by the Engineer-in Charge
- 1.11. **"Corrupt Practice"** means the offering, receiving, or soliciting, directly or indirectly, of anything of value to influence the action of a public official in the selection process or in contract execution.
- 1.12. **"Day"** means a calendar day, **"Months"** means calendar months and **"Year"** Means 365 days.


LMC
अपर नगर आयुक्त
नगर निगम लखनऊ

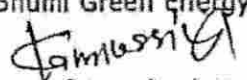
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For Bhumi Green Energy

Director
Concessionaire

- 1.13. **"Force Majeure Event"** means an event which is beyond the reasonable control of a Party and which makes a Party's performance of its obligations under the Agreement impossible or so impractical as to be considered impossible under the circumstances including but not limited to fire, storm, earthquake, flood, natural disaster, other casualty events; terrorist attacks; strikes that are not directly related to acts or labour relations of the Parties; riots or other civil unrest; or a combination of any of the foregoing, but not in any event, market or economic conditions or any such acts thereof occasioned due to negligence or willful acts or omissions of the Parties.
- 1.14. **"Fraudulent Practice"** means a misrepresentation or omission of facts to influence a selection process or the execution of a contract.
- 1.15. **"Inert"** means hazardous waste, bio medical waste, construction debris, sand, etc.
- 1.16. **"MT"** is unit for waste quantity means Metric Ton.
- 1.17. **"Mixed Solid Waste"** means any municipal Solid waste consisting of plastic, metal, thermacol, foam, glass, rexene, battery cells, paper, cloth, bio- degradable waste etc. excluding street sweepings, construction and demolition waste, Bio Medical waste, Hazardous waste, Industrial Waste, Hotel waste as defined in the SWM Rules.
- 1.18. **"Operating Year"** means each successive period, the first such period commencing from the Commencement Date of Phase-2 and ending after three hundred and sixty- five (365) days.
- 1.19. **"Phase-1"** means the period for which solid waste processing plant is installed and built and operate and maintain till the date of COD of phase 2.
- 1.20. **"Phase-2"** means the period of 3 (three) Years, wherein Concessionaire shall operate, maintain, repair and refurbish the Solid Waste Processing Plant.
- 1.21. **"Person"** means any natural person, firm, corporation, company, voluntary association, partnership, joint venture, trust, incorporated organization, unincorporated organization, Authority or other entity, having legal capacity to sue and be sued in its name.
- 1.22. **"Penalty"** means fine in rupees as per schedule 3 below.
- 1.23. **"RDF"** means Refuse-derived fuel, which is one of the By-Product of processing Mixed Solid Waste


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नगर निगम लखनऊ

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For Bhumi Green Energy

Concession Director