स्वच्छ भारत
एक कदम स्वच्छता की ओर

सत्यमेव जयते

एकच लक्ष्य शहरे स्वच्छ
स्वच्छ महाराष्ट्र अभियान (नागरी) २.०

Reference Book For
Integrated Waste Management Systems, Sanitation & IEC



KAUTILYA
MULTICREATION PVT LIMITED

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Reference Book For Integrated Waste Management Systems, Sanitation & IEC

FOREWORD

The Government of Maharashtra under Swach Bharat Mission, encourages ULBs in the state to adopt modern and scientific methods for urban solid waste management. To tackle the increasing challenges of Solid waste management, practicing the concepts of Resource recovery, circularity, and revenue generation from waste is essential. The mission aims to increase the capacities of urban local bodies (ULBs), towards meeting the sustainable development goals.

On behalf of GoM, I am pleased to launch this Handbook, 'Solid waste management, sanitation and IEC'. This handbook shall provide the technical guidance to all ULBs to incorporate sustainable waste management practices.

By equipping local bodies with the knowledge and tools necessary to develop efficient waste management systems, this handbook aims to promote cleaner, healthier, and more sustainable urban environments for residents and future generations. It will serve as a valuable reference for decision-makers, policymakers, and practitioners working towards achieving effective waste management solutions in Maharashtra.

I/We encourage the ULBs to use this handbook and thank KIF for preparing valuable resource

ABOUT THE HANDBOOK

Solid waste management practices are governed by several Central government rules, policies, State government resolutions and prescribed norms. This handbook aims to serve as a comprehensive guide or reference manual to decipher the essential information for a decision maker and practitioner of waste management for developing sustainable waste management systems for cities.

This is specifically designed for the smaller Urban Local bodies of Maharashtra to provide practical information, rules and guidelines, technologies, strategies, and best practices to address the complex challenges associated with waste management. This is meant to be a quick reference guide, and for detailed information sources and references are provided.

The handbook is structured to cover each topic related to solid waste management essential for urban local bodies. Topics covered are policies, waste quantification, waste collection, segregation, transportation, recycling, and disposal. For each topic the relevant rules, approved standards and norms; process guidelines and technologies are provided. The intent is to assist ULBs to inculcate the right practices, standards and techniques in their solid waste management related works and contracts throughout Maharashtra.

The handbook offers practical guidance on implementing sustainable waste management practices tailored to the specific needs of urban communities. It also includes information on relevant regulations, policies, and innovative technologies to optimize waste management processes and minimize environmental impact.

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List of Abbreviations

- **IEC** Information Education Communication
- **SWM** Solid Waste Management
- **HHW** Household Hazardous Waste
- **EPR** Extended Producers Responsibility
- **ULB** Urban Local Bodies
- **MoUHA** Ministry of Urban Housing and Urban Affairs
- **CPHEEO** Central Public Health and Environmental Engineering Organization
- **MOEFCC** Ministry of Environment Forest & Climate Control
- **SBM** Swachh Bharat Mission
- **BWG** Bulk waste Generator
- **GFC** Grazing Food Chain
- **CPCB** Central Pollution Control Board
- **MPCB** Maharashtra Pollution Control Board
- **C&D waste** Construction & Demolition Waste
- **WTE** Waste To Energy
- **TPD** ton per day
- **RDF** Refuse Derived Fuel
- **MSW** Municipal Solid Waste
- **MoUD** Ministry of Urban Development
- **MRF** Material Recovery Facility
- **PWM** Plastic Waste Management
- **GVP** Garbage Vulnerable Points
- **SHG** Self-help Group
- **NULM** National Livelihood Mission
- **DBO** Design Build Operate
- **BOO** Build Own Operate
- **DBOOT** Design Build Own Operate and Transfer
- **P&D** Processing & Development
- **SLB** Service Level Benchmarking
- **MSWM** Municipal Solid Waste Management
- **C&T System** Collection and Transfer System
- **Lits** Litres
- **HH** Household
- **CBO's** Community-Based Organizations
- **NGO's** Non-Government Organisations
- **RWA** Resident Welfare Associations
- **LCV** Low Calorific value
- **PPE** Personal Protective Equipment
- **MTs** Metric Tonnes
- **GPS** Global Positioning Systems

List of Abbreviations

- **MRF** Material Recovery Facilities
- **NA** Not Applicable
- **Sq. m** square meter
- **PET** Polyethylene Terephthalate
- **PP** Polypropene
- **PE** Poly Ethyne
- **SLF** Sanitary landfill
- **O&M** Operation and Maintenance
- **NGT** National Green Tribunal
- **QC** Quality Control
- **ASP** Activated Sludge Process
- **WSP** Waste Stabilization Pond
- **EA** Environmental Assessment
- **SBR** Sequential Batch Reactor-
- **MBBR** Moving Bed Biofilm Reactor
- **UASB** Up flow Anaerobic Sludge Blanket
- **DTS** Distributor Take Back Scheme
- **EAP** Emergency Action Plan
- **FAB** Fluidized Aerobic Bioreactor
- **MBR** Membrane Bio Reactor

Chapter 1:

Solid Waste Management Rules and Guidelines

Key Highlights of this Topic

- Waste Management Rules in India
- Highlights of SWM Rule 2016
- Interventions required from ULB at various stages of waste management.
- Highlights the roles and responsibilities of ULB for managing particular type of waste: Plastic waste, E-waste, C&D waste and Household hazardous waste.
- Introduction to EPR
- Policy and regulation for formalizing waste pickers as per SBM guidelines and CPHEEO norms

About the topic

- This topic covers important waste management aspects relevant to Urban Local Bodies w.r.t. MoEFCC Rules, MoUHA-CPHEEO Guidelines, CPCB and MPCB Guidelines, SBM Guidelines, and GFC Protocol.
- It covers highlights from rules and guides the user about important references from rules and the CPHEEO manual.

Summary:

General	Definition of BWG-	-Gated communities with >5000 sq.m area or >100 kg/day waste generation or properties exceeding 200 dwellings. -BWGs are mandated to install wet waste composting units, and civic bodies will only collect segregated dry waste from societies producing over 100 kg of wet waste daily.
Waste Processing	Wet waste-Duties of Department of Fertilizers	Promoting co-marketing of compost with chemical fertilizers in the ratio of 3 to 4 bags: 6 to 7 bags by the fertilizer companies
	Plastic waste (5-15%)	• ULB should set up infrastructure for segregation, collection, storage, transportation, processing and disposal of the plastic waste either on its own or by engaging agencies or producers. • Implementation of single use plastic (SUP) ban step by step.
	Criteria for waste to energy process	• The non-recyclable waste having calorific value >1500 Kcal/kg can be used for RDF and shall not be disposed of at landfill. • High calorific wastes shall be used for co-processing in cement or thermal power plants. • WTE Plant >5TPD capacity requires SPCB/CPCB approval (Form-I) • SPCB shall verify and grant permission within 60 days of application.
	C&D Waste (5%-15% of total waste)	• ULB should have 50sq.m facility for storage and sorting of C&D waste (SBM guidelines) • BWGs- >20 TPD or > 300 tons/project • Machineries for ULBs> 1 lakh population • Plant for cities with 1 millions population
Waste Disposal	Sanitary Landfill (inert + process rejects < 20% of total waste)	• The scientific landfill will be necessary for a population >1,00,000. • In case city is zero landfill: Evidence showcasing 100% processing of all municipal solid waste to be provided • The concept of Simple Landfill has been removed from both Swachh surveykshan and Star Rating Protocol. • Cities/ States are encouraged to set-up scientific landfills on a cluster basis.
	Duties of the State Authority	Facilitate establishment of **common regional sanitary landfill** for a group of cities and towns falling within a distance of 50 km (or more) from the regional facility on a cost sharing basis and ensure professional management of such sanitary landfills;
	Criteria and actions to be taken for SWM in hilly areas	• Suitable land shall be **identified in the plain areas down the hill within 25 kilometers** for setting up sanitary landfill. • In case of non-availability of such land, efforts shall be made to set up a **regional sanitary landfill** for the inert and residual waste. • Local bodies shall set up by-laws, **levy solid waste management charges for tourists.**
Other waste	Hazardous waste (0.65%)	• Establish a Hazardous waste deposit center - 1 center for 20 sq.km distance • Hazardous waste shall be collected from these facilities once in 15 days or as found appropriate by the ULB.

Table 1 : Summary of Solid Waste Management

1.1 Important Rules and Guidelines Regulate MSWM:

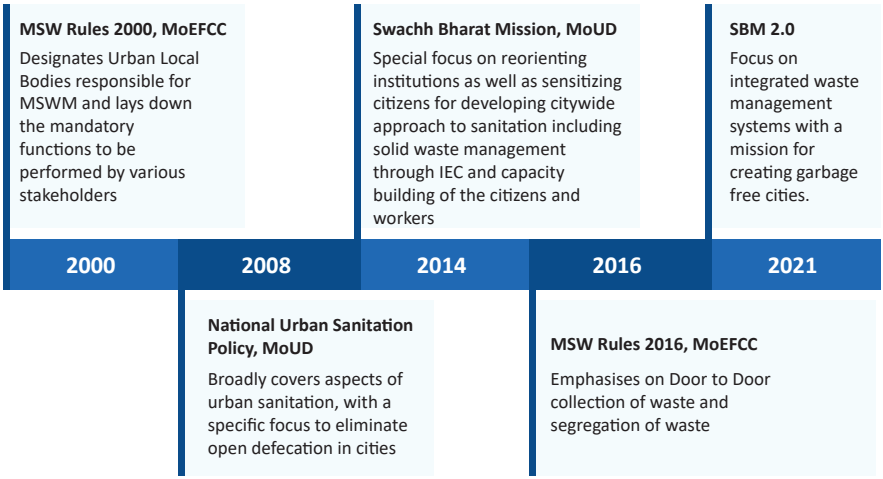


Figure 1 Importance of SWM rules

Complimenting Guidelines and Rules

- Plastic Waste Management Rules, 2011 and revised in 2016, amendments
- Bio-medical Waste (Management and Handling) Rules, 1998 and
- amended 2003, 2011 and Bio-Medical Waste Management Rules, 2016
- E-Waste Management Rules, 2011 and revised in 2016
- Battery (Management and Handling Rules) 2001
- Inter-ministerial Task Force on Integrated Plant and Nutrient Management using City Compost, 2005
- Fertilizer Control Order (FCO), 2009; PROM, 2013 by Ministry of Agriculture z Report of the Task Force on Waste to Energy, Planning Commission, 2014

1.2 The Regulatory Framework and Other Directive

MOEFCC-Rules	CPCB/MPCB/ Guidelines	SBM Guidelines and GFC Protocol	MoUHA-CPHEEO Manual	State Govt- GR

Key points of MSWM Rules 2016

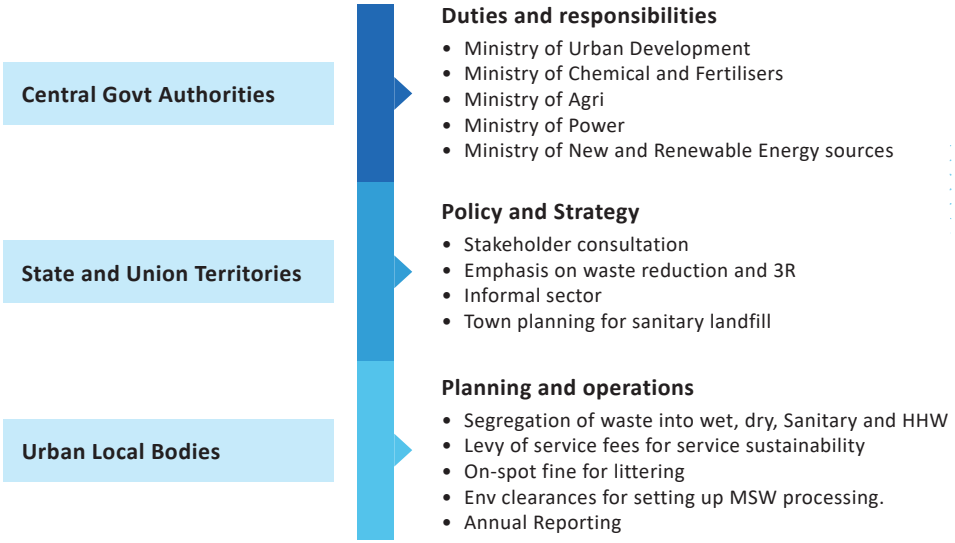


Figure 2 Key points of MSWM Rules 2016

1.3. Interventions required from ULB at various stages of waste management:

S. No.	Components	Description
1	**Source Segregation**	Source Segregation of waste at the place of its generation in following categories is fundamental to MSWM: • Biodegradable wastes (wet waste) • Non-biodegradable wastes (dry waste) • Sanitary waste • Domestic hazardous wastes • Construction and Demolition waste • E-waste (should not mixed with dry waste)
2	**Door to Door Collection**	Collection of solid waste from the doorstep of residential or any other non- residential premises, including collection of such waste from entry gate or a designated location on the ground floor in a housing society, multi storied building or apartments, large residential, commercial or institutional complex or premises;
3	**Separate transportation**	Transportation of the segregated waste collected from source premises in specially designed, partitioned and covered transport vehicles, to the respective processing facilities.
4	**Waste Processing**	Processing of different fractions of MSW i.e. dry, wet, C & D and plastic as per Solid Waste Management Rules 2016. Processing is to be done differently for different categories of waste
4(i).	**Wet Waste**	• Promoting of Home / Family sized Decentralized Composting Community /larger Decentralized (Less than 5 TPD) composting facilities • Setting up Centralized composting facilities (More than 5 TPD) • Setting up Bio-methanation - most suited for segregated wet waste like food waste from hotels/restaurants, and waste from dairy, vegetable market, meat/fish markets, mela waste etc.
4(ii).	**Dry Waste**	**Setting up the following:** **1. Material Recovery Facility (MRF)** - segregation, sorting of recyclables, non recyclables and inerts. • **Recyclables-** to nearby recycler • **Non-recyclables**-The non-recyclable/ combustible waste is to be sent to the Waste to Energy plant/ Cement kilns as Refuse Derived Fuel (RDF). • **Inerts-** To SLF 2. **Incinerators:** Sanitary napkins and Diapers are to be separated, specially marked and sent to a bio-medical waste/ waste to electricity plant for incineration. 3. **Waste to Electricity plants:** The combustible fraction of waste out of MRF/ Processing Facilities which is non-recyclable and has calorific value of 1,500 Kcal per kg and above can be used in waste to electricity plants.
4(iii).	**Sanitary Landfill**	• Only the inert waste (mostly from street sweeping) and process rejects (in no case should this exceed 20% of total waste) can be sent to sanitary landfills. • The scientific landfill will be necessary for a population >1,00,000. • In case city is zero landfill: Evidence showcasing 100% processing of all municipal solid waste to be provided • The concept of **Simple Landfill** has been removed from both Swachh Survekshan and Star Rating Protocol. Cities/ States are encouraged to set-up scientific landfills on cluster basis

4(iv).	**C&D Waste**	• Construction and Demolition (C&D) waste and unusable combustible: **5 – 15%.** • It consists mostly of inert, non-biodegradable material such as concrete, soil, steel, wood and plastics, bricks and mortar etc. C&D waste is sorted into different streams and sent to the C& D waste processing plant. • ULB should have **50sq.m facility** for storage and sorting of C&D waste (SBM guidelines)
5	**Bulk Waste Generators**	All Bulk waste generators have to manage their own wet waste and also make their own arrangements for dry waste management. **BWGs- >100 kg of waste or having >5000sq.m area**
6	**User Fee**	Suitable User Fee and relevant penalty provision needs to be notified by all ULBs as per Rule 15 (ze) (zf) of SWM Rules 2016 on the lines of advisory circulated by MoHUA.

Table 2 Interventions required from ULB at various stages of waste management easy references from SWM rule 2016

SPECIFIC ULB RESPONSIBILITIES - MSWM RULES 2016:

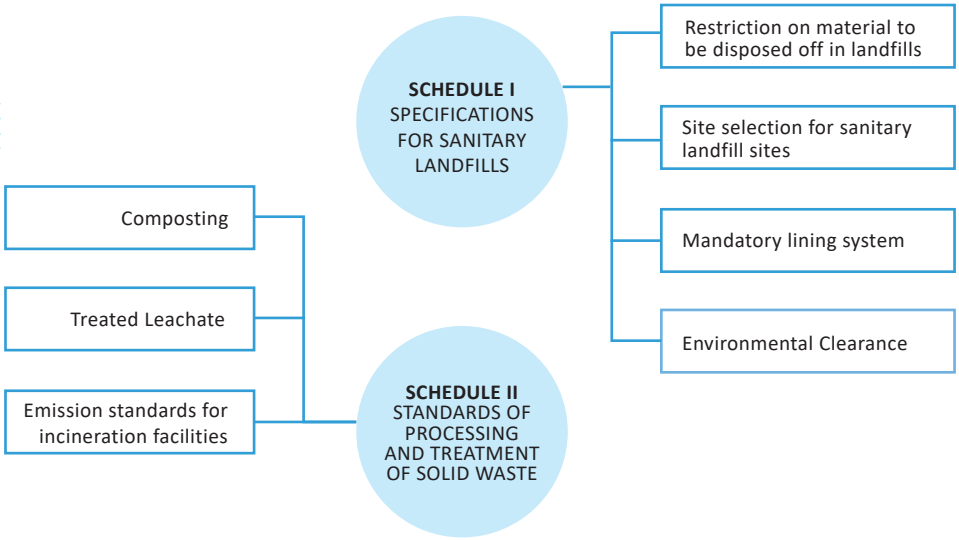


Figure 3 Responsibilities of ULB

1.4 Plastic Waste Management (PWM) Rule and Guidelines:

PWM Rule 2016 highlights the responsibilities of the producer, generator, manufacturer or importer, and local body.

1.4.1 Responsibility of the local body

- 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.
- Setting up, operationalization and coordination of the waste management system and for performing the associated functions.
- Setting up of system for plastic waste management and frame bye-laws for plastic waste

1.4.2 Classification of plastics

Category 1	Rigid plastic for packaging
Category 2	Flexible plastic packaging of a single layer or multilayer, plastic sheets and covers made of plastic sheets, carry bags, plastic sachet or pouches
Category 3	Multi-layered plastic packaging (at least one layer of plastic and at least one layer of material other than plastic)
Category 4	Plastic sheet or like used for packaging as well as carry bags made of compostable plastic

For more details refere: (https://cpcb.nic.in/uploads/plasticwaste/2-amendment-pwmrules-2022.pdf)

1.5 EWM - Rule, Amendment, and Guidelines

1.5.1 Responsibilities of Urban Local Bodies

1. To ensure that e-waste if found to be mixed with Municipal Solid Waste is properly segregated, collected, and is channelized to a registered recycler or refurbisher.
2. To facilitate setting up e-waste collection, segregation and disposal systems.
3. Conducting training sessions to develop capacities of the urban and rural local bodies

1.5.2 Types of E-waste

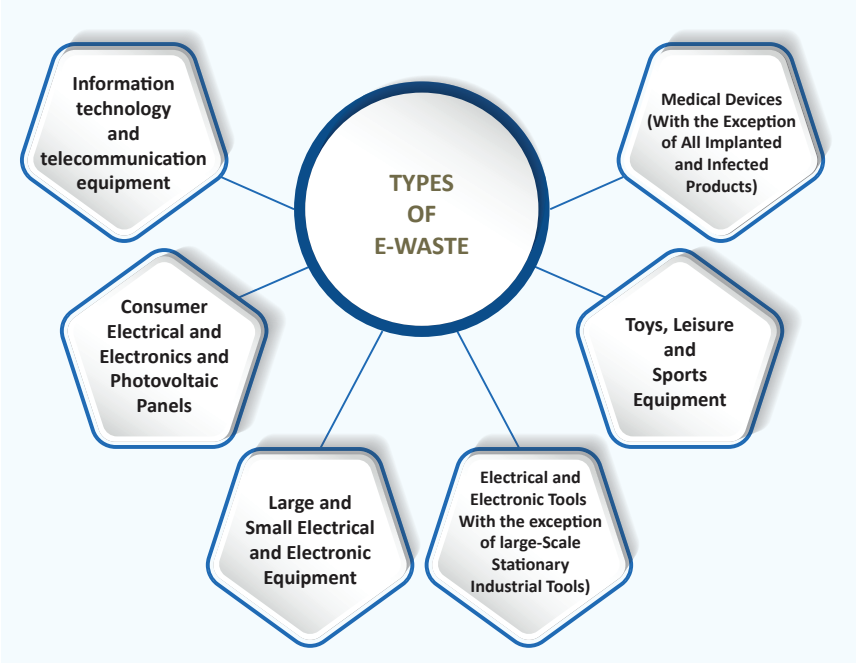


Figure 4 Types of E-waste

For details: Refer E-waste management Rule, Amendment 2022.
(https://cpcb.nic.in/uploads/Projects/E-Waste/e-waste_rules_2022.pdf)

1.5.3 Key Highlights:

Storage of e-waste	EPR Certificate Generation.	Refurbishing	Schedules	Form-I
Every manufacturer, producer, refurbished, and recycler may store for 180 days only and shall maintain a record of sale, transfer and storage of e-waste.	Through CPCB for registered recyclers in the prescribed format only Quantity eligible for generation of EPR certificate (QEPR= Qp x Cf) (Qp is the quantity of the end product and Cf is the conversion factor) Validity: 2yrs	Need to get registered on portal. EPR obligation will be extinguished only after end of life disposal through a registered recycler and producing EPR certificate and not by refurbishing certificate.	**SCHEDULE I:** List of types of E-waste **SCHEDULE II:** List of exempted appliances **SCHEDULE III:** E-Waste Recycling Target (Weight)	Applicable to producers seeking Extended Producer Responsibility

Table 3 Easy references from EWM rule

1.6 C&D waste management - Rule, Amendment, and Guidelines

1. Construction and Demolition (C&D) waste and unusable combustible: 5 – 15%.
2. Waste generators who generate **more than 20 tons or more in one day or 300 tons 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
3. The Ministry of Urban Development (MoUD) vide its circular dated 28th June, 2012 stated that all states **to set up C&D waste recycling facilities in all cities with a population of over 1 million.**

1.7 HMW - Rule, Amendment, and Guidelines

Hazardous waste means any waste that by reason of characteristics such as physical, chemical, biological, reactive, toxic, flammable, explosive or corrosive, causes danger or is likely to cause danger to health or the environment, whether alone or in contact with other wastes or substances.

1. At the household level, dry waste, wet waste, and domestic hazardous waste should be stored in separate garbage bins. Because the rule does not specify the color of the bins for storage of domestic hazardous waste, **urban local bodies (ULBs) should decide on an appropriately coloured bin.**
2. **Establish collection systems** (e.g., community pick-up points or delivery systems through the retail trade) for domestic hazardous waste and special waste. **Wastes may be collected from these facilities once in 15 days or as found appropriate by the ULB.**
3. ULB should establish waste deposition centers for domestic hazardous waste and give directions for waste generators to deposit domestic hazardous wastes at this center for its safe disposal. Such facility shall be established in a city or town in a manner that **one center** is set up for the area of **twenty square kilometers** or part thereof and notify the timings of receiving domestic hazardous waste at such centers;
4. 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.
5. 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.**
6. **Rotary kiln incinerators** are typically used for incineration of hazardous waste and biomedical waste

1.8 Introduction to EPR

EPR is defined as 'an environmental policy approach in which a producer's responsibility, physical and/or financial, for a product is extended to the post-consumer stage of a product's life cycle.' It brings in the approach of

1. Shifting of responsibility upstream towards the producer and away from municipalities.
2. Providing of incentives to producers to include environmental considerations in their product design, such as:
    - Reducing material consumption,
    - Using more secondary material,
    - Promoting product eco-design

1.8.1 Different tools used worldwide under EPR strategy:

Administrative tools	Economic tools	Informative tools	Agreements
Collection and/or take back	Material/ Product Taxes (Pay as you throw)	Environmental reports/ labeling	Social contracts
Recycling and reuse targets	Subsidies	Information provision to recyclers	Gentlemen's agreement
Emission Limit	Advanced disposal fee system	Consultation with authorities about collection network	
Recovery Obligation	Deposit- refund system		
Standards	Upstream Tax/Subsidy		
	Recycler/ Producer credits		

Table 4 Tools used worldwide under EPR strategy

1.8.2 EPR Timeline in India

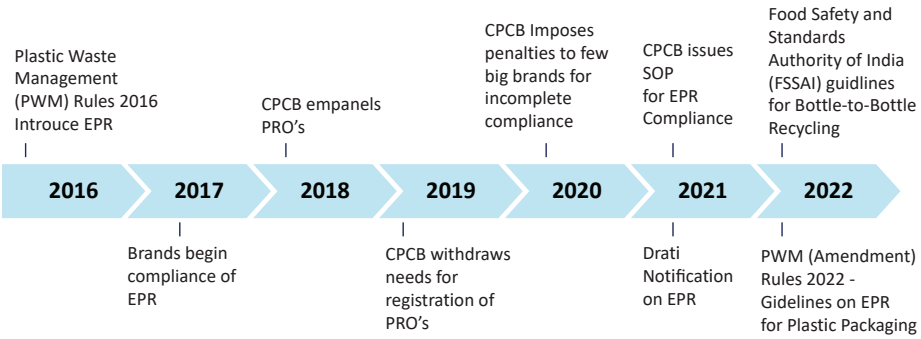


Figure 5 EPR Timeline in India

1.8.3 EPR Guidelines for ULB for Various Types of Waste

a) EPR on Plastic Waste Management

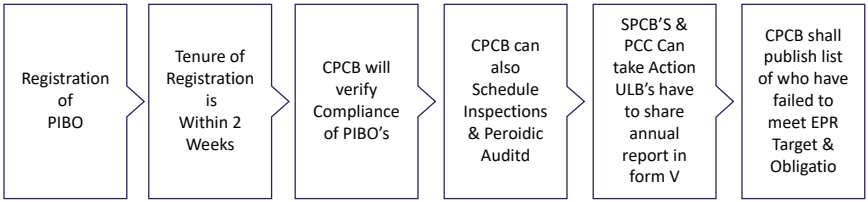


Figure 6 ERP on Plastic Waste Management

b) EPR for Tyre Waste

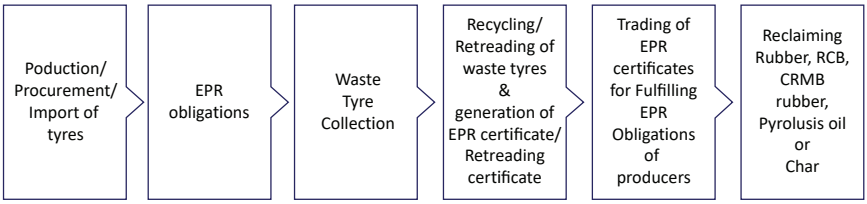


Figure 7 EPR on tyre waste

c) EPR for Battery Waste



Figure 8 EPR on Battery waste

d) EPR for E-Waste

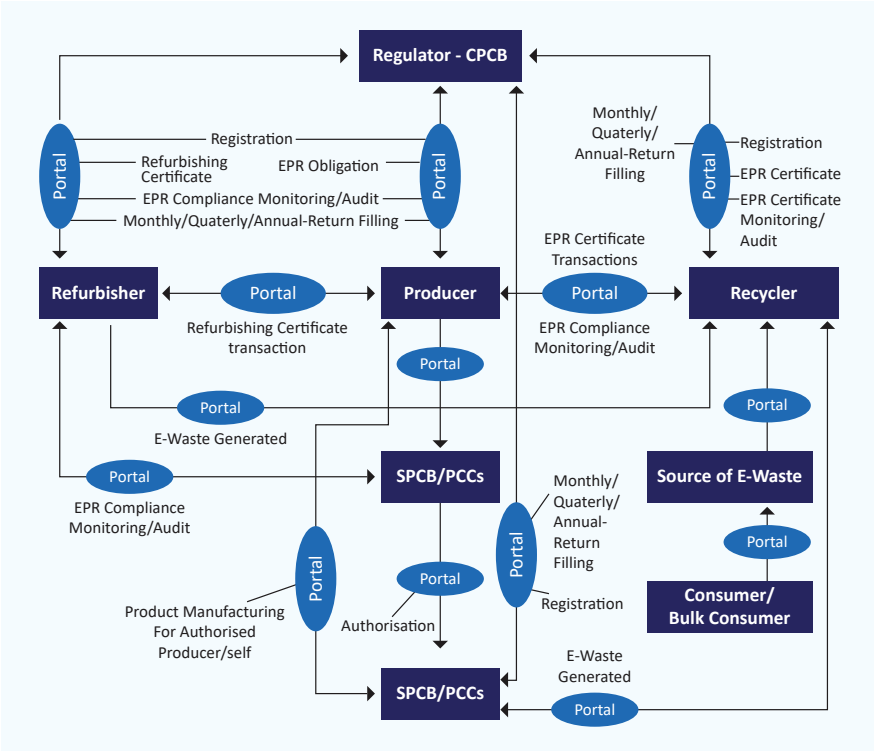


Figure 9 EPR on E-waste

As per CPHEEO Municipal Solid Waste Plan has clearly mentioned that "ULBs should also encourage local level initiatives based on the principles of EPR''

1.8.4 Indore's Achievements:

Indore Municipal Corporation (IMC) is the first urban body in India to receive Extended Producers Responsibility (EPR) credit.

Indore Initiative of EPR	• IMC first urban body in India to receive EPR credit • Complete ban on single-use plastic items. • Eight tonnes of plastic seized and recycled.
EPR & Recycling Plant	• EPR: Environmental policy for post-consumer product responsibility. • EPR credit: Rs 8,100 for IMC's responsible waste management. • Recycling plant: PPP model to convert plastic waste into reusable materials.
Efficient Solid Waste Management	• Solid waste: 1,162 tonnes daily, including 164 tonnes of plastic waste. • Waste collection system: Categorization and collection from every doorstep. • Waste disposal: Recycling plant for clean and sustainable city.
Achievements	• Cleanest city in India for six years in a row. • EPR model for other cities to follow.

Figure 10 EPR Indore Model

1.9 Integration of the informal sector in the value chain

1.9.1 Policies or regulations:

Policy and Guidelines	Key Highlights
National Environment Policy, 2006	It acknowledges the informal waste sector and states, "Give legal recognition to, and strengthen the informal sector systems of collection and recycling of various materials. In particular enhance their access to institutional finance and relevant technologies."
National Action Plan on Climate Change, 2009	It stresses the need for giving legal recognition to the informal sector, which it recognizes as the "backbone of India's highly effective recycling system"
National Labour Commission, 2002	It "recognizes the useful role played by the scrap collectors both in helping recycling activities as well as in maintaining civic hygiene. It is, therefore, essential that they should be protected from insecurity of various forms. The measures that could be thought of in this regard are providing identity cards, receipts for transactions, minimum wages when they are employed by contractors or other employers, health facilities, creation of welfare funds, prohibition of child labour from the activity and the likes. The Commission fully endorses the suggestions made by the United Nations Development Programme (UNDP) and the International Labour organization (ILO)
SWM Rules, 2016	Recognises the role of the informal sector in waste management, and emphasis on establishing a system for integration of these waste collectors in order to facilitate their participation in SWM. Progressive regional legislation that facilitates integration of the informal waste sector into formal systems has been made in some of the Indian states like Maharashtra.

Table 5 Policies and regulations for integration of informal sector

1.9.2 Certain enabling conditions and supportive actions for promoting the integration of the informal sector include:



Figure 11 Actions for promoting the integration of the Informal Sector

1.10 Maharashtra State SWM Byelaws for Urban Local Bodies

1.10.1 The State SWM Byelaws for Urban local bodies cover the following:

Chart of SWM byelaws:

Responsibilities of Citizens and ULB			
S. No.	**Parameter**	**Citizen**	**ULB**
1	Littering	1.Citizens need to avoid littering in any public or private place, occupied or vacant, except in authorized receptacles. 2. Do not throw the waste from any vehicles on streets, roads, sidewalks, etc.	Provide sufficient and accessible litter bins and waste receptacles along major roads and public places.
2	Awareness generation	Citizens need to follow the ULB guidelines about waste segregation, collection and other guidelines	ULB needs to regularly announce specific color codes and specifications for waste bins to ensure safe and efficient waste collection without mixing or spillage.
3	Waste Segregation	**A. Citizens should segregate their waste in 4 basic categories** 1. Dry waste. 2. Wet waste. 3. Sanitary waste. 4. Domestic hazardous waste **B. Generators should keep the following waste separate** 1. Construction and Demolition waste 2. Bulk Garden and horticulture waste	1. Provide segregated waste collection facilities with mandatory color coding. 2. Collect Segregated waste from citizens 3. Take actions if contractors/ employees for collection mix segregated waste.
4	Construction and Demolition waste	Generators should store and deliver the waste to spots notified by ULB or pay the stipulated charges for collection of the waste.	1. Set up a local help line for C&D waste collection service, 2. Stipulate charges for collection 3. Identify locations for depositing or processing of C&D waste.
5	Burning of waste	Disposal by burning of any type of solid waste at roadsides, or at any private or public property is prohibited.	1. Take strict action and fines for burning of waste. 2. Staff to be trained to ensure no burning of waste occurs.

6	Collection and Transportation	1. Citizens should follow the waste collection and transportation schedule set by the ULB. 2. Pay the regular user fee for waste collection and transportation	1.The waste collection schedules and routes for Urban Local Bodies (ULBs) will be predetermined, published by officials, and made accessible on the ULBs' website as well as at various city locations. 2.ULB or its licensees will provide information to the public and bulk waste generators regarding the collection of construction and demolition waste, and garden waste. 3. A bell/horn/ announcement (whose sound must not be over the permissible sound limit) should be fitted on the vehicle of garbage collection/blown by workers so that the residents can be made aware of collection being undertaken.
7	Recycling and reuse	Citizens should segregate recyclable materials and try to reuse possible items.	1. The ULB shall facilitate information about the recycling of dry waste by listing dry waste sorting centers on their website. 2. They should provide an MRF center or storage place for storing recyclables.
8	Processing of waste	1. Citizens should give segregated waste to the ULB collection system for proper processing of waste. 2. Citizens should compost their wet waste.	1.ULBs need to process the waste as per the MSW rule guidelines 2. ULB shall facilitate information about composting through composting centers listing them on its website.
9	Street sweeping	1. Citizens must segregate Construction and Demolition waste at its source. 2. Pay the user fee according to the rules for collecting C&D waste.	1. Ensure arrangements for cleaning daily or at set intervals and all the year through at all the public roads, places, colonies, slums, local body, markets and tourism places, parks of the urban body, cremation grounds etc.

10	Domestic Hazardous waste	Citizens should store Domestic hazardous waste in a covered Bin separately.	1. Provide vehicles weekly/ periodically for collection of Household Hazardous waste through MPCB authorized agency.
11	Garden waste	Garden and horticultural waste should be kept un-mixed and composted at source.	The ULB will issue instructions and guidelines concerning the pruning of trees, as well as the storage and delivery of tree trimmings, including segregated garden and horticultural waste. These guidelines will involve the imposition of appropriate fees, as notified by the ULB from time to time, for the purpose of collection and transportation to its facility.
12	Monitoring and Grievance redressal	Contact the ULB about any waste management issues.	Establish the complaint redressal center

Table 6 Chart of SWM bye-laws1.10.2 Action against Transport Contractors/Employees of Municipal Corporations:

If any worker of the contractor or of any Municipal Corporation mixes segregated waste at any point of collection, or fails to pick up waste as per the specified time schedule, action can be taken against the person or agency.

1.10.3 User fee As per Maharashtra state Bylaws-For MSW Generation Below 100 kg (Non-BWG)

S. No.	Particulars	Class A & B	Class C
1	Per Property	30	15
Commercial Establishment			
2	Shops, Hospitals	45	30
3	Showrooms	80	60
4	Storage Centres	80	60
5	Hotels and Snacks Centers	160	120
6	Hotels which have facilities of stay & food	200	160
Hospitals			
7	Bolow 70 Beds	80	60
8	More than 50 Beds	120	90

Institutions			
9	Educational Institutes,Hostels	60	45
10	Religious institutions	60	45
11	Government/semi government offices	60	45

Table 7 User fee as per Maharashtra state bylaws (Non-BWG)

1.10.4 User fee As per Maharashtra state Bylaws-For MSW Generation above100 kg (BWG)

S. No.	Categorization	Municipal Council	
		Class A & B	Class C
1	Marriage halls,/Recreational hall, 'Single Screen Theatre	1000	500
2	Mall "' Multiplex	30	15
3	Hackers	300	200
4	Seasonal stalls or Recreation Activities such as Anand mela/Satsang/Funfair/Cracker stall) etc	One-time charges as decided by ULBs and rust monthly based	

Table 8 User fee as per Maharashtra state bylaws (BWG)

1.10.5 Fines As per Maharashtra state Bylaws for littering and creating nuisance. (Minimum fines in Rupees)

Schedule-I
Part B: Fines

Littering, Creating Nuisance and Clean Aangan Violation fines (Minimum Fines In Rupees)			
S. No.	Categorization	Municipal Council	
		Class A & B	Class C & D
Segregation, storage, delivery and collection violations			
1	For delivering waste that is not segregated and not stored in separate bins:		
	a) Households/Commercial establishment		
	1st instance	300	200
	Every repeated instance	500	300
	b) bulk generator		
	1st instance	5000	3000
	Every repeated instance	15000	9000
2	For burning waste	5000	5000
Specific Categories / Situations			
3	For not cleaning-up after public gathering / event within 4 hours	Forfeiture of cleanliness deposits	

Table 9 Spot fines chart

Notes

Chapter 2:

Waste Quantification and Gap Analysis

Key Highlights of this Topic

- Source of waste and waste flow in waste management value chain
- Waste quantification and characterization as per the CPHEEO norms
- Methodology for Gap Analysis for setting up waste management system

About the topic

- For easy referencing important parameters in the overall waste management system are shown in flow diagrams.
- Decision making charts will guide users about actions required for effective waste management.

Summary:

Waste Processing	• Per capita/year increase in waste generation quantity-**1.3 %/ year** • Annual increase in waste quantities-**5% per year.** • Per capita waste generation for population **<1 lakh-300 gm/capita/day** • Per capita waste generation for population **1 lakh-10 lakh-450gm/capita/day**
Waste Disposal	• Organic/compostable fraction: 40 – 60%; • Recyclable/ Resource Recoverable fraction: 20 – 30%; • Non-Recyclable/ Combustible (RDF): 10 – 20%'; • Construction and Demolition (C&D) waste and unusable combustible: 5 – 15%.
Waste characterization	**Density of waste for design consideration:** • Wet waste-**0.5t/cum**[1] • Gross Density of Digested Compost- **0.7t/cum**[2] • Gross Density of Finished Compost - **1 t/cum**[3] • Dry waste-**0.45t/cum**[4] • Inert waste (10-15% of total waste)-**0.85t/cum**[5] • C&D waste-**0.6 t/cum**[6]

Table 10 Summary of Overview of Solid Waste Management

Volumetric calculation for designing processing facility							
Quantity of Wet waste in tons			**1**	**5**	**10**	**15**	**20**
	Volume	**Unit**	**Design Capacity(volume)**				
Wet waste	0.5	Ton/cum	0.50	2.50	5.00	7.50	10.00
Gross Density of digested Compost	0.7	Ton/cum	0.35	1.75	3.50	5.25	7.00
Gross Density of Finished Compost	1	Ton/cum	0.35	1.75	3.50	5.25	7.00
Quantity of Dry waste in tons			**1**	**5**	**10**	**15**	**20**
Dry waste	0.45	Ton/cum	0.45	2.25	4.50	6.75	9.00
Quantity of Inert waste in tons			**1**	**5**	**10**	**15**	**20**
Inert waste (10-15% of total waste)	0.85	Ton/cum	0.85	4.25	8.50	12.75	17.00
Quantity of C&D waste in tons			**1**	**5**	**10**	**15**	**20**
C & D waste(5-10% of total waste)	0.6	Ton/cum	1.67	8.33	16.67	25.00	33.33

Table 11 Volumetric calculation for designing processing facility

Reference:

*SBM 2.0 Operational Guidelines, Page no. 47

[1](1.4.3.3.3 Physical Characteristics of Municipal Waste, Page no 48 Part 2 of Solid Waste Management Manual 2016.)

[2]Page no 245 Technical aspects of processing and Treatment of municipal solid waste)

[3](CPHEEO Manual, Chapter 3.2.11.1 Quality Parameters for Compost Production (Page no 273)

[4](Physical Characteristics of Municipal Waste, Page on 43, Part 2 CPHEEO manual for SWM.)

[5](Annexure 17.1 of CPHEEO)

[6](Guidelines on Environmental Management of C&D Wastes (CPCB, 2017) , Page no 66 Case of Ghaziabad)

2.1 Source of waste and waste flow in waste management value chain

Waste flow Diagram

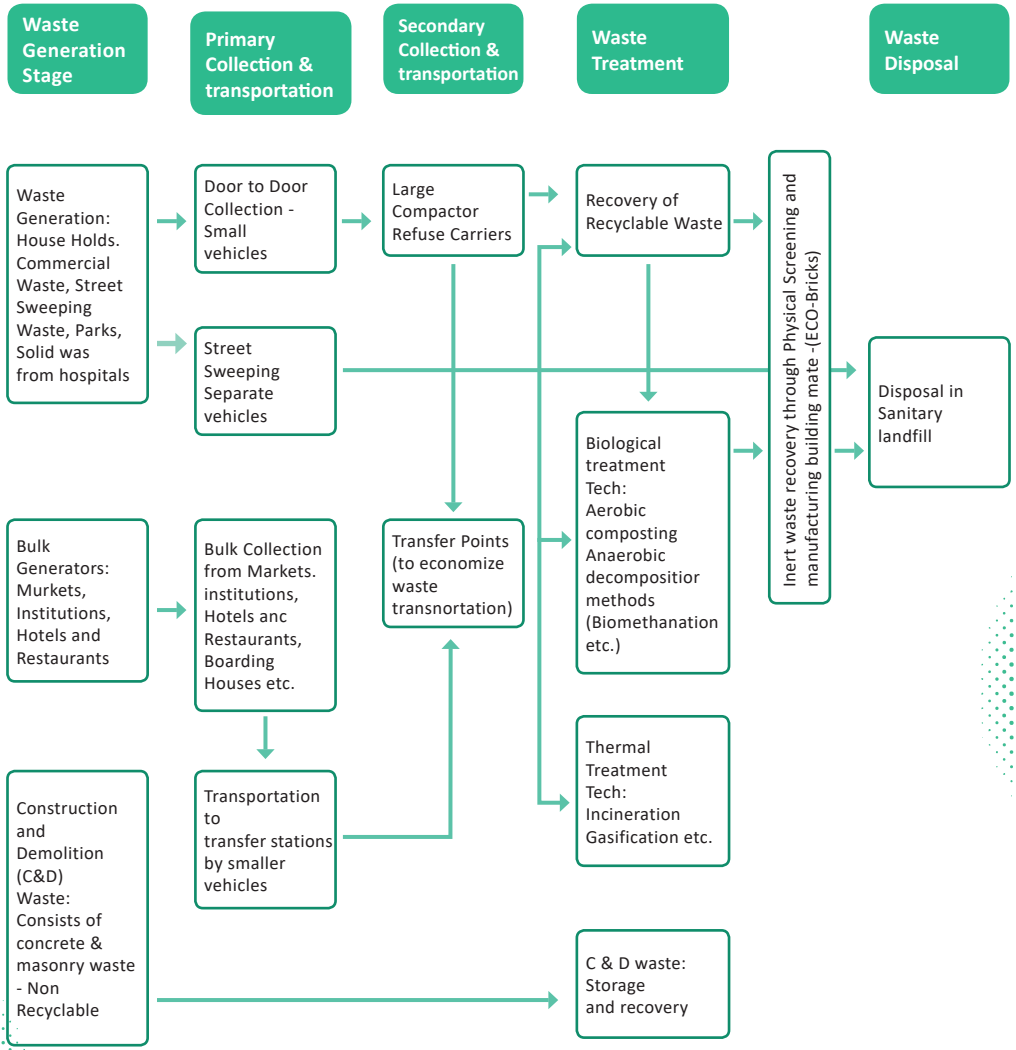


Figure 12 Waste Flow Diagram

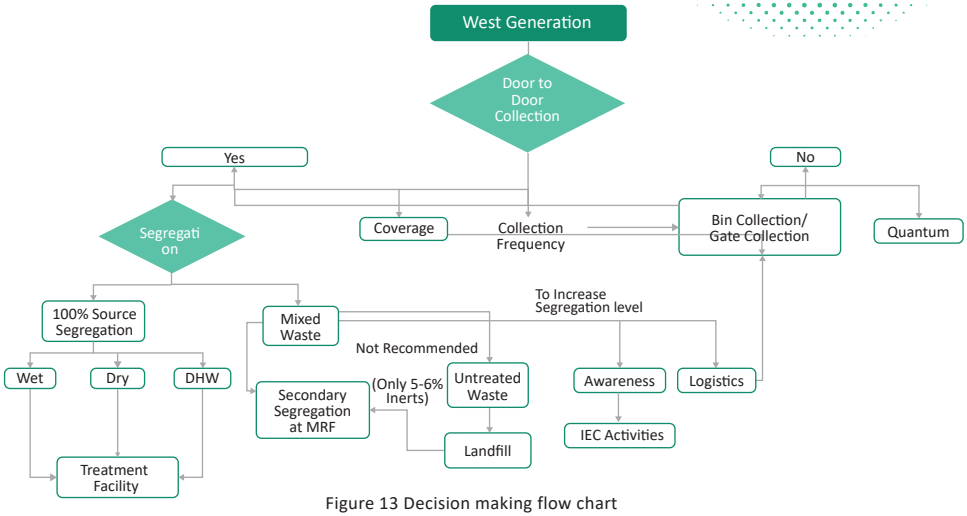


Figure 13 Decision making flow chart

2.2 Waste Quantification and Characterization

2.2.1 Per capita waste generation rate:[1]

Per capita/year increase in waste generation quantity	1.3 %/ year
Urban population growth rate	3.0%–3.5% per year
Annual increase in waste quantities	5% per year.

(reference 1: CPHEEO Manual Part 2: Page no, 42)
Table 12 Per capita waste generation rate

2.2.2 Other studies and observations indicate that the waste generation rate:[2]

Population below 2,00,000	200-300 gm/capita/day
2,00,000 and 5,00,000	300–350 gm/capita/day
between 5,00,000 and 10,00,000	350–400 gm/capita/ day
above 10,00,000.	400–600 gm/capita/day

(reference 2: CPHEEO Manual Part 2: Page no, 44)
Table 13 Waste generation rate

Sample calculations for per-year growth:

Population	Considerations	10000	25000	50000	100000
Total waste generation(ton/day)	300gm/cap/day	3	7.5	15	30
Total population in next year	3.0% per year	10300	25750	51500	103000
Total waste waste quantities in consecutive year (Ton/day)	5% per year.	3.24	8.11	16.22	32.45

Table 14 Sample calculation for yearly waste generation

2.2.3 Composition of Municipal Solid Waste: The range in municipal solid waste is as given below:

- Organic/compostable fraction: 40 – 60%;
- Recyclable/ Resource Recoverable fraction: 20 – 30%;
- Non-Recyclable/ Combustible (RDF): 10 – 20%';
- Construction and Demolition (C&D) waste and unusable combustible: 5 – 15%.

Sample calculation for waste – composition in the city:

Quantity of waste in tons	Composition % assumed	5	10	15	20
Wet waste	60%	3	6	9	12
Dry waste	40%	2	4	6	8
Recyclables in dry waste	25%	1.25	2.5	3.75	5
Non recyclables	15%	0.75	1.5	2.25	3
Inert +process rejects(%of total waste)	12%	0.6	1.2	1.8	2.4
C&D waste (% of total waste)	15%	0.75	1.5	2.25	3
Sanitary waste (% of total waste)	0.60%	0.03	0.06	0.09	0.12
HHW (% of total waste)	0.60%	0.03	0.06	0.09	0.12

Table 15 Sample calculation for types of waste generated in the city

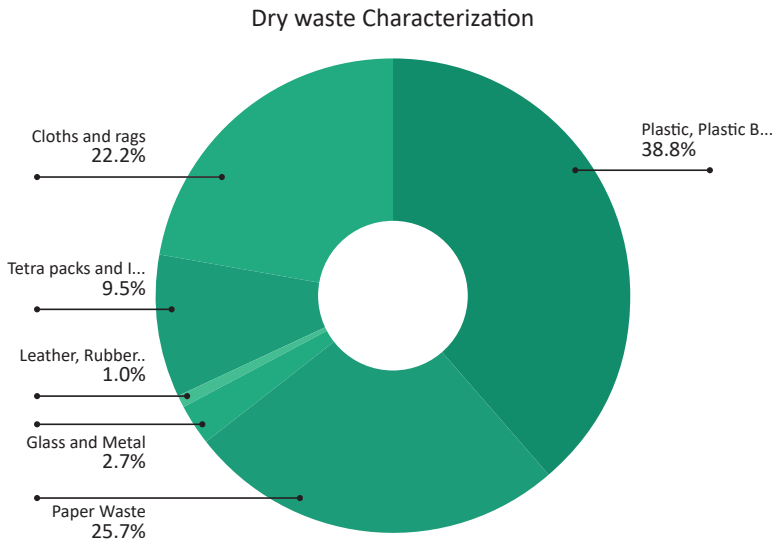


Figure 14 Dry Waste Characteristics

2.3 Identification of gaps

Methodology for Gap Analysis while setting up a waste management system for a ULB. The ULB should assess its current status on the below-mentioned parameters and project the desired future scenario for these parameters to identify the gap in waste management services.

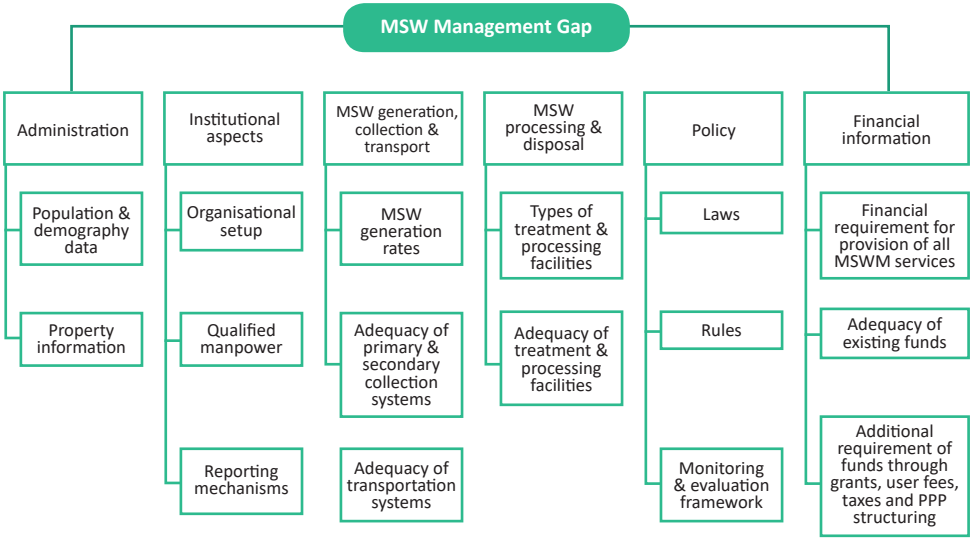


Figure 15 Identification of Gap Analysis
(Source: CPHEEO Manual: Part 2)

2.3.1 Service Level Benchmarks (SLB)

S. No.	Indicator	Unit & Definition	Value
1	Household level coverage of SWM services	As % of households and establishments that are covered by daily doorstep collection system	100%
2	Efficiency of MSW collection	As % of total waste collected by ULB and authorized service providers versus the total waste generated within the ULB, excluding recycling or processing at the generation point	100%
3	Extent of MSW segregation	As % of segregated waste from households and establishments (segregation should at least be at the level of separation of wet and dry waste at source)	100%
4	Extent of recovered MSW	As % of waste collected (this is an indication of the quantum of waste collected, which is either recycled or processed)	80%

S. No.	Indicator	Unit & Definition	Value
5	Extent of scientific disposal of MSW	As % of waste disposed in a sanitary landfill sites versus total quantum of waste disposed in all sanitary landfills and dumping sites	100%
6	Efficiency in redressal of customer complain	As % of total number of SWM related complaints resolved in 24 hours versus total number of SWM complaints received within the period	80%
7	Extent of cost recovery in SWM services	As % recovery of all operating expenses related to SWM services that the ULB is able to meet from the operating revenues of sources related exclusively to SWM	100%
8	Efficiency in collection of SWM charges	Current year revenues collected as a % of the total operating revenues for the corresponding period	90%

Table 16 Service level benchmarks for solid waste management

Notes

Chapter 3:

Behavior change and strategy to achieve source segregation

Key Highlights of this Topic

- Approaches for citizen awareness and participation
  1. Information Education and Communication (IEC)
  2. Behaviour Change Communication
  3. Six steps of Behaviour Change Model
  4. Nudges
- Modes of Communication
- Sample activities for citizen awareness
- Budget line items for citizen awareness and participation.

About the topic

- This chapter helps decision makers to decide an approaches for citizen awareness and participation
- Decide tools for communication to achieve awareness and desired impact in existing systems
- Chapter also gives some ready to use examples of awareness activities using different IEC tools

Summary:
BCC for Segregation:

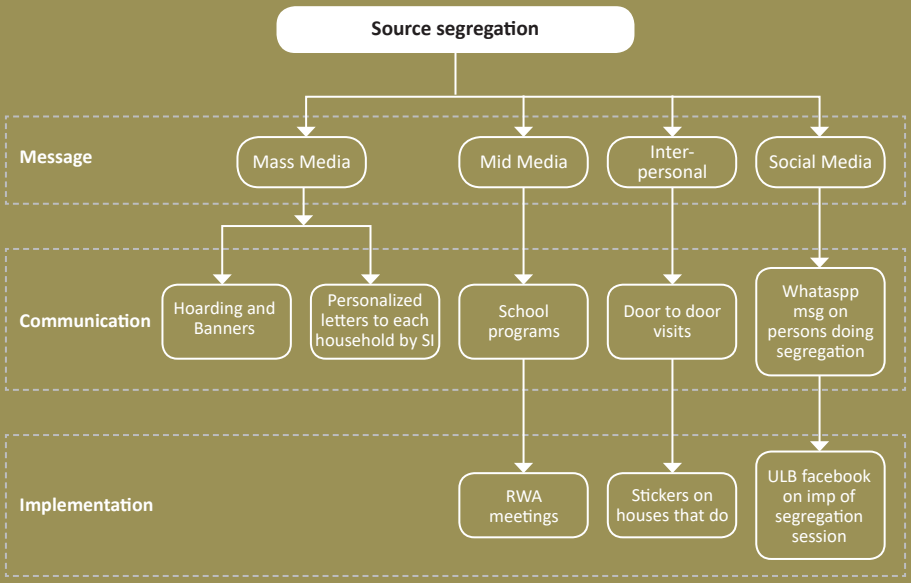


Figure 16 BCC for segregation

Expanded BCC activities for waste segregation is provided in Table 14.

3.1 Approaches for citizen awareness and participation

Following is an overview of a few approaches and concepts that can be used in designing a citizen awareness strategy:

3.1.1 Information Education and Communication

This is an approach based on three principles:

- Provide information in public domain
- Educate through formal system and targeted trainings
- Communicate through by spreading the message

This approach has been used extensively for several government programs such as Polio immunization, family planning etc.

3.1.2 Behavior Change Communication

A programmatic approach to creating long term shifts in habits. Behavior Change Communication (BCC) refers to the strategic use of communications to positively influence people's knowledge, attitudes, and practices.[1] The approach is based on first understanding why citizens behave in a certain way, then defining the changes required/expected and designing customized messages and activities for implementation. It thus relies on a good understanding of the psychology of humans.

It is an interesting approach and has shown excellent results especially in the WASH sector. The Behaviour Change Communication works on taking citizens through six stages of change through continuous nudges and communication to the desired behavior. Thus it needs time, and cities have to have a long term strategy to see its impact and success.

3.1.2 Behavior Change Communication

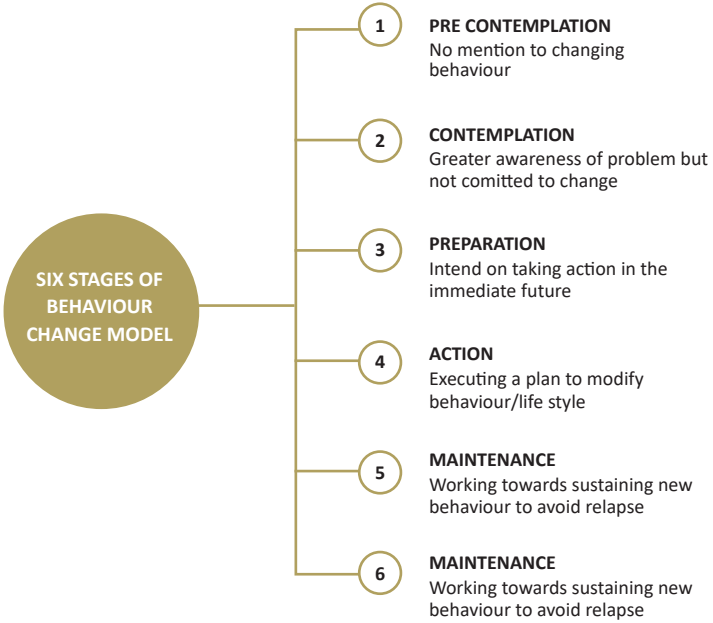


Figure 17 Six steps of Behaviour Change in Individuals

Example: Results of an experiment in the Netherlands showed that a sign around bins with messaging 'Help to keep it clean here: most people in this neighborhood do not litter around the containers' helped reduce the littering frequency from 50 percent to 30 percent.[3]

[1] https://iwrmactionhub.org/learn/iwrm-tools/behaviour-communication-change
[2] https://iwrmactionhub.org/learn/iwrm-tools/behaviour-communication-change
[3] https://yourstory.com/socialstory/2022/04/behavioural-nudges-sustainability

3.1.4 Nudges:

"An intervention, from either private or public institutions, that affects people's behavior while fully maintaining their freedom of choice" [4] A nudge is a gentle push given to a person to prompt them to behave or take action in a certain way. For e.g. placing a color-coded wet and dry litter bin, prompts a person to think whether the waste s/he has to throw is wet or dry.

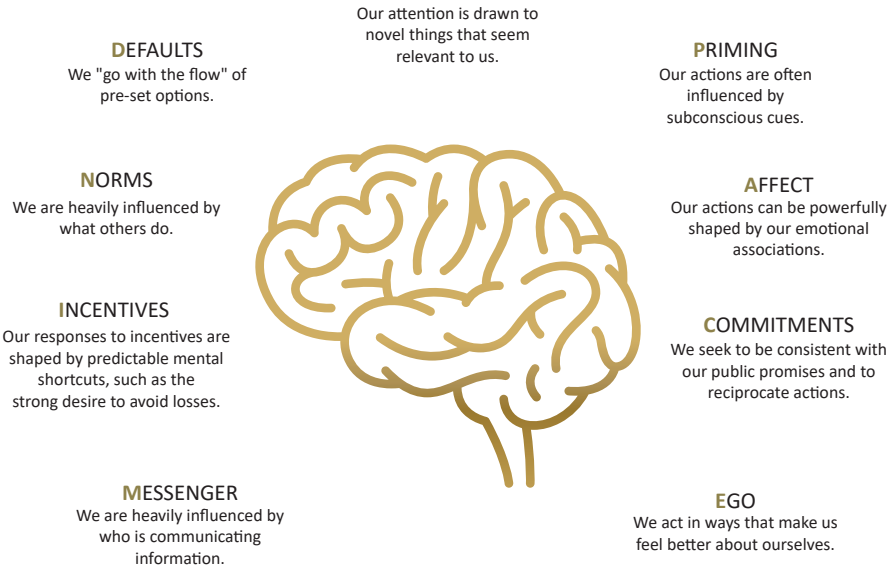


Figure 18 Nudge-approach for Behaviour Change Communication

Nudges on several aspects simultaneously will push citizens to take positive action. MINDSPACE is a framework that focuses on nine forces that drive behavior across a variety of contexts.

Figure 2 - MINDSPACE[5]

S. No.	Meaning	Example from SBM
Messenger	We are heavily influenced by who is communicating information.	Promoting Local Swach Ambassadors
Incentives	Our responses to incentives are shaped by predictable mental shortcuts, such as the strong desire to avoid losses.	Star ranking for schools, hotels and offices.
Norms	We are heavily influenced by what others do.	Posters showing prominent film stars doing composting
Defaults	We "go with the flow" of pre-set options.	Citizen survey questionnaire
Salience	Our attention is drawn to novel things that seem relevant to us.	Setting up waste to wonder parks, RRR centers.
Priming	Our actions are often influenced by subconscious cues.	Playing the jingle on waste collection vehicles
Affect	Our actions can be powerfully shaped by our emotional associations.	Involving citizens in cleanliness drives, where they see the waste.
Commitments	We seek to be consistent with our public promises and to reciprocate actions.	Taking the swachhta pledge
Ego	We act in ways that make us feel better about ourselves.	Felicitating the Sanitation workers

Table 17 MINDSPACE with relevant examples

[1] Sunstein CR. Behavioral Science and Public Policy. Elements in Public Economics [Internet]. 2020 Oct [cited 2021 Nov 11]; Available from: https://www.cambridge.org/core/elements/behavioral-science-and-public-policy/13D1F3EDA08E6446EADBFAF838606F91
[1] https://thedecisionlab.com/reference-guide/neuroscience/mindspace-framework

3.2 Modes of communication

Communication can be one way or two way as given below:

3.2.1 One-way communication

Print Medium	• Literate - News print, articles, Handbooks, Posters. • Visual impact- pictoral • Advertisements, Hoardings
Audiovisual	• Films, videos, reels. • Local radio, TV stations • Jingles, theme songs. • Outdoor and traditional media - Wall painting, Digital displays, Hoarding, Banners.
Internet	• Information on ULB websites • Interactive websites • Webinars

Figure 19 Mode of communication- one-way communication

3.2.2 Two-way communication

Social Media	• ULB pages - Facebook, Instagram, Twitter • Eminent personalities • Whatsapp groups • Should be interactive, with quick response from ULB.
Interpersonal	• Door to door visits, Individual counselling for tough nuts. • Community level interactions, Motivation sessions, talks • Small group discussions, peer education. • Engagement of local influencers - priests, sports leader, senior
Mid Media	• Rallies, Competitions, Walkathons, Roadshows • Cleanliness pledge, Drives • Street plays, Puppet shows, • Waste garden, Sculptures from waste

Figure 20 Mode of communication- two-way communication

3.3. Designing a Citizen Participation Strategy

The 5 Ws (Who, What, Where, When, Why) can be applied to design a citizen participation strategy to enhance awareness among citizens,adapted to promote awareness and understanding in a community or society. Here's how you can apply the 5 Ws theory for citizen awareness:

1. Who:

Identify Stakeholders: Determine who is involved or affected by the issue. This could include individuals, groups, organizations.

Community Leaders: Highlight the key figures or leaders who play a role in addressing or contributing to the awareness of the issue.

2. What:

Define the Issue: Clearly articulate what the issue or topic is. Provide relevant information, statistics, and examples to help citizens understand the importance and impact of the issue.

Key Messages: Develop concise and compelling messages that convey the core information citizens need to know.

3. Where:

Geographic Scope: Specify where the issue is prevalent or has the most significant impact. This could be a specific neighborhood, city, region, or even a global context.

Information Access Points: Identify where citizens can access more information, resources, or support related to the issue. This may include community centers, online platforms, or public events.

4. When:

Timeline: Provide a timeline or historical context of the issue. Understanding the evolution of the problem can help citizens connect the dots and see the broader picture.

Event Timing: Highlight any upcoming events, deadlines, or milestones related to the issue. This can create a sense of urgency and encourage citizen participation.

5. Why:

Purpose and Impact: Clearly explain why citizens should be aware of the issue. Emphasize the potential impact on individuals, communities, and society as a whole.

Call to Action: Communicate what actions citizens can take to contribute to addressing the issue. This could involve spreading awareness, participating in community initiatives, or advocating for change.

Applying the 5 Ws to citizen awareness helps create a comprehensive and easily understandable narrative that encourages active engagement and informed decision-making within the community.

Sample Activities for Citizen awareness

3.4 IEC activities



Package of Information, Education, and Communication Material[39]

The following information, education, and communication (IEC) tools are suggested in municipal solid waste management (MSWM):

- Dance, drama, puppetry, and street plays can be used as part of long term strategies.
- These can also be used for information dissemination in residential colonies.
- Short films clearly indicating do's and don'ts with respect to municipal solid waste management can be prepared for the benefit of citizens and MSWM department staff.
- A wall magazine or poster can be prepared for information and dissemination in schools and offices.
- Drawing and essay competitions on MSWM for school students should be arranged with prize incentives.
- Programs should be arranged by involving celebrities. Female celebrities can bring about specific awareness on women-related issues, sanitary issues, etc.
- Cooperation of spiritual leaders should be sought for propagation of the messages for proper MSWM.
- Municipal agencies, while licensing fairs and festivals, etc., should insist on the organizers to provide the banners with MSWM messages.
- All hoardings should carry a prominent line seeking cooperation of the citizens in maintaining the city clean.
- A logo, mascot, or slogan regarding the importance of keeping cities clean should be coined or framed with the help of expert agencies. This should be widely adopted.
- Literature on best practices should be prepared and distributed to the citizens.
- Notebooks for school children printed through government agencies should carry the message of cleanliness campaians.
- Small booklets to serve as a ready reckoner on MSWM should be prepared.
- Magic shows or simple magic programme should be popularized to propagate the ideas.
- Messages can be widely distributed by printing them on milk pouches, T-shirts, etc.

Source: Government of India, Ministry of Urban Development, Central Public Health and Environmental Engineering Organisation. 2005. Report of the Technology Advisory Group on Solid Waste Management. New Delhi.

39 Report of the Technology Advisory Group on Solid Waste Management (2005).

IEC activities are a part of a Behaviour Change Communication strategy

3.4.1. Sample strategies based on Behaviour Change Communication

Two sample matrices of activities that can be taken up as a BCC strategy for waste segregation and Plastic ban are given below for a set of target audience. Each ULB can customize similar strategies for your topic of awareness and target groups.

A. Waste segregation

Sr. No.	Target Audience	Mass Media	Mid Media	Interpersonal	Social Media
1	Houses - Apts/ Ind houses	Local Radio show host. Daily collection vehicle plays song	Personalized letter to each family to segregate from the Mayor. Line in property tax letter.	Door to door visits every week - Field staff or SHG groups or agency	Everyday, a new known citizen shown doing segregation- Twitter- whats app, local paper
2	School children	Large Poster at school lobby on segregation	Distribute registers to mark segregation at home. Distribute the Segregation booklet given by Center	Teachers to take a session per week - design a session	Prepare small videos/reels of schools doing segregation and send on Parent teacher grps
3	College going students	Organize a Flash mob on segregation	Practice in college by keeping separate litter bins, seeing teachers segregate, seeing senior classes segregating.	Youth leaders, Professors to take a session per month/ discuss	Organize a competition to create Reels on segregation at home
4	Senior citizens	Organize senior citizen events and Mayor or local leaders speak on Segregation	Ask senior citizens to sign a circular agreeing to segregate waste daily.	Home visits by Field staff/SHG members	Whatsapp forward video, message every week to the group admin of senior clubs.
5	Shopkeepers/ Hawkers	Banners at market places asking shopkeepers to keep waste segregated.	Provide two bins to each hawker/ or ask them to keep two bins. Displayed for customers too. Give a sticker, if complying.	Association leaders to discuss at monthly meetings. Field staff to meet each hawker weekly.	Put up the names of shops that comply with segregation on the ULB Facebook page. Every week a new shop.

6	Commercial - offices, banks	Conduct a Swach ranking of offices, with local publicity and campaign.	Provide posters to be put up in the offices	Organize meetings with the Head of the office, bank managers at CO level.	Send personalized email to each office, asking for compliance to measure of segregation
7	Hotels	Local Radio has a week promoting Hotels to segregate their waste.	Formal letter to each Hotel asking them to segregate the waste, and penalty clause if not complied.	Association leaders to discuss at monthly meetings	Give google feedback when Hotels are practicing segregation.
8	Slums/ Low income housing	Slum painting to improve visual aesthetics, and spread msg of segregation	Cleanliness drives in slums involving women SHGs.	Door to door visit by Asha worker/ NULM team explaining the health impacts of poor hygienic conditions.	Prepare small videos/reels of persons doing segregation in the slums and forward on social media.

Table 18 Behavior change activities for promoting waste segregation

B. Plastic Ban – Saying no to Plastic

Sr. No.	Target Audience	Mass Media	Mid Media	Interpersonal	Social Media
1	Houses - Apts/ Ind houses	Play a catchy tune on plastic reduction on vehicles.	Print articles in local newspapers on the ban on plastic, not to use plastic carry bags.	Provide cloth bags through SHGs and Resident associations to each HHs.	Share a video showing the impact of plastic in water bodies from the city.
2	School children	Place sculptures made from Plastic waste in schools.	Organize Plastic collection days in schools on a regular interval	Conduct awareness sessions and create a point system for plastic collected.	Share the stories of schools that collect the maximum plastic on instagram/ facebook.
3	College going students	Poster showing the harmful env impacts of plastic to be put up in College campus	At the end of the admission form, enter a line to tick that you will not use plastic. Or do a pledge signing on no to plastic.	Organize visits of students to the processing plants/ landfill to see the impact of plastic	Organize challenges on Social media to show ways using plastic alternatives.

4	Shopkeepers/ Hawkers	Put up permanent signages of Ban on plastic bags at prominent places.	Provide cloth bags to vegetable vendors, to sell to customers.	Weekly visits by SI to all shopkeepers and hawkers and enforce the ban on plastic	Share the names of the shops and hawkers who
5	Commercial - offices, banks	Give each office a poster to put up in the office on No to Plastic in ____ City.	Offices to organize Plogging events and plastic collection drives.	Ask employees to bring plastic, and keep a creatively designed cage to store the plastic at the office for a week of collection.	Share funny videos of saying no to plastic on office groups.
6	Hotels	Give each hotel/ restaurant a poster to put up in the office on No to Plastic in ____ City.	Measure the daily/ weekly plastic collection from the restaurant. And provide targets to achieve reduction.	Conduct regular meetings with Local Hotel associations, or hotel owners.	Give certificates to Hotels/ restaurants that reduce their plastic waste and implement no plastic. Have a ceremony for it.
7	Slums/ Low income housing	Paint No to plastic messages on walls near water bodies in slums, or GVPs.	Organize a no to Plastic event at slums, with screening of movies related to plastic pollution/ flash mob dances involving local youths.	Engage SHG groups from slums to stitch cloth bags and promote no to plastic by selling the bags house to house in the slum.	Record a rap song by local youth on saying no to plastic and share on social media.

Table 19 Behavior change activities for promoting plastic Ban

3.5 Budget line items for Citizen awareness and participation.

ULB has to invest in increasing citizen awareness and participation to manage their waste and reduce their expenditure in waste management in the long run. ULB can budget for citizen participation activities under the following budget line items.

A sample for a Rs. 10 Lakh budget for a year is provided below.

Activity	Proposed Amount (INR Lakhs)
School IEC Campaigns - Students engagement	30,000
Door to Door Ward level IEC campaigns - Citizens Engagement	3,50,000
Felicitation of Swachh Ambassadors	30,000
Mass media - Development of outdoor collaterals (Hoardings/Banners), Creating jingle song for city	1,50,000
Mid Media activities - Meetings, workshops, Slum awareness activities.	1,40,000
Wall Paintings and Beautification	50,000
Special Events and Campaigns, Rallies.	1,00,000
Swachh Bharat Diwas (2nd Oct) and Women's Day Event	50,000
Plastic Waste and E-Waste Awareness campaign Events	20,000
Print Creatives (Poster, Banner, Leaflet)	10,000
Merchandise (T-shirt, Caps, Trophies etc)	20,000
Photography and Short Films/Documentaries	50,000
Total	**10,00,000**

Table 20 Budget line items for citizen awareness and participation

ULBs should source CSR funds to support these activities.

As per **National Behaviour Change Communication Framework For Garbage Free Cities, funding for IEC should be distributed as given below:**

Medium	Proposed Amount (INR Lakhs)
Interpersonal Communication	30,000
Mid Media	3,50,000
Digital media	30,000
Mass media	1,50,000

Table 21 Funding pattern for IEC as per National Behaviour Change Communication Framework For Garbage Free Cities

Notes

Chapter 4:

Instituting sustainable solid waste management by local authorities

Key Highlights of this Topic

- Human resource requirements as per the norms based on population of city
- Roles and responsibilities of administrative wing
- Maharashtra State SWM Byelaws for Urban Local Bodies
  - Action against Transport Contractors/Employees of Municipal Corporations
  - User fee As per Maharashtra state Bylaws-For MSW Generation Below 100 kg (Non-BWG)
  - Fines As per Maharashtra state Bylaws for littering and creating nuisance (Minimum fines in Rupees)

About the topic

- This chapter provides easy references for deployment of staff
- It gives downloads from State bylaws regarding user fee, penalty, and actions against violation of contracts

Summary:

Key messages for decision makers

Outsourcing MSWM services should be carefully considered taking into account all relevant aspects. There is no one-size-fits-all solution for ULBs. Each PPP option should be assessed considering pros and cons of the respective community. Contracting models should be performance-based, and the payment to private partners should be based on measured outputs reflecting the service quality levels as defined in the contract.

For large projects and sophisticated technology applications, higher weightage of technical considerations (say, 70%–80%) is desirable plus strict performance monitoring.

4.1 Introduction

A capable SWM unit within the ULB can efficiently manage the solid waste generated in the city. The capability, expertise, and experience of the ULB staff is critical in operating and making the right decisions for waste management on a daily basis. Having adequate staff to discharge the duties is also critical. The ULB's SWM staff has to be supported by policies, authority, and rules that ensure appropriate waste management. Thus, legal framework and institutional set-up play a pivotal role in the ULBs waste management.

4.2 Human resource requirements as per population

Position	ULB - Population			
	Up to 50,000	50,000 - 1,00,000	1,00,000 - 5,00,000	Above 5,00,000
Public Health Engineer	1	2	3 to 4	5+
Sanitary Inspector	1	2	3	4+
Health Officer	1	2	3 to 4	5+

Table 22 Human resource (Administration)

Source: CPHEEO Manual on Sewerage and Sewage Treatment (2019 Edition), Chapter 9, Section 9.1 and MoHFW Guidelines for Urban Health, 2015

Other Human Resource:

- Sanitary sub inspector 1 per 25000 population
- Sanitary Supervisor 1 per 12500 population

Sweeping Beat allocation per sweeper

High density roads:	Medium density roads:	Low density Roads
1 person per 300–350 running meters of road length	1 person per 500 running meters of road length	1 person per 500 running meters of road length

Table 23 Human resource (Sweeping Staff)

4.3 Roles and responsibilities

As per the CPHEEO manual, Maharashtra State Government GRs the roles and responsibilities of each person

Chief Officer	Health Officer	Sanitary Inspector (Si)	Mukadam	Sweeper	Vehicle Waste Collector
Duties: • Overseeing all sanitation activities including waste collection, transportation, treatment, and disposal. • Approving project plans and budgets. • Monitoring progress and reporting to higher authorities. • Motivating and coordinating with other officials and stakeholders. • Ensuring proper utilization of funds and resources. • Addressing public grievances related to sanitation.	**Duties:** • Supervising sanitation programs and ensuring adherence to health and safety standards. • Conducting sanitation surveys and assessments. • Monitoring the health of sanitation workers and providing necessary medical support. • Educating the community about sanitation practices and hygiene. • Coordinating with other health departments for integrated sanitation initiatives.	**Duties:** • Supervising the work of Mukadams and sweepers. • Ensuring efficient waste collection and transportation. • Monitoring the cleanliness of public spaces and streets. • Reporting any sanitation issues to the Health Officer. • Conducting surprise inspections and taking corrective action. • Ensuring proper maintenance of sanitation equipment and infrastructure.	**Duties:** • Leading a team of sweepers and overseeing their work. • Assigning tasks and ensuring timely completion. • Maintaining cleanliness of designated areas. • Reporting any sanitation problems to the Sanitary Inspector. • Mobilizing the community for sanitation activities.	**Duties:**• Sweeping streets and public spaces. • Collecting and disposing of waste. • Cleaning drains and toilets. • Maintaining hygiene at waste collection points. • Reporting any sanitation issues to the Mukadam.	**Duties:** • Collecting waste from households and designated collection points. • Transporting waste to treatment or disposal facilities. • Maintaining cleanliness of vehicles and equipment. • Following safety regulations while handling waste.

4.4 Grievance redressal

ULBs should have clear channels to address grievances of citizens. The participation of citizens is based on effective and prompt grievance redressal. The main grievance redressal mechanism that can be used by ULBs are:

Traitional

1. **Kothi register:** Citizens log complaints in a physical register with local representatives, offering direct access and personal interaction.
2. **Phone to Mukadam:** Quicker option, calling local representatives, but relies on personal connections and lacks a documented process.
3. **Through elected officials:** Citizens raise their concerns to elected officials, who then approach the SWM field staff or officers.

Modern

Swachata App:

Most ULBs now have dedicated online portals or mobile apps like Swachata App for registering grievances related to various services like sanitation, water supply, drainage, etc. This offers convenience and transparency, allowing citizens to track their complaints and receive updates

Other Mechanisms

ULB websites: Online complaint forms on ULB websites offer another access point.

Citizen Grievance Redressal System (CPGRAMS): This national online platform allows filing complaints against various government authorities, including ULBs.

Toll-free helplines: Some ULBs have dedicated helplines for complaint registration.

Public Hearings: Some ULBs conduct regular public hearings where citizens can voice their concerns directly to officials.

4.5 Street Sweeping

- ULBs should adjust the frequency of street cleaning based on local conditions.
- Also, the time of street cleaning should be carefully defined to avoid conflicts with traffic, parked vehicles, and pedestrians.
- The service should be carried out preferably during hours of less activities in the streets, e.g., early morning and at night. Night time service is only advisable on well-lit main or commercial roads, mainly because street cleaning activities can disturb residents and could be potentially dangerous, especially for women workers.
- ULBs should ensure the safety of all workers at night by providing them with appropriate personal protective equipment (PPE).
- Street sweeping in residential areas may be carried out in two spells—5 hours in the morning and 3–4 hours in the afternoon. Staff involved in street sweeping should also be responsible for cleaning drains (up to 18 inches depth), along the same "beat."

4.5.1 Street Sweeping Norms for Small to medium Cities

PLANNING FOR STREET SWEEPING		
	Small town	Medium City
Equipment	• Long handled broom • Metal tray and mela plate • Containerised handcart or tricycle • Tractor with covered trolley • Container lifting device	• Long handled broom • Metal tray and metal plate • Containerised handcart or tricycle • Secondary storage bin • Dumper placer or compactor • Mechanical street sweeper • Container lifting device
Staff requirement based on road density	• High density roads: 1 person per 300- 350 running meters of road length • Medium density roads: 1 person per 500 running meters of road length • Low density roads: 1 person per 750- 1,000 meters of road length	• High density roads: 1 person per 300-350 running meters of road length • Medium density roads: 1 person per 500 running meters of road length • Low density roads: 1 person per 750-1,000 meters of road length

Table 24 Street sweeping norms for small to medium Cities

4.5.2 Typical Classification of Streets and Frequency of Sweeping

CLASS	CHARACTER OF STREET	FREQUENCY OF SWEEPING
A	City centre - shopping areas	Daily or twice, depending on need
B	Market areas	Daily
C	Minor streets	Daily
D	Sub-urban shopping streets	Daily
E	Residential streets	Daily
F	Roads and streets having no house-holds or establishments on either sides	Once a week
G	Highways	Rarely necessary to sweep highways as motor traffic creates turbulence
H	Suburban main streets	Twice a week
I	Open spaces	Occasionally, when required (minimum once in 2 weeks)

Table 25 Typical classification of streets and frequency of sweeping

4.5.3 Commonly used equipment for street cleaning

Equipment	Details	Specification
Long handled brooms		
	City centre - shopping areas	Daily or twice, depending on need
Fan shaped filament broom	The filaments of the broom fan out, removing litter from the streets but leaving behind sand and silt	• Length of the broom: 80–85 cm • Weight of the broom: 1kg • Binding material: 20 gauge MS sheet ring having width of 1.5–2.0 cm • Handle of the broom: bamboo of 135 cm length, 3–4 cm diameter • Weight of the bamboo handle: 900g (approximately)
Bunched filament broom:	The filaments are bunched together to facilitate removal of litter, sand and silt from the streets.	
Shovel	Heaps of street wastes gathered by brooms have to be picked up and placed in a container. The conventional tool for this purpose is a large straight-blade shovel or metal plate and metal tray.	
Pair of flat boards	when the waste comprise large quantities of light materials such as leaves, a shovel is ineffective because dried leaves fall of or are blown away during transfer. A solution is a pair of flat boards, usually plywood, between which the waste is retained by hand-pressure	
Handcarts	Handcarts facilitate transportation of street waste.	• Handcarts should have four to six detachable plastic containers with a capacity of 25–40 l each to allow easy transferring of waste into community waste storage bins. • It must have sealed ball bearings and handles having a crossbar up to navel height, and its wheels should have rubber strips or tyres for ease of handling and minimising fatigue.

Table 26 Commonly used equipment for street cleaning

4.6 CONTRACTING ARRANGEMENTS FOR MUNICIPAL SOLID WASTE SERVICE PROVISION

- Cost benefit analysis of the existing solid waste management system is necessary.
- Services to be outsourced shall be identified maintaining clear accountability.
- Characterization 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 estimation of cost related to operation and maintenance should be done.
- Detailed project definition and key performance indicators have to be established.
- Land requirements 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 an monitoring) is crucial.
- The contracting period for each of the activity should be for a minimum of a two year and maximum of 5 years, to maintain continuity.

Not all contracting models are suitable for each of the MSWM operations. Municipal authorities may adopt one or more of the following contracting models:

Waste management system	Type of contracts
Door to Door collection And Transportation	Service contract, Management contract
Secondary storage, and Transportation of waste	Management contract
Transfer Station	Build and transfer
Compost Plant,	Build-Operate-Transfer,(BOT),Build-Own-Operate (BOO)
Bio methanation,	Build-Operate-Transfer (BOT)
RDF plants, Incineration plant(large scale)	Build-Own-Operate (BOO)
Sanitary landfill	Build and transfer, Build-Operate-Transfer (BOT)
Construction and demolition [C&D] waste collection	Management contract

Table 27 Waste management systems and relevant contracts

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.

4.6.1 Special attention is required for:

A. **Vehicle Maintenance** – Vehicles used for transfer of waste have reduced life if not maintained properly. Usually, a SWM vehicle can operate for 7 to 10 years with proper maintenance. The waste carrying body of the vehicle should be repaired and maintained well to increase the life of the vehicle.

B. **Machinery and infrastructure maintenance** – The waste processing machinery should be operated by trained labour/ persons if outsourced. Regular maintenance should be part of the contract.

MSW MANAGEMENT and OPERATION	CHARACTERISTICS	RELEVANT CONTRACT MODELS
Collection and Transportation	Large number of work force, vehicles and equipment	Service contracts
	Logistics-intensive	Management contracts
	Citizen interface	Concession for 7 years or more
	Investment ranges widely depending on scope of work	
Street sweeping	Labor-intensive	Service contracts subject to contract labor (Regulation and Abolition) Act, 1970
	Logistics-intensive	
	Minimal investment in tool and equipment	
	Limited technical skills	
Transport	Capital-intensive	Concession contracts
	Fleet management skills	
Processing and disposal	Capital-intensive	Concession contracts (DBO, BOO, DBOOT) for
	Technically skilled staffing required	20 years or more
	Experience of technology deployed	

Table 28 Contract models as per scope of the project

Measures to Minimise the Burden of Service Charges Making Solid Waste Management Effective and Affordable

1. Street sweeping and its disposal should be charged to general taxes. Costs for provision of basic municipal solid waste management services such as general street cleaning, drainage cleaning, cleaning of public spaces, etc. can be met through general taxes which are typically used to finance public services.
2. Municipal authority should introduce 100% door-to-door collection. Door-to-door collection, transportation, processing, and disposal of waste may be completely entrusted to the private sector to ensure efficiency and to economize expenditure of the urban local body (ULB). User fees may be levied to cover full operation and maintenance (0&M) cost of collection and transportation and part of the cost of treatment and disposal of waste. Processing facilities may be created on a public- private partnership (PPP) basis to keep costs under control. Smaller municipalities should go in for simple contracts which can be financed and managed by the ULB.

ULBs may decide to bundle certain services while contracting out MSWM operations to build accountability and efficiency in the system

TYPE OF PROJECT	DESCRIPTION OF PROJECT	ADVANTAGES	RISKS	UNIT OF MEASUREMENT
MSWM: Model 1 (ISWM)	This model consists of the following: 1. Collection 2. Transportation 3. Processing 4. Sanitary landfill	1.Clear accountability 2.Minimizes hassles among different contractors. 3. No blaming	1. This creates a monopoly of the contractor 2. The entire city service may get disrupted if the contractor fails to perform 3.Ooff-loads might increase substantially. 4. Delay in execution of one service will result in overall system delays.	1. Quantity of segregated waste collected and transported on a daily basis 2. Tonnes of segregated waste received at the processing plant and product produced 3. Tonnes of reject from processed waste landfilled

MSWM: Model 2	This model consists of two packages: Package 1: Collection and transportation Package 2: Processing and disposal (P &D)	1. Hiring specialized agencies and expert processing agencies is possible. 2. Responsibility divided among multiple players (on an area basis in a decentralised model), leading to a better control on quality of work	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. ULB has to constantly facilitate between the two agencies.	1. Package 1: Tonnes of segregated waste collected and transported Number of properties/ household covered daily GVP formed in areas of collection Number of vehicles deployed and daily % coverage against planned as per GPS. 2. Package 2: i. Tonnes of segregated waste processed per processing plant and product produced ii. Quantity of product (Compost/ Recyclable / RDF) generated. iii. Tonnes of reject from processed waste at disposal facilities iv. Annual Env reports of water, soil quality from neighbouring water bodies and land.
MSWM: Model 3	This model consists of three packages: Package 1: Collection and transportation Package 2: Processing Package3: Sanitary landfill	1. Agencies with expertise in MSWM service areas at a very competitive rate. 2. It provides scope for competition 3. It does not create a monopoly 4. It enables the ULB to replace a non performing contractor	Same as above	Same as above
MSWM: Model 4 (decentralized 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	same as above	The risk of lack of synchronization between waste collection and transportation agencies can disrupt overall service provision. This in turn can adversely affect the processing and disposal services.	Package 1: Daily average attendance of Persons empl oyed or tonnes of segregated waste collected Others as given above.

Table 29 Matrix for contract model based on type of project

4.7 Monitoring and record keeping:

DATA REQUIRED	MINIMUM FREQUENCY OF MEASUREMENT	POINT OF DATA COLLECTION	DATA USE AND POTENTIAL ANALYSIS
GENERAL ULB INFORMATION			
Area of the ULB, ward wise population, decadal growth, No. of HHs, slum, commercial, Institutes, Markets, Health care facilities, 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			
Quantity of segregated waste and total 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	Semi-annually	Ward level (from weighbridge)	Assess household collection efficiency of segregated waste Assess requirement or capacity of waste management facilities needed by the ULB
The total amount of waste generated in the ULB Quantity of waste collected in segregated fractions	Monthly	Ward level (from weighbridge)	Assess household collection efficiency Extent of segregation of waste
Capacity of vehicles dedicated to primary, secondary and tertiary collection Number of trips made per day per vehicle type	Monthly	Ward	Assess sufficiency of infrastructure for primary collection of waste
Average number of carcasses removed each day	Daily	Processing or disposal facility	Assess requirement for management of carcasses along with slaughterhouse wastes
Total number of vehicles, tricycles and human resources allotted for segregated door to door collection of waste Number of vehicles, tricycles and human resources actually reporting for duty	Daily	Ward	Assess sufficiency of infrastructure for primary collection of waste Assess utilization rates of existing infrastructure
Short fall in human resources	Daily	Ward	Assess sufficiency of existing staffing
Areas left unattended Arrangements made or proposed to be made for clearing the backlog of pending work	Daily	Ward	Assess efficiency of door-to-door service provision and identify problem areas Ensuring daily management of service provision
Quantity of waste recycled or extracted for recycling by wastepickers/ waste collectors.	Monthly	Ward	Assess the waste recycled at local level
STREET SWEEPING			
Number of sanitation workers on duty for street sweeping (contractual vs pay-roll), absenteeism, arrangement for backlog	Daily	Ward	Ensuring efficiency and daily management of street sweeping service provision

SILT REMOVAL OR DRAINAGE CLEANING			
Number of sanitation workers on roll for silt removal in the ward, absenteeism, backlog of silt removal	Daily	Ward	Ensuring efficiency and daily management of street sweeping service provision
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 unauthorized 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 unauthorized 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	
Waste Recycling Sites/ initiatives			
Quantity of waste recycled through monthly collection intitiatives for plastic collection, ewaste collection, domestic hazardous waste collection	Monthly	ULB	Assess the recycling potential and qty of waste reduced from processing and transportation
RRR center – quantity of products/ collected and donated/sold from the center	Monthly	ULB	
Home composting – Number of properties/ households processing their own waste. Estimated quantity of waste	Annually	ULB	
BWG – Number of BWGs processing their own waste. Estimated quantity of waste	Annually	ULB	
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. Recyclables from MRF, RDF) produced at the plant	Monthly and per batch	Plant	
Quality of end products (compost, Recyclables, 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**	
Any irregularities noticed	**Monthly**	**Plant**	
WASTE DISPOSAL SITE			
Number of waste disposal sites in the ULB - Number of dumpsites - Number of sanitary landfills	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
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	
FINANCIAL ASPECTS			
Operating Cost	Annually	ULB	1. Assess cost of MSWM services in the ULB 2. Assess collection efficiency of waste management charges 3. Assess which of the MSWM services are financially viable 4. Extent of cost recovery for the ULB in the MSWM services
Cost of collection per tonnes per day	Quarterly (once in three months)	ULB	
Cost of transport per tonnes per day	Quarterly (once in three months)	ULB	
Cost of disposal per tonnes per day	Quarterly (once in three months)	ULB	
Human resource costs	Quarterly (once in three months)	ULB	
Cost of operations and maintenance for services managed by the ULB (recurrent fuel, electricity and maintenance costs)	Quarterly (once in three months)	ULB	
Cost recovery for MSWM service through tax, user fees, etc.	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	Daily	ULB	1. Assess and identify repeated problem areas 2. Assess efficiency of complaint redressal
Types of complaints received	Daily	ULB	
Time taken for issues to be resolved and appropriate actions taken	Daily	ULB	
Number of defaults for which penalties are collected	Quarterly (once in three months)	ULB	Assess efficiency of penalizing 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	

Table 30 Systems for monitoring and record keeping

Notes

Chapter 5:

SWM Economy

Key Highlights of this Topic

- Current SWM expenditure heads and revenue sources
- Potential revenue sources for SWM for ULBs.

About the topic

- This chapter provides a overview of SWM budgets for smaller ULBs in Maharashtra
- It provides ULBs means to generate revenue through efficient SW operations.

5.1 Solid waste management expenditure:

ULB budgets for swm should provide budgets broadly under these heads:

A. Staff • Management staff • Sanitary Inspector • Mukadam	**B. Sweeping** • Staff - Sweepers • Equipment for sweeping • Uniforms & PPE • Sweeping vehicles • Litter bin purchase and repair	**C. Citizen Awareness** • Interpersonal • Mid media • Mass media	**D. Collection and Transportation** • Vehicles purchase • Vehicle Operations • Vehicle Maintenance • Collection staff • Vehicle GPS tracking system • Weighbridge
E. Processing • Composting plant operations • MRF operations • Biogas Operations • Other processing plant operations • Security at processing plant • C&D waste collection and processing	**F. Sanitary Landfill** • Operations	**G. Other** • Administrative • Technical support • Wastepicker integration • Innovative projects	

SWM operations cost should consider all front end costs, operating costs, contingency costs etc. as given below.

Front-end Costs
- Land acquisition
- Permits
- Building Construction
- IEC Activities

Capital Costs
- Fixed cost for plant and machinery
- Cost of capital

Operating Costs
- Debt service cost
- Operation and maintenance costs involved in daily activities
- Cost of refurbishment
- IEC activities

Back-end Costs
- Site closure
- Building and equipment decommissioning
- Retirement and health benefits for current employees

Environmental Costs
- Costs involved in mitigating adverseeffect on environment (costs for implementing Environmental Management Plan [emp])
- Downstream impacts

Contingent Costs
- Remediation costs
- Liability costs (e.g., property damage personal injury)

Social Costs
- Quality of life
- Aesthetic impacts
- Community image
- Effects on property values

5.2 Alternate Revenue Options:

Waste is a resource and there are several revenue sources available for ULBs to raise revenue through SWM operations. A few are given below:

a. **User Fee** - The State has defined the user fee is the State SWM byelaws, as per call of Municipal COuncils. ULBs can directly collect these from waste generators by setting up a collection system for the same. This can be collected by the collection agency directly as their part payment or through an annual collection system by the ULB.

b. **Sale of End products** - With good source segregation, the value of segregated collected waste is higher and can be used for revenue. The value of processed end products is also a good revenue source.

SALE OF END PRODUCTS

Compost

Good quality compost can earn the ULB Rs 3 to 17 per kg. ULB can generate 12% of its waste as compost

Refuse Derived Fuel

The shredded RDF can be sold at an average rate of Rs.200 per MT, depending upon the distance to transport

C&D products

Crushed sand, aggregate can be directly used in ULB construction works, or sold at market rates.

Other waste

Paper, Cardboard, Glass, Plastic, can be sold to the aggregators at about Rs.5/kg

E waste

E waste can sell at an average price of Rs.15- 20 per kg. Depends on the electronic components.

c. **Corporate Social Responsibility.**

Solid waste management is one of the permitted activities under CSR. It comes as - Eradicating poverty, hunger, and malnutrition, promoting health care which includes sanitation and preventive health care, contributing to the Swach Bharat Kosh set-up by the Central Government for the promotion of sanitation and making available safe drinking water.

ULBs will have to facilitate and engage with NGOs and COrporates to access CSR funds for its activities. Activities that can be planned through CSR support are:

- Citizen awareness activities
- School awareness programs
- Cleanliness drives
- Beautification of GVPs
- Sponsoring jingles and radio spots
- SHG and wastepicker integration programs
- Capital machinery for waste mng

d. Public Private Partnership

Several waste processing technology providers are willing to partner to set up and operate a waste processing facility, however ULBs should verify the technology and financial obligations for these. The success of PPPs depends on the three necessary conditions: Competition, transparency and Accountability. Projects under PPP also need regular monitoring and review by the ULB.

e. Extender Producer Responsibility

EPR is defined as 'an environmental policy approach in which a producer's responsibility, physical and/ or financial, for a product is extended to the post-consumer stage of a product's life cycle. EPR can be used for Plastic waste and E waste. ULB can set up plastic processing facilities and register themselves as PRO on EPR portal, and can directly access funds. This requires ULB to have regular quantities of good segregated plastic, proper record keeping, and processing of plastic/ or forward linkages with authorized plastic recycler. Alternatively ULB can engage with a PRO agency.

f. Carbon Credits

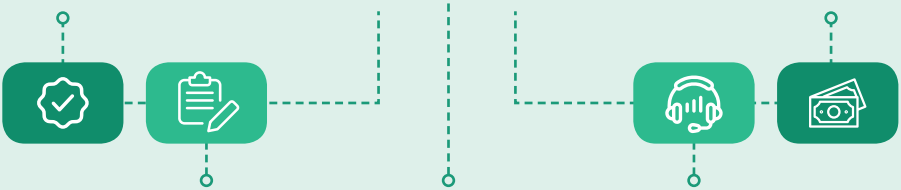
What is Carbon Credits

- Measurement of GHG Emission Reduction **(1 Carbon Credit = 1 Tonne of CO2e emission)**
- Certificates issued to Entities in developing countries that reduce their GHG emissions



Challenges

- High Project registration charges - $10000
- Complex process requires team
- No open trading platform
- Fluctuating Carbon Credit Markets



Process to get Carbon Credits

- There are multiple Carbon credit Mechanisms - VCS, CDM, GCC etc.
- Project has to be registered and validated
- Auditors verify the process
- The operations are monitored
- Trading process begins

Indore Model

- Registered its Composting and Biomethanation plants and earned Rs. **69 lakhs in 2017-2019,**
- Same project - **July 2019 to 31 Dec 2020 Earned - Rs. 8.34 CR**

Next steps

- Green Credit Program (GCP): Incentivizing Environmental Actions

Notes

Chapter 6:

Collection and Transportation

Key Highlights of this Topic

- Types and sources of waste and waste value chain
- Collection of segregated waste
- Primary waste collection systems
- Transfer and Secondary collection of waste
- Tender conditions for outsourcing C and T system

About the topic

- This chapter provides information on norms for setting up a collection system for a city.
- It gives a complete picture on the waste value chain and required collection systems at each stage.

Summary:
Sources of waste and collection system requirements:

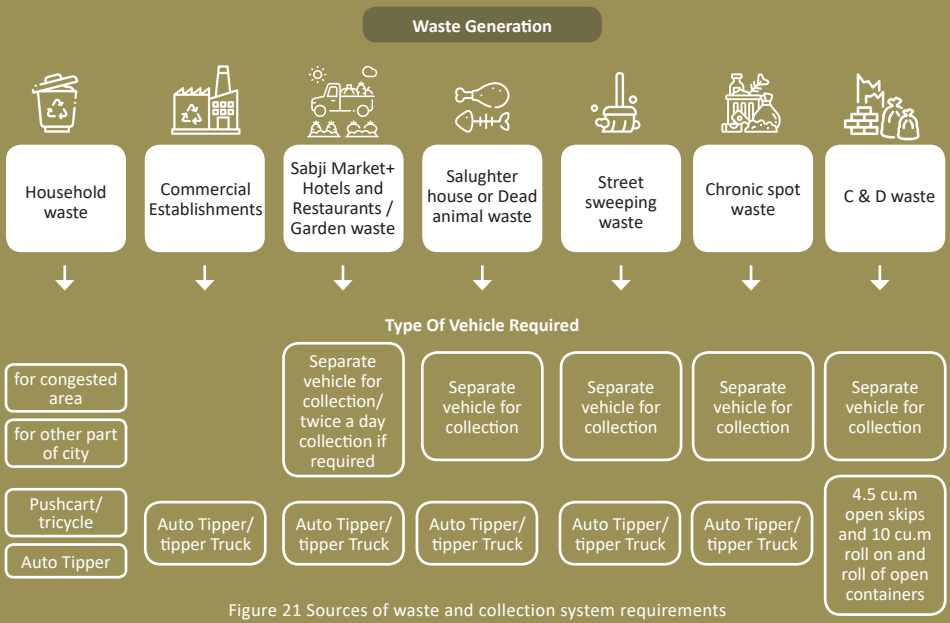


Figure 21 Sources of waste and collection system requirements

Vehicle deployment as per CPHEEO norms:

Type of vehicle	Travel Distance	Capacity	Expected trips	Household Covered per trip	Human resource requirement
Pushcart/ Tri-cycle	500M-1km	100 Kg	3-4	100-150	1
Ape Rickshaw	4 Km	350 Kg	6	350-400	1+1(driver + helper)
Auto Tipper	6Km	750 Kg	4	750-800	1+2(driver + helper)

Table 31 Vehicle deployment as per CPHEEO norms

6.1 Solid waste Management Value chain:

Considering different types of sources of waste and characteristics of waste, there is a requirement of a separate collection, transportation, processing and disposal system.

Below are important value chain of waste management:

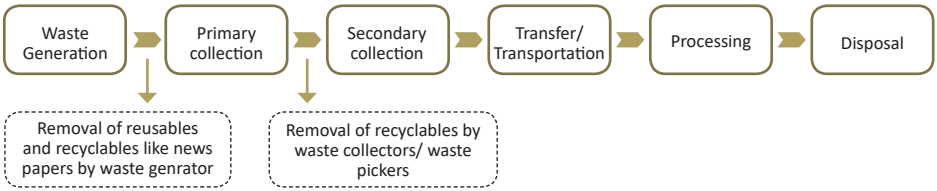
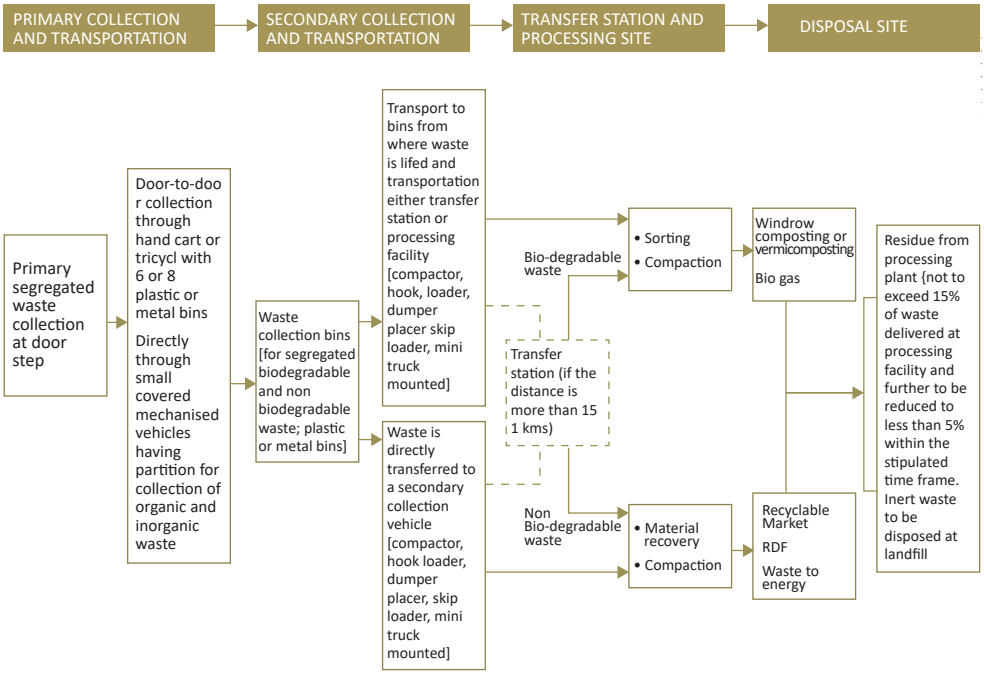


Figure 22 Important value chain in waste management

Figure 2.5: Flow Chart for Household Waste Collection, Transportation and Disposall°



- The compactor is an appropriate vehicle for collecting biodegradable and recyclable component of MSW
- Skip loaders/ Hook loaders are preferred for collecting inert waste or Construction and Demolition waste
- Waste may be trarsferred to the transfer station if the processing site is located at least 15 kms away from the city

Figure 23 Flow chart for household waste collection, transportation, and disposal

6.2 Elements of Primary Waste Collection System

SOURCE	PRIMARY COLLECTION SERVICES	TRANSPORTATION
Societies/ Apartment Complexes	Size and No of Bins to be provided at society level for gate collection should be equivalent to No of Houses to be served, Capacity of Bins (Lits.)=5X where X is no. of HHs	Containerised lightweight handcarts Tricycles for both men and women Pickup vans Motorized waste collection vehicle Any suitable combination of the above All collection vehicles to have segregated collection capacity for 3 to 4 types of waste
	Contract for door-to-door collection with private sector, CBOs, NGOs, RWAs, or SHGs	
Inaccessible Residential Areas	• 2 community bins or containers of 60–120 l capacity for 20–40 dwelling units for feeder point collection. • 2 domestic bins for storage of waste at source—5, 10, 15, 20 l (for 2–8 kg waste)	• Containerised lightweight hand carts • Tricycle for both men and women • Waste collected from the area should be transferred to a light commercial vehicle (LCV) outside the slum area.
Residential areas	• Door-to-door collection services for segregated waste • Contract for door-to-door collection with private sector, NGOs, RWAs, or SHGs	• Containerised handcarts • Tricycles for both men and women • Pickup vans • Motorized waste collection vehicle
Markets/ Bulk Waste Generators	• Doorstep collection services • Markets: 1.1–4.0m3 covered bins for storage of waste as per the quantity of waste generated in the market	• Motorized waste collection vehicle with container lifting device • Compactors compatible with containers
	• Large commercial complexes: 3.0–7.0m3 containers	• Non-compactor trucks
Hilly areas	• Door-to-door collection service for segregated waste—manual collection or with small motorized vehicles	• Lightweight containerised handcarts • Tricycles for both men and women • Pickup vans • Motorized waste collection vehicle • Combination of vehicles specified above

Table 32 Elements of primary waste collection system

* Community bins are only for gate collection from societies, or feeder points or vegetable market areas only. They should be emptied with set frequency.

6.2 Collection of segregated waste:



Figure 24 Provisions on vehicle for segregated waste collection

ULB should also identify sources of good segregated wet waste such as Agriculture Market/ Mandai, hotels waste, marriage halls etc. This waste should be collected separately to promote implementation of circularity model reducing waste going to the landfill.

6.3 Primary Collection System

VEHICLE FOR PRIMARY COLLECTION	NUMBER OF HOUSEHOLDS TO BE COVERED IN DIFFERENT AREAS	POPULATION SERVED	STAFF REQUIRED
Push Carts	• Congested area: 250 - 300 • Medium Density area: 200 • Scattered Area: 125 • Hill area: 85-90	• 1,250–1,500 • 1,000 • 625 • 400–450	1 person per push cart
Tricycle	• Congested area: 300 • Medium Density area: 250 • Scattered Area: 200 • Hilly area: 125	• 1,500 • 1,250 • 1,000 • Should be decided based on operational conditions	1 person per tricycle
Light Commercial Vehicles (LCV) having 500 to 700 kg capacity	• 1,000	• 5,000	1 driver and two labor per LCV
LCV with more than 700 kg capacity	• 1,500 to 2,000	• 7,500 to 10,000	1 driver and two labor per LCV

Reference: CPHEEO Manual Part 2
Table 33 Suggestive norms and assumption for setting up primary waste collection system

Primary waste collection systems:



Figure 25 Vehicles for primary waste collection

APPROXIMATE POPULATION	ULB GENERATING TONNES/DAY	PRIMARY DOORSTEP SEGREGATED COLLECTION EQUIPMENT AND VEHICLES	SECONDARY COLLECTION OF STREET WASTE EQUIPMENT AND VEHICLES
Up to 50000	3Ton-15 Ton	-Door-to-door collection services through containerized handcarts or tricycles -Bulk generators at source requires 120 l (49 kg), 240 l (96 kg) bins Contract with private firm, RWA, and NGO, if possible	3–4 m3 containers to be placed at the rate of 4 per km2 area or 1 per 5,000 population Transportation of containers by tractor having container lifting device
50,000 to 100,000	15-30 TPD	80% households to be served by covered tractor or covered LCV for door-to-door collection at 1 vehicle per 1,500 house- holds, shops, etc. 20% households to be served by tricycles with container for door-to-door collection or handcarts for narrow lanes at 1 tricycle per 200 units Direct transfer of waste from tricycle to tractor or LCV to processing facility	100% street sweeping waste to be collected in containerised hand- carts and deposited in 3-4 m3 containers Containers to be placed at 4 per km2 area or 1 per 5,000 population. Containers to be lifted by tractors or twin bin dumper placers

Table 34 Suggestive norms and assumption for setting up waste collection system

6.4 Transfer and Secondary collection of waste:

Transfer of waste	Secondary Collection System
• Transfer points should be designed to optimize the fleet of smaller vehicles and can be be utilized to manage segregated waste flow • The locations for the transfers points should not be in direct vicinity of the residential area to avoid hazards from the possibility spillage of waste and thus dirt and leachate • The infrastructure improvisation should be done to design vehicle to vehicle transfer of waste and thus avoid manual interference • Transfer points should be designed to avoid • a. Littering of waste at the time of transfer • b. Increased human interaction of the waste collected • The space used for transferring of the waste should be cleaned after the activity and deep cleaning of the space should be done with jet spray at least once in a month to avoid converting it into a chronic spot • Prescribed use of PPE should be mandated at the transfer station while handling the waste • Based on the quantities of waste and available secondary vehicles, temporary storage facilities can be provided at these points	• The Secondary Collection vehicles should also be covered vehicles of higher capacity • There should be provision for compressing the dry waste either hydraulically or JCB or using right instruments by the deployed human resource. In case of wet waste and mixed waste avoid compaction as it hampers further segregation. • The vehicles should be designed to avoid littering of waste while in transit and should also have provision to hold or collect the leachate in case of wet waste collection. • The capacity of vehicles which are used of secondary transfer is around 5MTs, 9 MTs and 13MTs • Considering the density of the waste, the waste carrying capacity of these vehicles should be considered to be around 60%-70% or 70%-80% based on the compaction provision provided. • These vehicles should do minimum of 2 -3 trips in a day while traveling around 15 Kms in a single trip.

Table 35 Transfer and Secondary collection of waste





Figure 26 Transfer and secondary collection of waste

General Rule of Thumb

If the one-way travel distance to disposal is over 15 km or over 30 minutes, the need for transfer stations should be assessed.

Transfer stations should be made only when the cost of direct haul in collection vehicles would outweigh the cost of supplemental haul in large bulk-haul transfer vehicles plus the cost of the supporting transfer system infrastructure at the transfer station and disposal site.

6.5 Tender conditions

Suggestive Clauses/Scope of work
Scope of work - 100% Collection and transportation of segregated waste. Mention segregated waste collection and four type of segregation in tender.
The operations are required to be conducted by the contractor on everyday basis for all 365 days of the calendar year.
The contractor should ensure that the collection route is clean with no spilling of waste from collection vehicles after the operations.
If outsourcing vehicles- provide details of the type of vehicles and number of vehicles, provision for additional vehicles for emergency breakdown.
Contractor to submit a microplan of route map of the vehicles along with bid proposal. GPS tracking system on vehicles should be mandatory and weekly reporting/ availability of dashboard service for monitoring.
Provide daily Labor attendance data; provide for replacement staff in case of absent staff, make arrangement for clearing of any backlog within 24 hours. Staff Health and safety,and training shall be contractors responsibility.
To maintain disciplined and efficient services, it would be necessary to appoint supervisors to manage operations on field and provide them uniforms, safety gears and mobile facilities as required .

Contractor shall adhere to norms of Minimum Wages Act and other applicable labour laws including PF/ ESIC etc. Salaries of all the employees to be done on time as per applicable rules governed by labour laws in the state. It shall be the duty of the contractor to ensure proper documentation as per various labour laws are maintained.
Monitoring - Monthly reports to be submitted of Quantity of waste collected and transported on a daily basis, workers attendance report, vehicle status- daily trips, grievance redressal attended.
Suggestive Clause - Chronic spot should reduce over the time while claiming the 100% collection coverage for residential and commercial pockets

Table 36 Suggestive scope of work

Notes

Chapter 7:

Processing and treatment of various waste streams: Wet waste

Key Highlights of this Topic

- Introduction to Wet waste management
- Types of Technologies for wet waste processing
- Comparative of the Wet waste processing technologies
- 8 steps of composting
- Importance of Compost quality and standards.
- Selection of appropriate technology

About the topic

- This topics provides information about various technologies used for wet waste management,
- The matrix provided in the chapter will help decision makers for selection of technologies which is based on waste generation, segregation level, waste characterization and funds and land availability.

Summary:

Technology Selection has to be based on:

- Quantity of Waste
- Source of waste
- Climatic conditions
- Land availability
- Availability of skilled human resources as per technology
- and financial feasibility

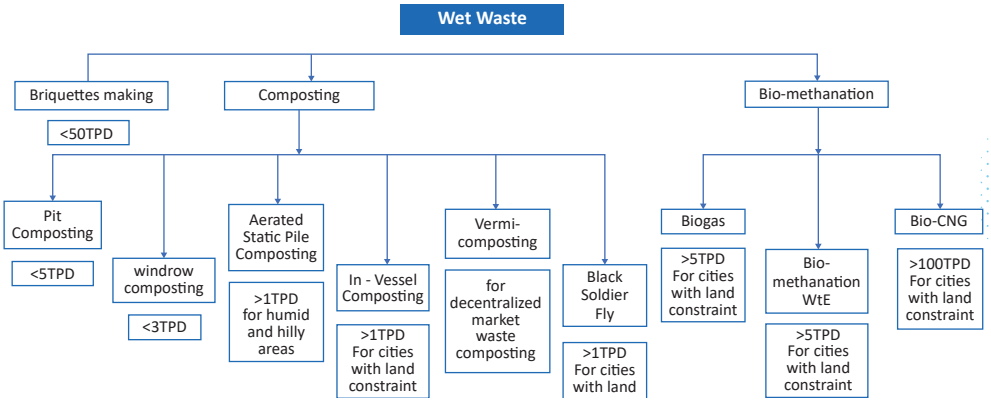


Figure 27 Wet waste management technologies

7.1 Introduction to wet waste management:

Wet waste is a valuable resource, and approximately 50 to 70% of our waste is wet waste. Processing of wet waste appropriately has the following benefits:

- We can reduce the quantity of waste going to landfill,
- Reduce greenhouse gas emissions
- Recover a valuable resource as compost for soil or energy from gas.

7.2 Types of Technologies for wet waste processing:

Aerobic	Anaerobic	Home processing	Other
• In presence of free oxygen • Is a faster process compared to other	• In the absence of free oxygen • Biomethanation is a anaerobic process generating gas	• Both Aerobic and Anaerobic methods • At source processing reduces transport cost.	• Briquette making • Garden waste • Slaughter house waste - incineration

Figure 28 Types of technologies for wet waste processing

7.3 Comparative of the Wet waste processing technologies

Parameter	Windrow Composting	Pit Composting	Aerated Static Pile Composting	In – Vessel Composting/ rotary drum composting	Vermi-composting	Black Soldier Fly	Biogas	Briquettes
General	Suitable for >3-5 TPD	Small scale < 5 TPD	For humid and hilly areas.	Large scale systems for commercial applications	For market waste-decentralized waste management	Innovative Technology-Medium scale,	For sources of pure organic waste such as vegetable Market, hotels, restaurants, caterers, institutions etc.	Waste to energy Plant
Advantages	Basic process, good quality compost can be achieved through skilled supervision	Basic process, good quality compost can be achieved through skilled supervision	Best suitable and cost effective for areas with high rainfall or humid areas where moisture content needs to be controlled. Time for composting can be regulated.	- Reduced land requirement as compare to windrow composting -Time requirement for composting is reduced.	-Suitable for small quantity of waste/ decentralized waste management. Produces superior quality Compost.	Can be used for any kind of wet waste-kitchen waste, market waste, garden or mutton and fish market waste.	By product like Biogas, slurry and/or electricity generation having high market value than compost	Suitable for A class cities and corpor-ations > 70 TPD of wet waste

Limitations	Large land requirement	Feasible for small waste quantum	-Higher level of monitoring and supervision required	-Electricity consumption -Need dewatering of waste through squeezing -High capital and operational cost	Need to take care of moisture content and temperature for the survival of worms.	-Requires proper management - Moisture content 60%-85%	-Required strict monitoring and need segregated waste - Need to regulate monotonous food container - Need to avoid citric food	-Requires setting up of proper forward market linkages
Amount of input waste per day to be treated	1 to 500 tonnes	1 to 5 tonnes	1 to 500 tonnes	1 to 300 tonnes	1 to 50 tonnes	1 to 50 tonnes	1 to 5 TPD-Biogas >5 TPD WTE >100 TPD Bio-CNG	70 tonnes or more
Land Requirement	1TPD-350 sq.m to 8 ha for 500 TPD including buffer zone	1 ton-150 sq.m to 5 TPD-750sq.m	1TPD-150 sq.m to 5 Ha for 500 TPD	1TPD-150sq.m 4 ha for 500 TPD (Limited land due to rapid rates)	1TPD-150 sq.m t0 2 ha for 50 TPD	280 sq.m for 1TPD to 1.4 ha for 50 TPD	For 1 tpd 200 sq.m to 0.6 Ha for 50 TPD	for 100 Tons 0.4 Ha
Time	8 weeks	8 weeks	5 weeks	4 weeks (3-5 days in vessel, 3 weeks to mature)	8 – 10 weeks	8 weeks	1 day	4 weeks
Ambient Temperature	Not Temperature sensitive	Not Temperature sensitive	Controlled Temperature conditions	Controlled Temperature conditions	Temperature sensitive (20 C – 40C ideal range, max 40C)	Temperature sensitive-	Not Temperature sensitive	Not Temperature sensitive, faster drying in warm temperature
Energy Input	Low	Low	Moderate	High	Low	Moderate	Moderate	High
Financial implications (relative)	Low	**Low**	Costly	Very Costly	Moderate but purchase of exotic earthworms suitable for MSW vermicomposting are expensive.	Slightly costly, Need for enclosed greenhouse shed, and labs	Costly	Costly – If natural drying is used, land requirements will increase.
Odor and aesthetic issues	Odour is an issue if turning is inadequate	**Odour is an issue if turning is inadequate**	Moderate but controls can be used such as pile insulation and filters on air systems	Can be an issue during equipment failure or system failure.	None	None	Odor during waste shredding and input of waste	Odor during waste shredding and input of waste.

Table 37 Matrix for technology selection for wet waste processing

7.4 Eight Steps of Composting:

INPUT WASTE
unloading of wet waste on waste receiving platform



PREPROCESSING
It includes shredding and squeezing of wet waste to extract moisture content of wet waste and mixing dry leaves, cocopeat etc



HARVEST
1. Take out the compost from the windrow/pit and transfer to screening area.
2. Take care to demarcate each batch separately.
3. Pass the harvested compost through a 35mm, and then 16mm trommel. Or a stationary sieve of 16mm.



QUALITY CHECK
The compost has to meet the compliance requirements of the FCO 2013 Norms. After curing Physical Parameters, Chemical Composition and Presence of Heavy Metals should be checked to ensure quality of compost



1 2 3 4 5 6 7 8



PRESORTING OF WASTE
Presorting can be done manually or by using trommel and conveyor system. Its an important step to ensure quality of wet waste



FORMATION OF PITS /WINDORWS
Pit composting for>5 TPD Wet waste Windrow composting > 3 TPD wet waste



CURING OF COMPOST
1. Store the screened compost by forming piles under a shed and let it rest for minimum 7 Days.
2. Pass the compost through 4mm sieve/trommel. This will ensure a uniform size



PACKING AND STORAGE
Packed Compost to be stored in a dry and enclosed facility with ventilation. The Compost should to be branded under a trusted creditworthy brand.

Figure 29 Eight Steps of composting

7.5 Importance of compost quality and standards

- Good quality compost provides the nutrients to the soil that are transferred to the crops.
- Bad quality compost can cause chemical contamination of the soil.
- Nutrient deficient compost may not harm plants but will add no value.
- Compost with heavy metals is detrimental to crop health, yield and eventually human beings.
- The compost which is to be used as soil conditioner for food crops should abide by the more stringent FCO, 2009 norms, Whereas compost used for floriculture or ornamental plants can abide by SWM Rules 2016

7.6 Selection of Appropriate Technology:

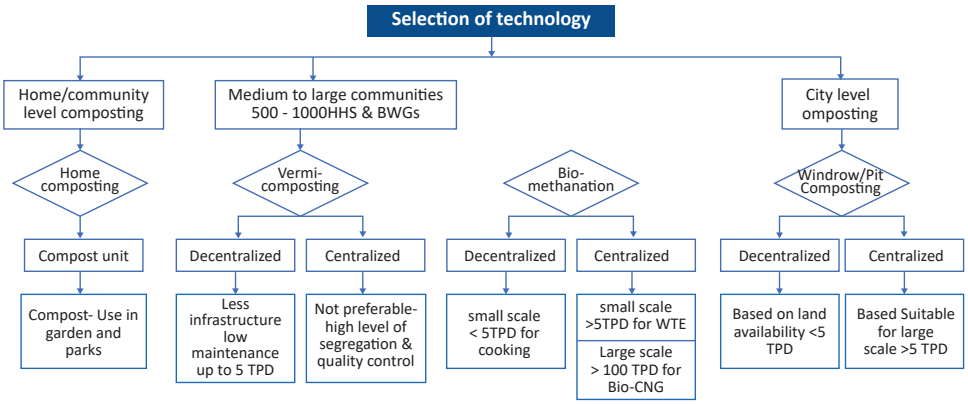


Figure 30 Decision making map for technology selection

Chapter 8:

Processing and treatment of various waste streams: Dry waste

Key Highlights of this Topic

- Flow of dry waste
- Types of dry waste and approximate percentage
- Recyclables and Non-Recyclables
- Different processes or stages and equipment employed in a Material Recovery Facility
- Requirement of MRF as per the scale of city
- List of machineries involved while pre-processing dry waste
- DO's and DON'Ts at Material Recovery Facility

About the topic

- This topics provides information about characteristics of dry waste
- Various technologies used for dry waste management,
- The matrix provided in the chapter will help decision makers for selection of technologies which are based on waste generation, segregation level, waste characterization, funds and land availability.

Summary:

Dry waste Value chain:

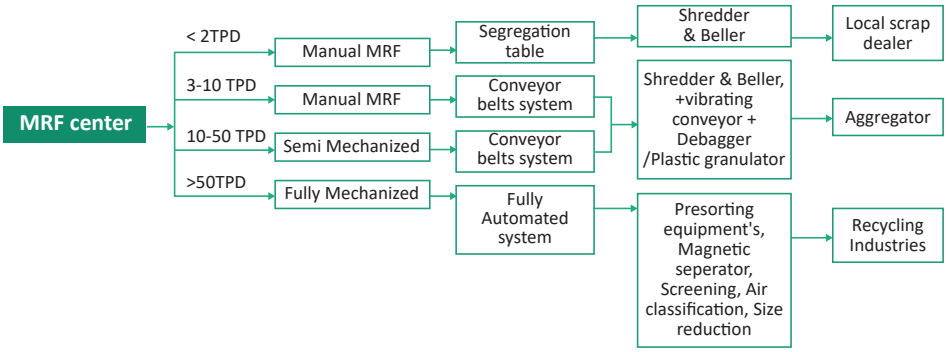


Figure 31 Dry waste value chain

Dry Waste Processing Technologies:

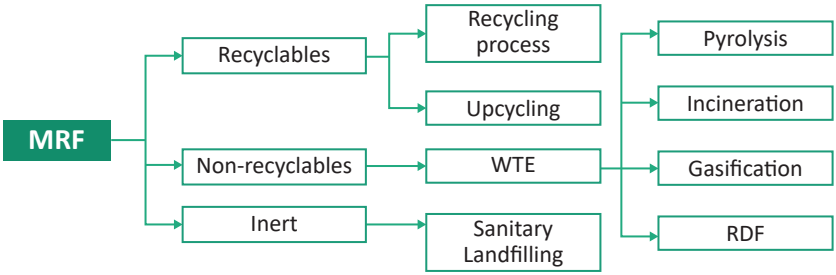


Figure 32 Dry waste processing technologies

8.1 Type of dry waste and average content

Type of waste	Average content
Plastic, Plastic Bags etc.	8.85%
Paper Waste	5.86%
Glass and Metal	0.61%
Leather, Rubber and Synthetics	0.23%
Tetra packs and laminated plastics	2.17%
Cloths and rags	5.07%
Food waste/ Organic	53.14%
Horticulture waste and Wood	3.99%
Miscellaneous, Inerts, ash, Soil, Silts	20.09%

Table 38 Type of dry waste and average content

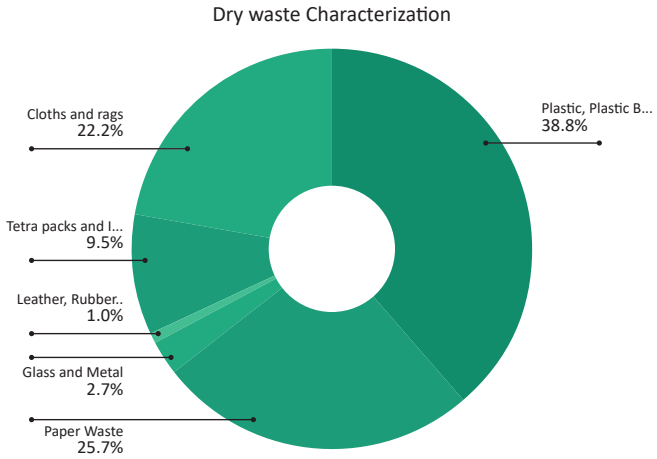


Figure 33 Characterization of dry waste

8.2 Recyclables and Non-Recyclables



Figure 34 Recyclable and non- recyclable waste

8.3 High-value recyclables

The advantage of door-to-door collection system is that it enables, waste collectors to remove high-value recyclables at source. High value recyclables product are:

- HDPE plastic – Oil cans, shampoo, cream and other product bottles.
- PET – Water bottles, soft drink bottles
- Metal –
- Rubber –
- Cardboard – boxes, packaging material.
- Glass – Beer and liquor bottles.

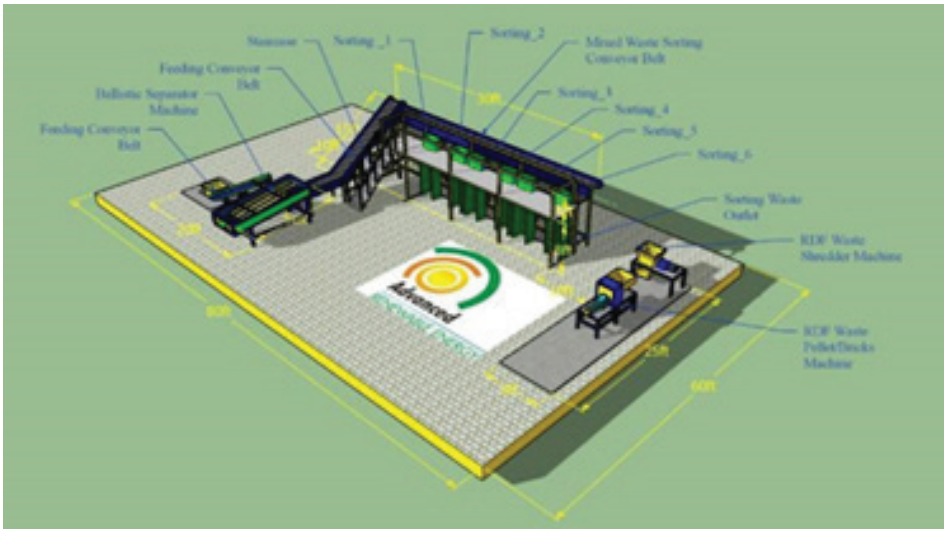
The advantage of door-to-door collection system is that it enables, waste collectors to remove high-value recyclables at source. High value recyclables product are:

8.4 Different Processes or Stages and Equipment Employed in a Material Recovery Facility:

8.4.1 For corporations: These are machines used for large quantities of waste, given here for reference

PROCESS OR STAGES	EQUIPMENT
Pre-sorting material handling equipment	• Belt conveyor • Screw conveyor • Apron conveyor • Bucket elevator • Drag conveyor • Pneumatic conveyor • Vibrating conveyor • Debagger
Ferrous metal separation	• Magnetic separator and screening
Screening	• Disc Screening • Trommels
Air classification	• Horizontal air classifier • Vibrating inclined air classifier • Inclined air classifier
Non-ferrous metal separation	• Rotating disk separator • Eddy current separator
Size reduction	• Can densifier • Can flattener • Glass crusher • Plastic granulator • Plastic perforator • Baler
Pollution control	• Dust collection system • Noise suppression devices • Odour control system • Heating, ventilating, and air conditioning (hvac)
Other fixed equipment	• Fixed storage bin • Live-bottom storage bin • Floor scale for pallet or bin loads • Truck scale • Belt scale

Table 39 Different processes or stages and equipment employed in a Material Recovery Facility



8.4.2 For Municipal Councils and Nagar Panchayat

Equipment required	Cities< 1 lakh population	Cities >1 lakh population
Pre-sorting material and handling equipment	Belt conveyor/screw conveyor	Belt conveyor/screw conveyor +vibrating conveyor + Debagger
Ferrous metal separator	NA	NA
Air Density Separator	NA	NA
Non-Ferrous metal separator	NA	NA
Size reduction	Baler	Baler/Plastic granulator
Pollution control	Ventilators	Ventilators
Other Fixed equipment	Storage Bins. Weighing machine	Storage Bins. Weighing machine

Table 40 Equipment requirement for small to medium-scale ULBs



Waste receiving Platform



Platform for secondary segregation of dry waste



Balling of recyclable plastic, paper, cardboard etc



Storage compartments for dry waste



Weighing scale



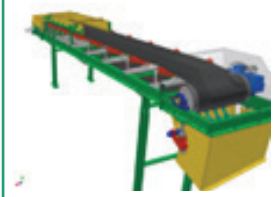
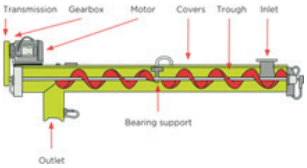
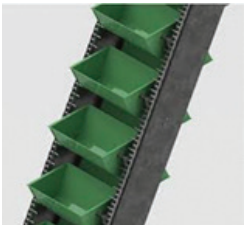
PPE

Figure 35 MRF facility for municipal councils

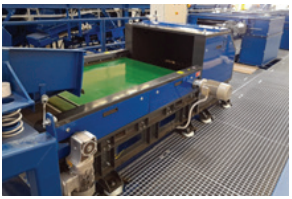
8.5 Requirement of MRF facility as per the scale of city

Population Range	upto 10k	upto 25k	upto 50k	50k-1 lac
Population	10000	25000	50000	100000
waste generation (TPD)	2.8	7.5	15	35
Dry waste (TPD)	**1.1**	**3**	**6**	**14**
workers req.(600kg/worker)	2	5	10	23
Type of MRF facility	Manual MRF	Manual MRF	Manual/Semi-Automatic MRF	Semi-Automatic/ fully automated
Area Requirement (sq.m)	80	80-120	120-250	250-500 (depend upon automation in MRF)
Indicative Capital Investment(excluding cost of land) in lacs	30	45	88	165
Operation Cost per Year in lacs (includes honorarium/ salary and regular repair, maintenance cost and consumables)	0.8	2.5	5	10
Approx potential earning (per month) for ULB (excluding operational cost+salary) in thousand	33.6	90	180	420

Table 41 Requirement of MRF Facility as per the scale of city

Machine	Photo	Application
Pre-sorting and material handling equipment:		
Belt Conveyor		•Secondary sorting of dry waste (manually) •simple conveyor with limited features
Screw Conveyor		•Used for handling of bulk material •Screw conveyors can have multiple inlet and discharge points. •Screw conveyors can be utilized in the horizontal, vertical or any inclined position depending upon
Apron Conveyor		• Apron feeders have a much more heavy-duty nature and can handle heavy and bulky material
Bucket Elevator		In municipal waste treatment plants, elevators can be used to lift the waste from the bottom to the top for further processing, such as sorting, compression, etc
Drag Conveyor		•Drag conveyors can be used to meter or transfer bulk materials from one process to another. •Drag conveyors are a great complement to screw conveyors and belt conveyors
Pneumatic Conveyor		Pneumatic conveyors use vacuum as a driving force to transfer the material to the designated process machinery

Vibrating Conveyor		Separate lighter material based on density of the material. Separates plastics, paper from other dry waste
Debagger		•Bag openers or bursters •Trommels were adapted as bag openers because the rotating motion of the trommel could allow hooks or blades to grab, tear and empty the collection bags while screening the organics from them. •In its absence manually bags should be opened.
Ferrous material separator		
Magnetic Separator		•Magnetic separation is primarily used in solid waste treatment systems to recover, or in certain processes to remove ferrous materials from solid waste. •It is important to remove the metallic content both for compost and RDF preparation. Metals can damage the RDF shredders.
Screening:		
Trommel		•To separate different fractions of dry waste •Typical sizes used are 200mm, 100mm, 50mm, 35mm, 16mm, and 4mm. •Consists of a perforated cylindrical drum that is normally elevated at an angle at the feed end
Disc Screen Separator		•Disc screens are capable of separating contaminants, dust, combustible and non-combustible waste

Air Classification:		
Air Classifier		•Air classifier pneumatically removes light impurities like paper and plastic labels from rigid plastics and plastic films. Typically used for eliminating PP/PE labels from PET bottles and labels from blue drums and plastic films
Non-Ferrous Metal separator:		
Rotating Disc Separator		•Not use commonly
Eddy Current Separator		•The eddy current separator is applied to a conveyor belt carrying mixed waste. At the end of the conveyor belt, there is an eddy current rotor. Non-ferrous metals are pushed forward by eddy current poles from the belt into the metal chute, the rest of material simply falls off the belt due to gravity to the second chute.
Size Reduction:		
Can densifier	Can Flattener	Glass Crusher
		

Plastic Granular	Plastic Perforator	Baler
		

(Image source: Google)
Table 42 List of Machineries while processing the dry waste

8.7 DO's and Don'ts at material recovery facility

	DO'S	DON'TS
1	Do check the working and maintenance of the equipment on monthly basis	Avoid use of inflammable objects in the premises
2	Ensure indoor air quality and adequate lighting	No smoking
3	Provision of suitable exhausts/vents/ scrubbers, etc. Secure the MRF, with walls and security guards.	Pregnant women to avoid operating equipment and strict prohibition of child labor
4	Mark and separately maintain areas for recovered material	Do not mix unsegregated waste with segregated waste.
5	Workers shall be covered under social security and insurance schemes	Avoid wastage of water and electricity
6	Use Personal Protective Equipment	Avoid discrimination
7	Use first aid whenever required	No animals allowed and no littering in the premises
8	Ensure proper segregation of waste	**Do not burn waste**

9	Clean all the equipment after use	Do not use explosives or firearms and avoid long term storage of Refuse Derived Fuel (RDF
10	Ensure adequate fire protection measures	Keep hands away from moving parts of equipment
11	Ensure good hygiene and sanitation practices including safe drinking water	Do not wear loose clothing around equipment

Source: Advisory on Material Recovery Facility (MRF) for Municipal Solid Waste, MoHUA, June 2020
Table 43 Do's and don'ts at material recovery facility

8.8 Dry waste Processing

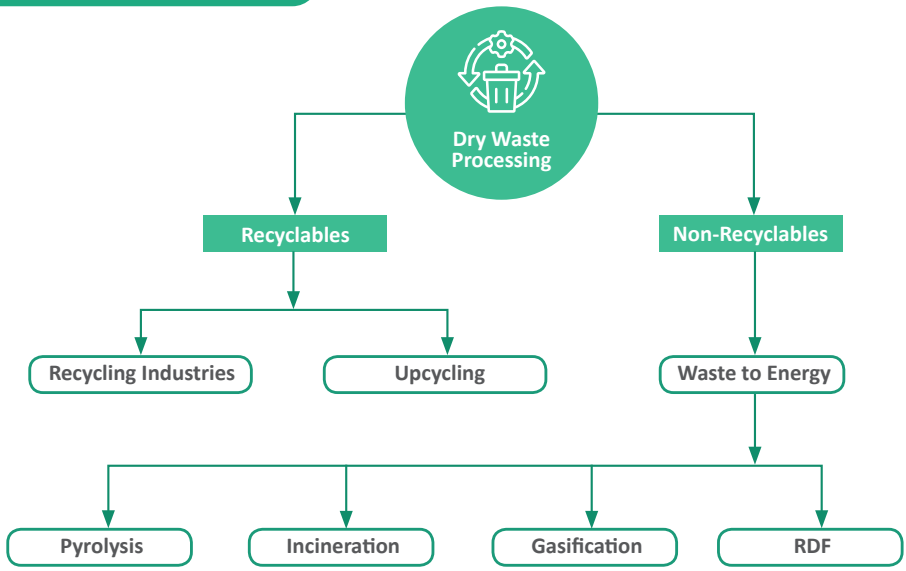


Figure 36 Dry waste processing systems and technologies

8.8.1 Recycling

Recycling is the process of converting waste into new products. This method can be used for dry waste such as paper, plastic, metal, and glass. The technical guidelines for recycling include setting up collection points for recyclable materials, transporting them to the recycling facility, and ensuring that the recycled products meet the required quality standards.

8.8.2 Upcycling

Upcycling is the process of transforming waste materials or products that are no longer useful into new materials or products of better quality and value. In India, the upcycling market for dry waste has been gaining traction in recent years, with several organizations and individuals contributing to this growing industry.

8.8.3 Waste-to-energy (WTE)

WTE technologies convert waste into energy in the form of electricity or heat. This method can be used for dry waste such as non-recyclable plastics and waste paper. The technical guidelines for WTE include setting up the facility in a designated area, ensuring proper ventilation, providing safety equipment for workers, and monitoring emissions to minimize the impact on the environment.

This technology can reduce the volume of waste sent to landfills, and generate renewable energy.

- **Incineration**: Incineration is a thermal process that uses high temperatures to burn waste and convert it into ash, gasses, and heat. In India, incineration is used to convert non-recyclable dry waste into energy in waste-to-energy plants. This method requires proper air pollution control measures to reduce emissions.
- **Pyrolysis:** Pyrolysis is a thermal process that decomposes organic matter in the absence of oxygen and converts it into fuel, gas, and char. This method is commonly used for processing dry biomass waste, such as agricultural residues, wood waste, and municipal solid waste.
- **Gasification:** Gasification is a thermal process that converts carbon-based materials into a gas mixture consisting of carbon monoxide, hydrogen, and methane. This gas mixture can be used to generate electricity or heat. In India, gasification technology is used for waste-to-energy projects.
- **Plasma Arc Gasification:** Plasma arc gasification is a high-temperature process that converts waste into a synthetic gas (syngas) by exposing it to a plasma arc. The syngas can be used for energy production, and the solid waste is converted into an inert slag that can be used as a construction material.
- **Refuse-derived fuel (RDF):** RDF is produced by shredding and drying solid waste and converting it into a fuel that can be burned in boilers or furnaces to generate energy. This method is commonly used in cement kilns and power plants in India.

Notes

Chapter 9:

Processing and treatment of various waste streams: Sanitary and Household Hazardous Waste

Key Highlights of this Topic

Part A: Sanitary waste Management

- Definition of Sanitary waste
- Current practices for disposal
- Handling and collection guidelines for transportation of Sanitary Waste
- Technique of disposal in ULB's and Institutions for Sanitary Waste
- Case study

Part B: Household Hazardous waste Management

- Household Hazardous waste and its types
- Regulatory Framework for managing Household Hazardous Waste (HHW)
- Treatment and Disposal

About the topic

- This topic focuses on importance of handling and safe disposal of Sanitary waste and HHW
- Its highlight the regulatory framework and technologies for disposal of Sanitary waste and HHW

Summary

At-source segregation of HHW and sanitary waste is essential for the safety of waste workers, protecting the environment, conserving resources, ensuring compliance with regulations, and fostering a culture of responsible waste management.

Role of ULB:

- Citizen awareness for at source segregation
- Establishing collection and transportation system- provision on vehicle for separate collection of Sanitary waste and HHW
- Provide a storage facility for HHW for 15 days if Incinerator is not available within the ULB, ULB can set up collection and storage center as per the norms i.e. for HHW 1 center for 20 sq.km area
- Considering the quantity of sanitary waste i.e. 0.65% of total waste ULB should have an incinerator for disposing of the waste as per the CPCB/MPCB norms.
- For small ULBs, ULB can tie-up with MPCB Authorised waste processing agencies of biomedical waste and handover the waste at a set frequency (not > 15 days)

9.1 Definition of Sanitary Waste

"Sanitary waste" means wastes comprising of used diapers, sanitary towels or napkins, tampons, condoms, incontinence sheets and any other similar waste.

Sanitary Waste means waste that contains human feces, urine, blood or body fluids originating from sanitary conveniences or other sources.

Menstruation Waste	Sanitary Convenience Waste	Biomedical Waste
Used Sanitary pads/ napkins, tampons, etc.	Waste that contains human feces, urine, blood or body fluids originating from sanitary conveniences or other sources.	As per biomedical rules, 2016, biomedical 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.
This forms a larger part of the sanitary waste.	These are used baby diapers, adult diapers, pads, personal hygiene products etc.	

Table 44 Types of Sanitary Waste

9.2 Sanitary Waste Practices

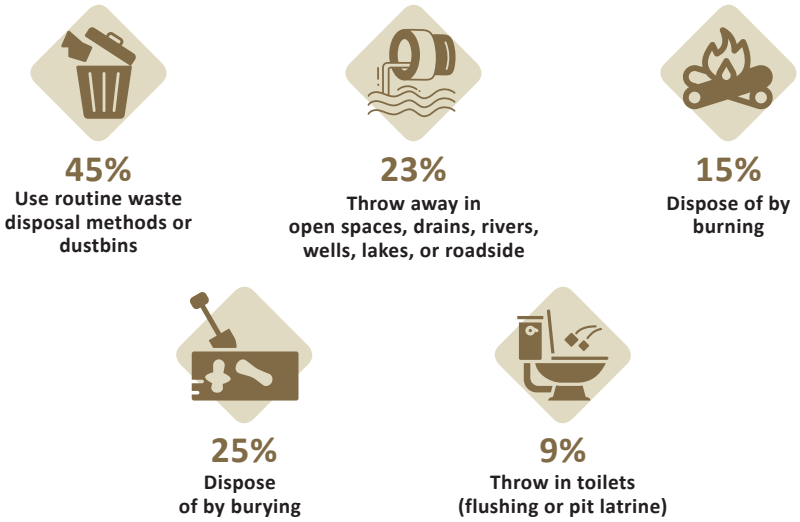


Figure 37 Sanitary waste practices

9.3 Handling and Collection Guidelines Transportation of Sanitary Waste

- **Consumers Responsibility (CPCB & SWM Rules, 2016)**

  Use Manufacturer's Wrapper or Pouch
  No Provided Wrapper?
  Use Old Newspaper

- **SWM Rules Awareness through IEC Initiatives (CPC & SWM Rules, 2016)**

  Comprehensive Awareness
  Handling and Disposal Education
  Collaborative Efforts

- **Producers Responsibility (CPCB & SWM Rules, 2016)**

  Producer's Responsibility Utilize Information.
  Education, and Communication (IEC)
  Facilitating Disposal
  Local Agency Collaboration

- **Effective Disposal Alternatives for Collected Waste**

  Sanitary Waste Disposal Alternatives.
  Storage or Disposal Facilities
  Centralized Biomedical Waste Treatment
  Waste-to-Energy Treatment Plants
  Community-Incinerators Establishment

- **Community Toilet Construction Specifications**

  Incinerators for Toilets with Over Ten Seats
  Promoting Menstrual Hygiene in Ladies' Toilets

Figure 38 Handling and Collection Guidelines Transportation of Sanitary Waste

9.4 Technique of Disposal in ULBs and Institutions for Sanitary Waste

Disposal Option	Type of use	Advantages	Disadvantages	Example of Use
Electric incinerators	Institutional/ public settings	• Hygienic, Easy to use • Some models have emission control	• Dependent on electric supply, • High cost • May release toxic gasses if temperature below 800 degrees Celsius • Unable to efficiently burn pads with high moisture content	Public toilet, Chennai, Central Railway Station
Locally-made incinerators.	Small Scale institutional/ public settings	• Low cost, • Easy to install	• No emission controls, • Burns at low temperature, • hence waste may not burn efficiently, • Design is highly variable and not standardized	Schools in Nepal, Schools in Uttar Pradesh
Padcare Solutions	Institutional/ public settings	• Environmentally friendly solution • Segregates pulp and plastic	• It is a start-up thus limited reach and processing capacity currently.	Mumbai, Bengaluru, Hyderabad, and Gurugram.

Table 45 Technique of Disposal in ULBs and Institutional Body for Sanitary Waste

9.4.1 Processing of Sanitary Waste

- In ULB mainly centralized Incinerators or Electric incinerators are utilized
- In large and medium level institutes Electric Incinerators are used.
- It may also be processed along with the Biomedical waste incinerator
- Sanitary waste processing technologies to retrieve the polymer waste are also being piloted.

9.5 Sample calculation for quantit

Karad City is successfully managing its Menstrual Waste. Below is their calculation for estimating the quantity generated.

Total population	76000
Female population	39370
Menstruating Population(15-39)	16065
Sanitary Waste Generation (Per day)	245 kgs
Considering Menstruating Cycle Days	6 Days
After utilization of Pad Wt in gms	15gms
Utilization of Pads for day	4
Per menstruating Women Waste Generation (per cycle)	4*6= 24.(24*0.015=360 gms)
Menstruating Waste generated in Karad in 1 Day	192 kgs

Ref: CSE report 2022
Table 46 Case study of Karad Municipal Council

9.5 Sample calculation for quantit

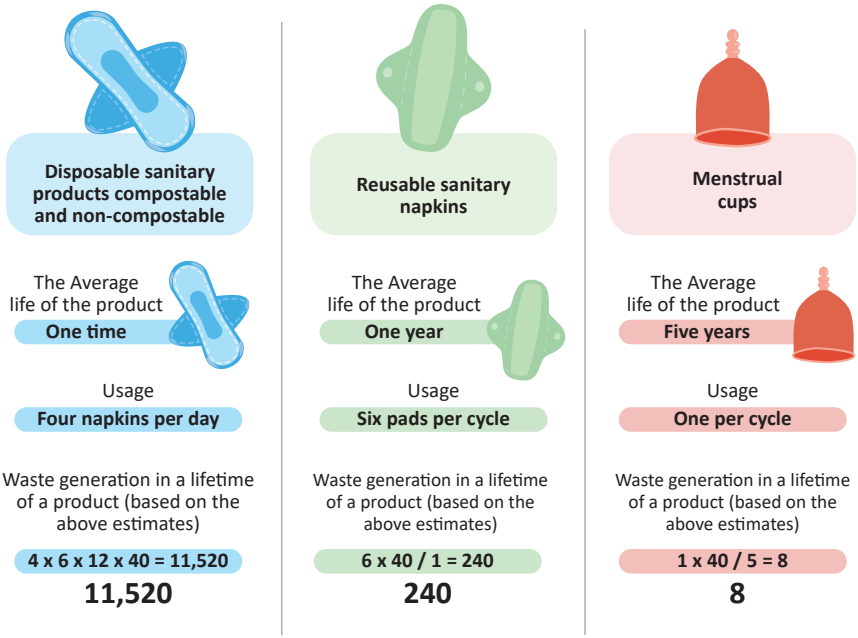


Figure 39 Sanitary waste generation

9.6 Definition of Household Hazardous Waste (HHW)

"Household Hazardous waste" means any waste that by reason of characteristics such as physical, chemical, biological, reactive, toxic, flammable, explosive or corrosive, causes danger or is likely to cause danger to health or the environment, whether alone or in contact with other wastes or substances.

9.7 Types of Hazardous Waste

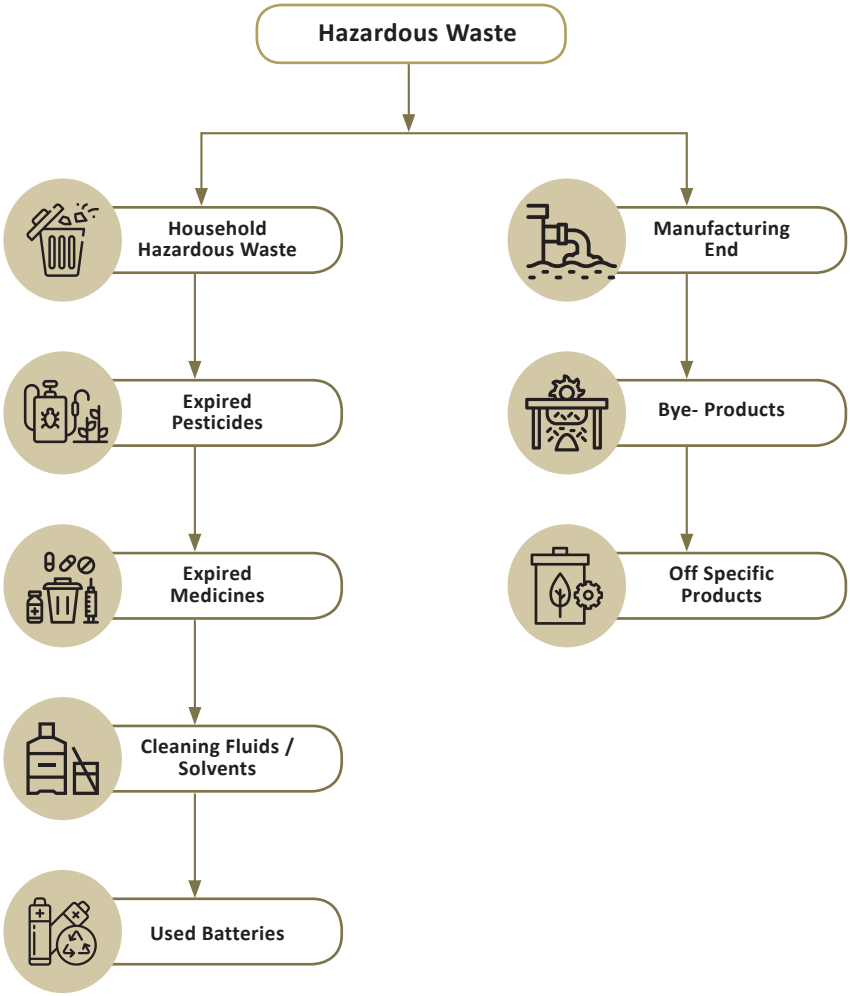


Figure 40 Types of Hazardous Waste

9.8 Pollutants of concern in household products

Lead | Nickel | Cadmium | Arsenic & Zinc | Mercury | Other Hazardous Chemicals



HOUSEHOLD CLEANERS

Oven cleaners, drain cleaners, wood and metal cleaners and polishes, toilet cleaners, tile and shower cleaners, bleach (laundry)



AUTOMOTIVE PRODUCTS

Motor oil, fuel additives, air conditioning refrigerants, starter fluids, automotive batteries, transmission and brake fluid antifreeze



HOUSEHOLD INSECTICIDES

Herbicides, insecticides, fungicides/wood preservatives



MISCELLANEOUS

Mercury thermostats or thermometers, fluorescent light bulbs, discarded PVC toys, batteries, computer components and end-of-life electronics items



PAINTING SUPPLIES

Adhesives and glues, furniture strippers, oil or enamel-based paint, latex or water-based paint, stains and finishes, paint thinners and turpentine, paint strippers and removers, fixatives and other solvents



INDOOR PESTICIDES

Ant sprays and baits, cockroach sprays and baits, flea repellents and shampoos, bug sprays, houseplant insecticides, mosquito coils, moth repellents, pet care products, pet food items



OTHER FLAMMABLE PRODUCTS

Compressed gas cylinders, kerosene diesel fuel gas/oil mix, lighter fluids, shoe polish, cigarette butts

Figure 41 SEQ Figure * ARABIC 42 Pollutants of concern in household products

9.9 Regulatory Framework Managing Domestic Hazardous Waste

Segregation Mandate

- SWM Rules, 2016 Section 1(a) requires waste generators to segregate waste into three streams: bio-degradable, non-biodegradable, and domestic hazardous.
- Source segregation, especially for domestic hazardous waste, is crucial for proper disposal and to minimize occupational health hazards for waste-workers handling mixed waste.

Storage and Collection Practices:

- Waste should be stored in suitable bins and handed over to authorized waste collectors as per local authority directions by generators.
- Section 15(j) mandates local authorities to ensure the safe storage and transportation of domestic hazardous waste to suitable disposal facilities, following pollution control board directives.

Establishment of Waste Deposition Centers:

- SWM Rules, 2016 Section 15(i) mandates local authorities to establish waste deposition centers specifically for domestic hazardous waste.
- Facility shall be established in a city or town in a manner thatn one center is set up for the area of 20 sq km, and notify timings of receiving the waste.

Figure 42 Regulatory Framework Managing Domestic Hazardous Waste

9.10 Treatment and Disposal

Secured landfill Disposal - Deep Burial

HHW has to be buried securely in a deep compartment, through which the chemicals will not leak. Design resembles sanitary landfills, but secured landfills have double protective layers (primary and secondary leachate collection, and double liner system). It has to be as per Pollution Control Board guidelines and permissions.

Thermal Processing - Incineration

The State Pollution Control Board is responsible for setting up a Hazardous waste processing facility. ULBs should transport the hazardous waste to the nearest facility identified by the State Pollution Control Board.

Figure 43 Treatment and Disposal of HHW

Notes

Chapter 10:

Construction and Demolition Waste Management

Key Highlights of this Topic

- Introduction to C&D waste- Thumb rule and composition
- C&D waste processing technologies and recycled products from C&D waste
- Status of C&D waste management in Maharashtra

About the topic

- This topic gives a brief idea about C&D waste management systems required for ULBs.

C & D waste flow dig:

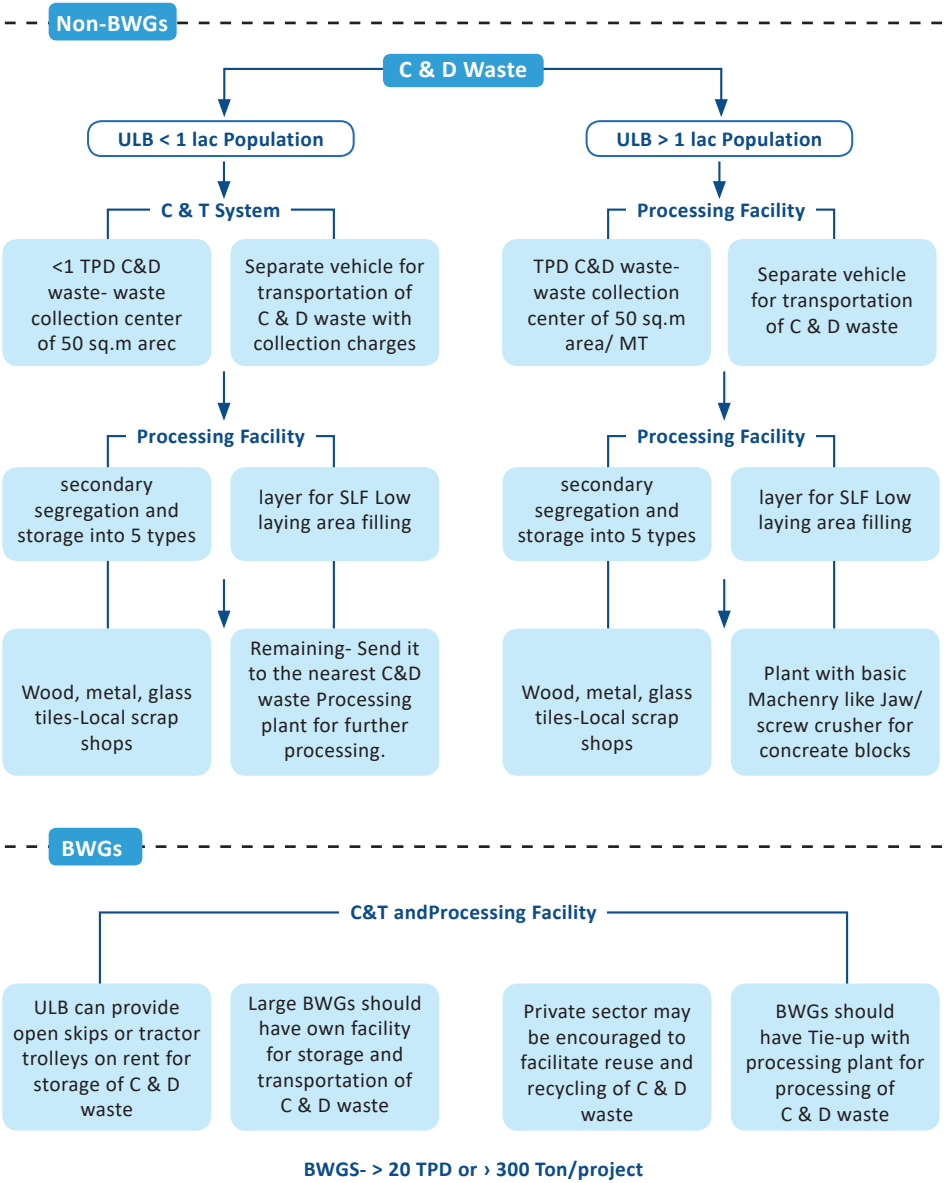


Figure 44 C & D Waste generators

C&D Waste process flow dig:

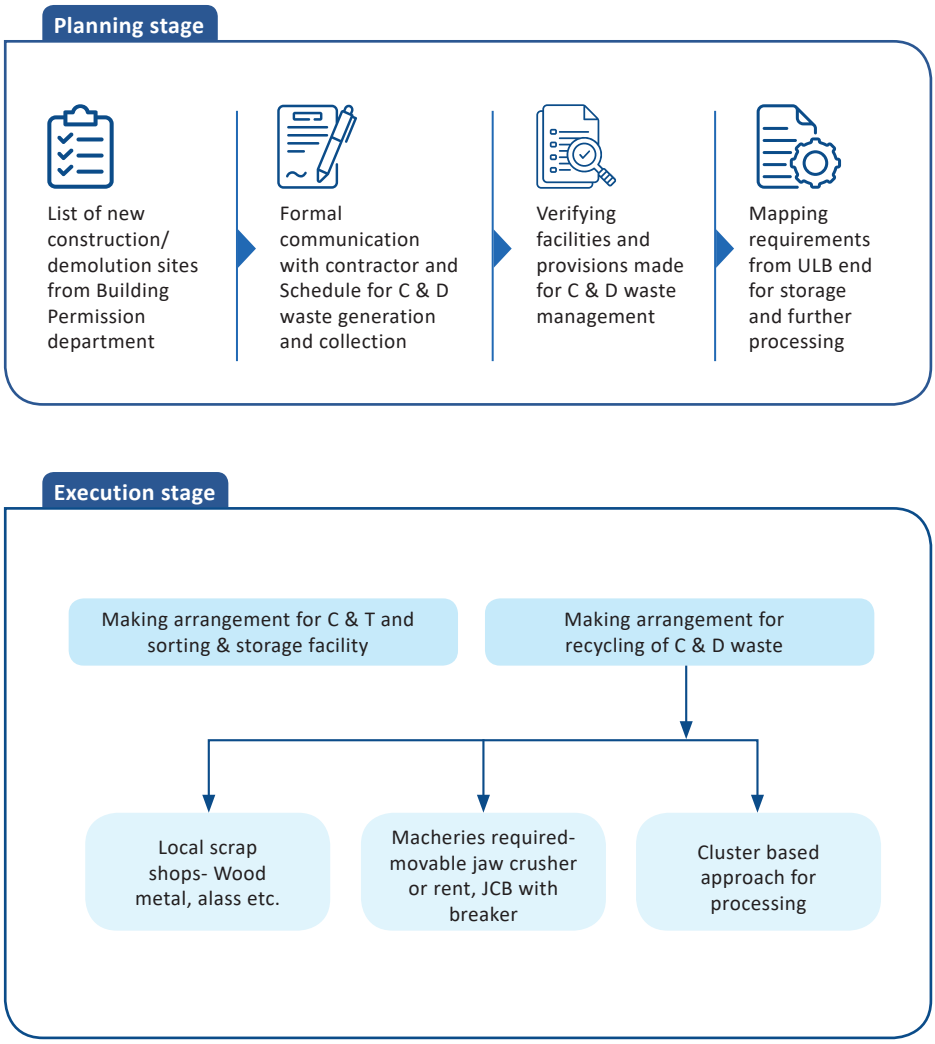


Figure 45 C & D Waste Flow Diagram

10.1 Introduction

In the rapidly developing and urbanizing India, Construction and Demolition waste is being generated at a high rate. C&D waste if not managed properly leads to problems such as

1. The mixing of C&D waste with Municipal Solid waste hampers the recycling and processing of MSW.
2. Wastes are quite often given away for filling in low lying areas or plots to private agencies, or disposed of at open spaces or on the roadside illegally.
3. They become the start of chronic spots, and attract more waste.
4. They deteriorate the soil quality and hamper vegetation growth in the area deposited
5. The waste finds its way into drains and nallahs, clogging them.

Thus, separate management of C&D waste is essential in all ULBs as mandated by the C&D waste Rules 2016.

10.1.1 Thumb Rules for Estimation of C&D Waste Generation

TIFA's thumb rules for estimation of C&D waste recognizes that the generation is project-specific.

TIFA's C&D waste estimations are as follows:

1. Range 40-60 kg per sq.m. Of new construction
2. Range 40-50 kg per sq.m. Of building repair
3. Range 300-500 kg per sq.m For demolition buildings

10.1.2 Composition of C&D waste:

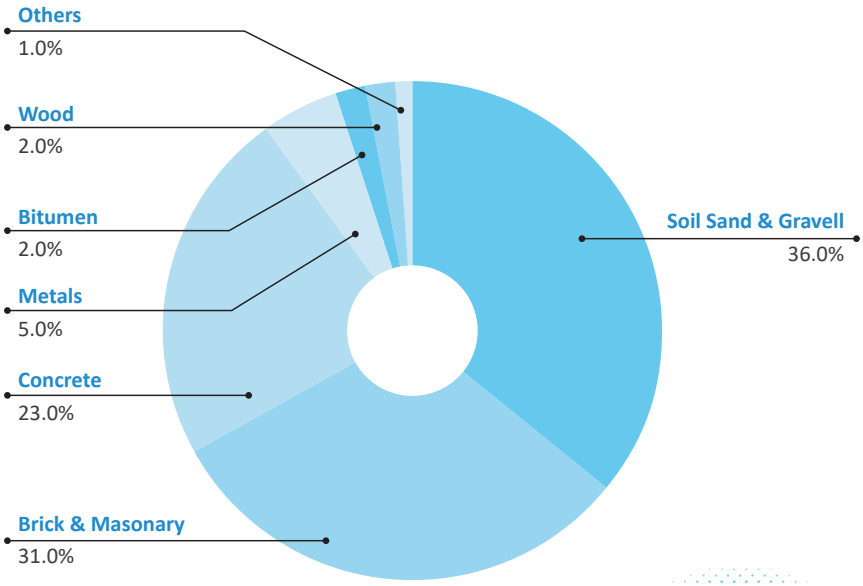


Figure 46 Composition of C&D Waste

10.2 C&D waste processing type technologies

Mobile C&D waste recycling plants:

These are easily transportable and can be moved from one location to another as needed. Ideal for processing small to medium volumes of C&D waste at different locations or temporary construction sites.

Semi-mobile C&D waste recycling plants:

Partially portable, these can be relocated within a site or to a different site. They are typically larger than mobile plants and can process higher volumes of C&D waste. Suitable for processing medium to large volumes of waste generated at a specific construction site or demolition project.

Stationary C&D waste recycling plants:

These are permanently installed at a single location and are typically the largest and most advanced type of recycling plant. Suitable for processing large volumes of waste generated in a city or region over an extended period.

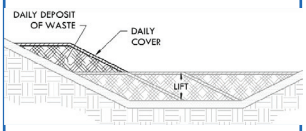
10.3 Permissible Applications of C&D waste

Layering in Leachate colln system and Sanitary Landfill



- Use of only crushed and graded hard material of 2 mm to 4.5 mm
- Use as drainage layer in top cover system above Gas Collection Layer of Sanitary Landfill
- Use for Capping of Sanitary Landfill

Daily Cover



- Fine sand of 2mm from the processed C&D waste shall be used as daily cover over fresh waste for the sanitary landfill.
- This use of C&D waste is mandatory instead of fresh soil

Civil Construction



- Use for civil works in sanitary landfill
- Use for non structural applications such as kerb stones, drain covers, paving blocks in pedestrian areas.

Figure 47 Permissible Applications of C&D waste

10.3.1 Use of Processed Construction and Demolition Waste

Recycled Aggregate (RA):	• Used for nonstructural purposes, up to 20% replacement of natural aggregates in plain concrete work, and up to 30% in road sub-base/base.
Quality of RA:	• Free from deleterious material and harmful chemicals.
Uses of RA:	• Making kerb stones, paving blocks, concrete blocks, bricks, road sub-base, pathways, rural roads.
Recycled Concrete Aggregate (RCA)	• Used in all grades of PCC (non-structural and structural), needs to be pre-wetted near to SSD conditions before use.
Fine Washed Aggregates:	• Separated from C&D waste using 'wet' process, used as 'manufactured sand" for non-load hearing structures
Daily Cover Waste:	• Placed at the landfill, covered at the end of operations each day, cover should be at least 10 cm thick.

Figure 48 Use of Processed Construction and Demolition Waste

10.3.2 Final Processed Products



Figure 49 Final Processed Product

10.3.3 C&D Waste Processing and Its Recycled Products

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	Recycled concrete aggregate for recycling
Clay bricks, roof tiles	Cleaned	Reused for masonry
Calcium silicate bricks	Pulverised, Cleaned	Mixed with lime to produce mortar, Recycled into new calcium silicate bricks
Natural stone masonry	Cleaned	Reused for masonry
Natural stone slabs	Crushed	Aggregate
Ceramic tiles	Crushed, Cleaned	Aggregate, Flooring, cladding
Asphalt paving	Crushed, Crushed cold mixed, Crush hot mixed	Road construction excluding wearing course

Table 47 C&D Waste Processing and Its Recycled Products

Notes

Chapter 11:

Scientific Disposal of waste

Key Highlights of this Topic

- Types of waste to be accepted at Sanitary Landfills(SLF)
- Guidance for Sanitary Landfill area requirements
- Requirements for site selection and execution
- Operation and maintenance of SLF
- Components of SLF

About the topic

- This topic gives details about SLF site selection, operations and maintenance

Summary:

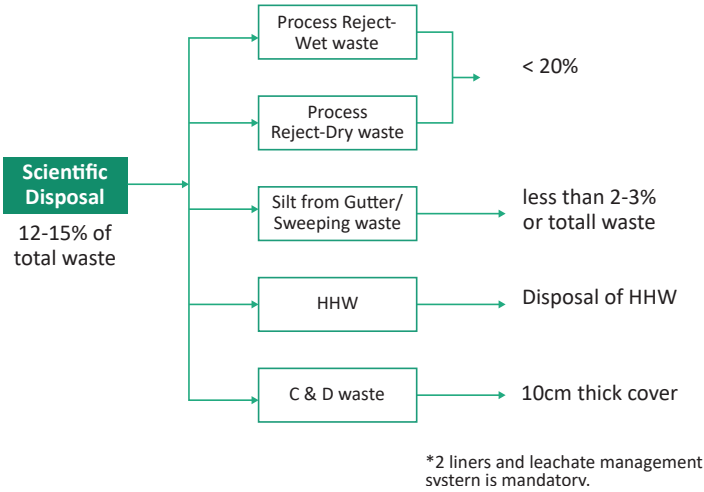


Figure 50 Waste to be feed to sanitary landfill

Sanitary Landfill Definition as per SWM Rule 2016

A carefully engineered disposal facility for municipal solid waste (MSW) designed and operated to ensure the protection of the environment and public health. It is a fully engineered structure which is lined with a clay liner to prevent leachate from entering the groundwater and a synthetic liner to prevent landfill gas from escaping.

Sanitary Landfill and Dumpsites:

Sanitary landfills and dumpsites are waste disposal methods with **distinct design, management, and environmental impact.** Sanitary landfills are designed to minimize environmental impact and health risks, with liners at the bottom to prevent leachate from contaminating soil and groundwater. They are compacted and covered regularly to reduce odors, littering, and pests, and can capture methane gas for energy production. They have lower pollution and environmental degradation risks compared to traditional dumpsites.

On the other hand, dumpsites are unregulated disposal sites where waste is dumped without proper planning or infrastructure, often lacking protective liners or proper waste management systems. They often leave waste uncovered, attracting pests and vermin, and lack proper drainage systems, leading to soil and water contamination and health risks.

11.1 Types of waste to be accepted at Sanitary Landfills

MSW Type	Accepted for Landfill?	Reason
Mixed Waste	Yes, with limitations	Only if not readily separable into other categories
Pre-processing/Post-processing Rejects	Yes	After exploring other disposal options
Non-hazardous Waste (unprocessed/unrecycled)	Yes, with caution	Prioritize processing/recycling when possible
Biodegradable Waste	No	Can be composted or anaerobically digested
Dry Recyclables	No	Should be recycled to conserve resources
Hazardous Waste	No	Requires special treatment and disposal

Table 48 Types of MSW to be Accepted at Landfills

11.2 Rough guidance for Sanitary Landfill area requirements:

WASTE QUANTITY (TONNES PER DESIGN LIFE OF LANDFILL)		REQUIRED SITE AREA (HA)
in million	in lakhs	
1	< 10	15-20
1.0 - 2.0	10-20	20-30
2.0 - 3.0	20 - 30	30-40
3	> 30	40

Table 49 Land requirements for sanitary landfill

11.3 Requirements for Site selection and Execution:

Element	Data	Units
Site Selection		
-Minimum distance to sensitive receptors (residential areas, water bodies, etc.)	500 m	Meters
- Maximum slope of land	25%	Percentage
- Minimum depth to groundwater	1 m	Meters
Liner System		
- Thickness of clay liner	1 m	Meters (compacted)
- Hydraulic conductivity of clay liner	1 x 10^-7 cm/sec	Centimeters per second
- Thickness of HDPE geomembrane	1.5 mm	Millimeters
- Drainage layer thickness (above liner)	30 cm	Centimeters (gravel)
Landfill Cells		
- Maximum width of a cell	60 m	Meters
- Maximum side slope of a cell	4:1 (above ground), 2:1 (below ground)	Ratio
- Minimum daily cover thickness	30 cm	Centimeters (soil)
- Minimum intermediate cover thickness	60 cm	Centimeters (soil)
Leachate Management		
- Maximum leachate collection pipe spacing	30 m	Meters
- Minimum leachate sump size	2 m x 2 m x 2 m	Cubic meters
- Maximum storage capacity of leachate treatment plant	1.5 times daily leachate generation	Ratio
Gas Management		
- Minimum horizontal spacing of gas extraction wells	60 m	Meters
- Minimum vertical spacing of gas extraction wells	3 m	Meters
- Maximum allowable methane concentration at landfill boundary	5 ppm	Parts per million
Closure and Cover System		
- Thickness of final cover soil layer	60 cm	Centimeters
- Thickness of final cover drainage layer	30 cm	Centimeters (gravel)
- Permeability of final cover soil layer	1 x 10^-7 cm/sec	Centimeters per second

Table 50 Requirements for Site selection and Execution

11.4 Operation and Maintenance of SLF

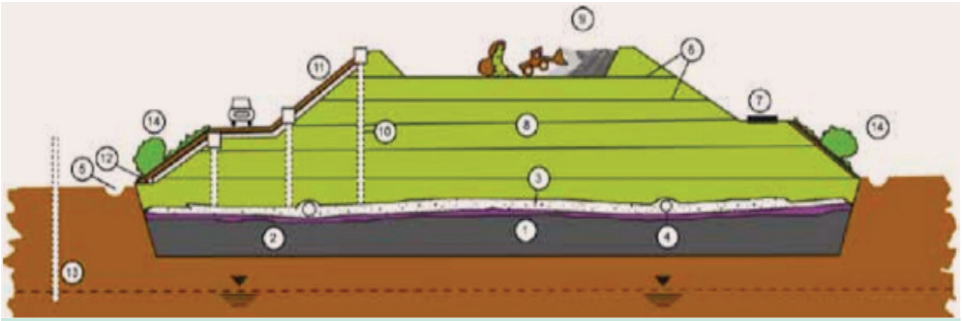
Unloading of rejects into the Sanitary Landfill: The Landfill should be constructed such as to provide a ramp for vehicles to drive down to the base of the landfill for unloading. The truck should tip the reject waste on the floor of the landfill. This should then be spread evenly on the surface, and layered on top with compacted soil or crushed C&D waste. Care should be taken to keep the gas collection system obstruction free.

Aspect	Requirement/Guideline	Operation	Maintenance
Site Selection	- Should be located away from populated areas, water bodies, and ecologically sensitive areas. - Minimum distance from habitations: 500 m. - Not in floodplains, earthquake zones, or areas with unstable soil.	- Regular monitoring of groundwater and surface water quality. - Landfill gas monitoring. - Leachate collection and treatment system monitoring.	- Repair of landfill liner and cover systems. - Maintenance of leachate collection and treatment systems. - Gas collection and treatment system maintenance.
Liner System	- Clay liner with minimum thickness of 1 m or composite liner with synthetic geomembrane.	- Regular inspection of liner for tears or punctures. - Immediate repair of any damage to the liner.	- Monitoring of liner integrity through leak detection systems. - Replacement of liner if necessary.
Leachate Collection and Treatment	- Leachate collection system to prevent contamination of groundwater. - Leachate treatment to meet prescribed standards before discharge.	- Regular operation and maintenance of the leachate collection system. - Monitoring of leachate quality and flow. - Proper operation and maintenance of the leachate treatment plant.	- Cleaning and maintenance of leachate collection pipes and sumps. - Desludging of leachate treatment ponds or tanks. - Repair or replacement of treatment plant components as needed.
Landfill Gas Collection and Treatment	- Gas collection system to prevent methane emissions and odors. - Gas treatment to meet prescribed emission standards before release or use for energy generation.	- Regular monitoring of gas collection systems for leaks and efficiency. - Proper operation and maintenance of gas collection and treatment equipment.	- Repair or replacement of gas collection pipes and wells. - Maintenance of gas treatment plant components. - Monitoring and adjustment of gas treatment parameters.
Waste Acceptance and Spreading	- Only authorized waste types should be accepted at the landfill. - Waste should be spread and compacted in layers to minimize void space.	- Visual inspection of incoming waste for prohibited items. - Rejection of unauthorized waste. - Proper spreading and compaction of waste using appropriate equipment.	- Control of vectors and pests at the landfill site. - Fire prevention and control measures. - Dust control measures.
Daily Cover	- Daily cover of waste with a minimum of 150 mm of compacted soil to prevent odors, flies, and windblown litter.	- Application of daily cover material to all exposed waste surfaces at the end of each day.	- Maintenance of a stockpile of daily cover material readily available. - Wetting of daily cover material during dry periods to prevent dust generation.

Final Cover	- Final cover with a minimum thickness of 1 m of compacted clay or a combination of clay and synthetic geomembrane after filling is complete.	- Application of final cover material after waste placement is complete. - Grading and shaping of the final cover to promote drainage and prevent erosion.	- Maintenance of vegetation cover on the final cover to prevent erosion and promote stability. - Monitoring of final cover for settlement and erosion.
Monitoring and Reporting	- Regular monitoring of groundwater, surface water, air quality, and landfill gas. - Recordkeeping of all monitoring data and operational activities. - Reporting of monitoring results to the regulatory authorities.	- Implementation of a monitoring plan as per the landfill permit. - Calibration and maintenance of monitoring equipment. - Data analysis and interpretation.	- Preparation of monitoring reports and submission to the regulatory authorities. - Implementation of corrective actions based on monitoring results.
Closure and Post-Closure Care	- Proper closure of the landfill after filling is complete. - Post-closure care for a minimum of 30 years to ensure the long-term stability and environmental protection of the landfill.	- Implementation of a closure plan as per the landfill permit. - Removal of landfill gas collection and treatment systems. - Grading and shaping of the final cover. - Planting of vegetation on the final cover.	- Regular inspections of the closed landfill for signs of settlement, erosion, or leachate leakage. - Maintenance of the final cover and vegetation. - Monitoring of groundwater and surface water quality.

Table 51 Operation and maintenance of SLF

11.5 Essential Components of Sanitary Landfills



1. Geological barrier
2. Impermeable base liner
3. Drainage layer
4. Leachate collection system
5. Storm - water drain ditch
6. Bordering dams
7. Circulation roads
8. Landfill body
9. Filling and compacting in layers
10. Gas venting system
11. Protective cover system
12. Gas collectors
13. Groundwater control
14. Re-planting

Figure 51 Essential Components of Sanitary Landfills

Notes

Chapter 12:

Remediation of Legacy Waste

Key Highlights of this Topic

- Methods for remediation of waste
- Approach for remediation of Legacy Waste
- Models for implementing dumpsite remediation
- Project implementation for remediation of legacy waste
- Bioremediation process schematics
- Indicative Human Resource requirement
- Equipment required for the processing of Legacy Waste

About the topic

- This topic gives details about requirement of legacy waste remediation, methods and models.

Summary:

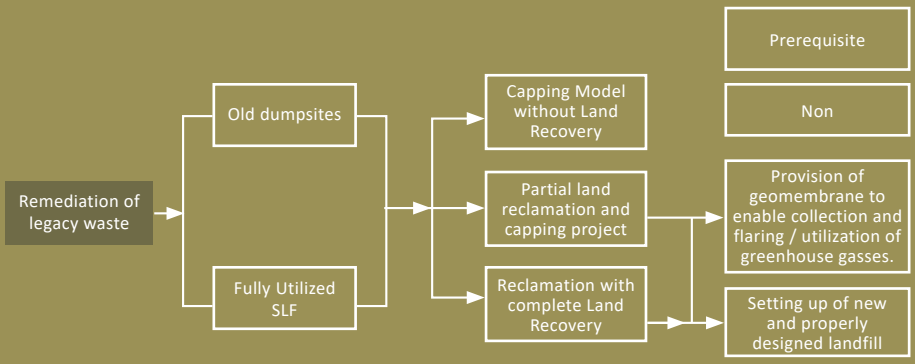


Figure 52 Prerequisite for remediation of legacy waste

12.1 Remediation of Legacy Waste

The Solid Waste Management Rules of 2016 directed Urban Local Bodies to clear legacy waste dumps as well as existing operational dumpsite down to pre-existing ground level through a process called bioremediation or biomining, which refers to an environment-friendly technique to separate soil and recyclables from legacy waste.

The treatment and disposal of Legacy MSW can be done by Bio-remediation. A total station survey or drone mapping of any landfill/dumping site must be done prior to start of the project.

Photo or diagram of total station survey

Type of Remediation	Advantages	Disadvantages
Capping Model without Land Recovery	1. Can be completed fast 2. Process requires less environmental clearances 3. Relatively cheaper 4. Land capped can be developed into parks/recreational areas	1. No land recovery, no financial benefit from land capped (except parks/ recreation) 2. Regular operation and maintenance required, thus recurring expenditure 3. Problems with leachate collection and gas generation 4. Post closure O and M is required
Partial land reclamation and capping project	1. Cheaper than 100% reclamation 2. Can be faster than 100% reclamation 3. Volume of waste is reduced 4. Waste components can be recovered such as RDF material 5. Improvement in aesthetics and quality of environment in the area 6. Land capped can be developed into parks/recreational areas	1. Only partial compliance to SWM 2. Rules and NGT orders 3. Only partial land recovery 4. Methodology is time taking, extensive work 5. Disposal of segregated portions is a challenge (transportation etc.) 6. Industry expertise is limited (only a few contractors) 7. Difficult to quantify the waste
Reclamation with complete Land Recovery	1. 100% Land recovery 2. Volume of waste is reduced 3. Waste components can be recovered such as RDF material 4. Increase in land value 5. Compliance to SWM Rules and NGT orders 6. Improvement in aesthetics and environment in the area	1. Expensive, requires heavy machinery 2. Methodology is time taking, extensive work 3. Disposal of segregated portions is a challenge (transportation etc.) 4. Industry expertise is limited (only a few contractors) 5. Difficult to quantify the waste. 6. Expensive to weigh all recovered fractions 7. Addition of fresh waste to site can hamper complete recovery.

Table 52 Methods for remediation of legacy waste

Note: Although capping is mentioned as a method in this advisory, it must be noted that SWM Rules 2016 and NGT have mandated that for remediation of legacy waste dumpsites Bioremediation is preferred over Capping.

12.2 Approach for Remediation of Legacy Waste

Unloading of rejects into the Sanitary Landfill: The Landfill should be constructed such as to provide a ramp for vehicles to drive down to the base of the landfill for unloading. The truck should tip the reject waste on the floor of the landfill. This should then be spread evenly on the surface, and layered on top with compacted soil or crushed C&D waste. Care should be taken to keep the gas collection system obstruction free.

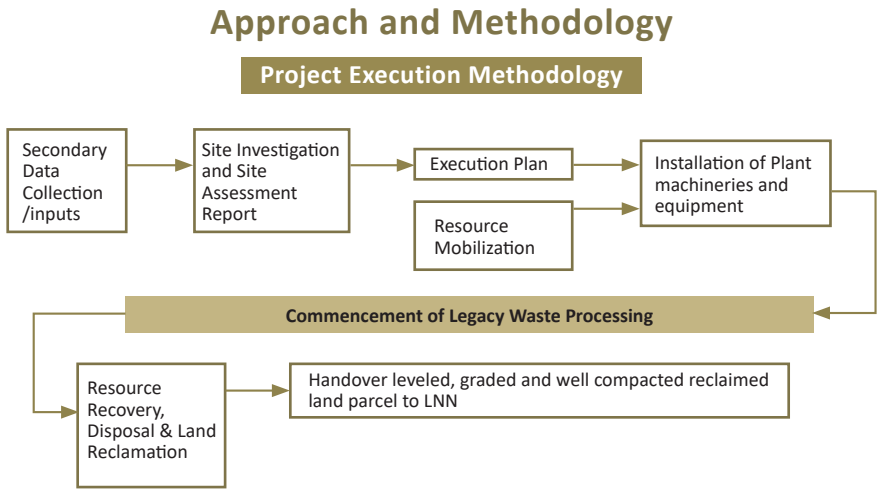


Figure 53 Approach and Methodology for Dumpsite Bioremediation

12.3 Models for Implementing Dumpsite Remediation

100% Outsourced Model

ULB	Contractor
Assess the quantity of waste and hand over the land for	Set up the plant at his own cos
Provide electricity connection for the plant	Pay electricity charges for the usage of the plant
Facilitate the disposal arrangements with their processing facilities	(To be included) Responsibility for disposal of RDF, recyclables and aggregates
Appoint academic institution as Third party to verify the activities	Carry out bio-mining as per SWM rules 2016 and CPCB guidelines
Make payment for the quantity of waste removed subject to verification by Third party	Make all investment for machineries and daily operational cost in advance

100% Work done by ULB with Rental Equipment

ULB	Contractor
Rent Machines as per DPR/Technical Feasibility Report	Provide machines as per the specification provided in DPR/Feasibility report/tender
Arrange human resources to operate and manage the project as per CPCB guideline	Process the waste at their processing site
Excavation and subsequent transportation of waste	Segregate excavated waste into as many kinds as possible in compliance with CPCB
Set up an eco-friendly and non polluting processing system	Explore the possibility of minimizing the disposal of inert
Carry out the transportation of the byproducts at its own cost	No responsibility for the disposal of such segregated fractions

100% Work done by ULB with Rental Equipment

ULB	Contractor
Rent Machines as per DPR/Technical Feasibility Report	Provide machines as per the specification provided in DPR/Feasibility report/tender
Arrange human resources to operate and manage the project as per CPCB guideline	Process the waste at their processing site
Excavation and subsequent transportation of waste	Segregate excavated waste into as many kinds as possible in compliance with CPCB
Set up an eco-friendly and non polluting processing system	Explore the possibility of minimizing the disposal of inert
Carry out the transportation of the byproducts at its own cost	No responsibility for the disposal of such segregated fractions

Combination of private operator and ULB

ULB	Contractor
Provide machines as per DPR Technical feasibility report at the cost of ULB.	Provide operational and maintenance support during the contract period
Human resources and operations related to processing shall be carried out by the ULB	Ensure that provided machinery in an operational condition at all times.
Respective sale and disposal of by-products shall be carried out by the ULB.	Repairand maintain the machines within the stipulated time as informed by the site supervisor
Appoint academic institution as Third party to verify the activities	Replacements for damaged components at the cost of ULB for that equipment
All the consumables for the regular maintenance purpose will be provided by the ULB.	Make all investment for machineries and daily operational cost in advance

Qualification criteria

- Bidding entity: Joint Venture, max 3 entities
- Lead Member: Owns 51% equity during Project.
- Other members: Each owns min 10% equity.
- Bidder: Min net worth and 20% turnover of project cost.

Technical criteria

- 2+ years in waste management projects.
- Operated 1 project with 70% of Estimated Capacity.
- Operated 1 Solid Waste Management Project with 60% of Estimated Capacity.
- Operated 2 projects, each with 50% of Estimated Capacity

- Supplied machinery and manpower in waste projects for 5 years.
- Supplied for a project with 70% capacity in the last 5 years.
- Supplied for 2 projects, each with 50% capacity in the last 5 years.

- Supplied machinery, manpower, and O&M in waste projects for 5 years.
- Supplied machinery and O&M for a project with 70% capacity in the last 5 years.
- Supplied machinery and O&M for 2 projects, each with 50% capacity in the last 5 years.

Figure 54 Models for remediation of legacy waste

12.4 Project implementation remediation of legacy waste

12.4.1 Points to consider for seamless operations during Project implementation

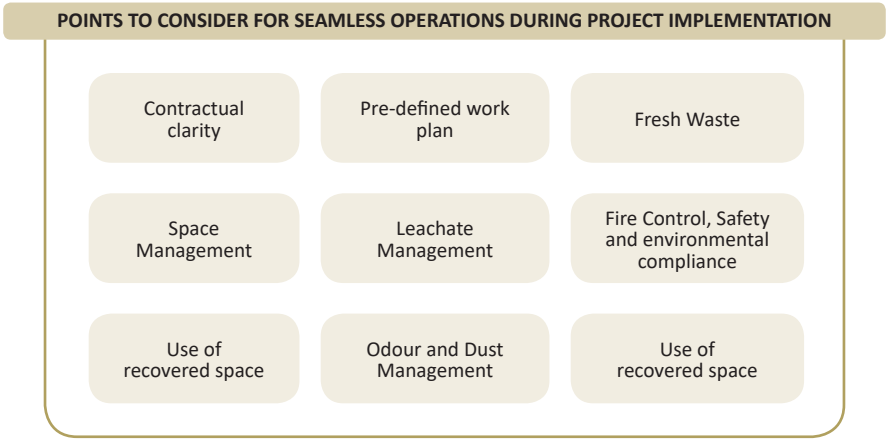


Figure 55 Points to consider for seamless operations during project implementation

12.4.2 Survey and Steps for Bioremediation

Unit operation	Operational requirement	Support
Preoperational period		Base-line monitoring Community consultation
Site preparation	Site services (power/water/drainage) • Site access / internal access / working platforms Temporary storage/recycling / materials treatment areas • Disposal area • Site security • Wheel and vehicle washing • Weigh bridge • Roads	Environmental protection measures (whole area, operational areas) • Monitoring (equipment/ support facilities) • Health and safety requirement/emergency support area)

Excavation	Depth and extent of excavation Means of controlling depth and extent of excavation (physical stability nature of strata degree of contamination) • Size zoning/phasing (horizontally) vertically/over time) • Volumes, types and variability of material to be excavated Rate of excavation (material flows) Number, types and variability of material to be handled Segregation, separation and dewatering needs Material flows Nos. and types of vehicles or other transport means Plant and equipment need	Environmental protection (air/ water protection measures, vehicle decontamination, temporary cover over excavation) • Monitoring (QC an arising/ recycled material/effluent, in support of health and environmental protection, in respect of residual contamination for partial excavation) Health and safety (equipment/procedures) • Record-keeping procedure
Materials handling	Volume, types, and variability of material to be handled Segregation, separation and dewatering needs Material flows Numbers and types of vehicles or other transport means Plant and equipment needs	Environmental protection for operational areas Monitoring (QC on material flows, in support of health and environmental protection) Health and safety (equipment/ procedures) Record-keeping procedures
Replacement	Method of placement Plant and equipment required Protection against further migration of waste	Environmental protection for operational areas Monitoring (QC on material flows, in support of health and environmental protection) Health and safety (equipment/ procedures) Record-keeping procedures
Final disposal off-site	Transport arrangements	Environmental protection for transit vehicles/trains etc. • Record-keeping procedures
Final disposal on-site	Technical characterization of designated area Volumes and types of materials to be placed	Environmental protection (containment for soils/ liquids/gasses)
Post-treatment management	Post-excavation validation for excavated area and periodic review and maintenance	Collection of long-term monitoring data from on-site deposits • Record-keeping procedures

Table 53 Steps for Bioremediation Process on Legacy Waste

12.4.3 Bioremediation Process Schematics:

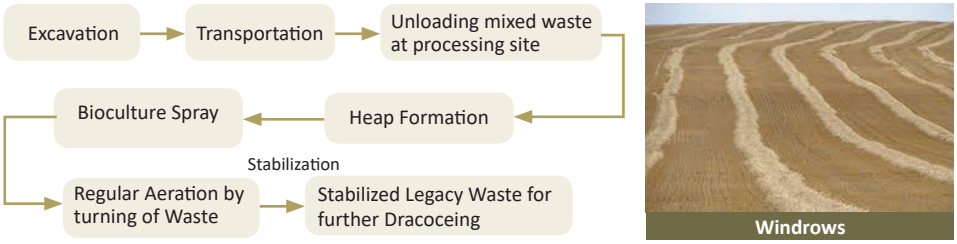


Figure 56 Bio-stabilization of waste

The different screening sizes of waste have been mentioned in the figure below. Detailed Screening sizes and their respective outcomes have been shown in the figures

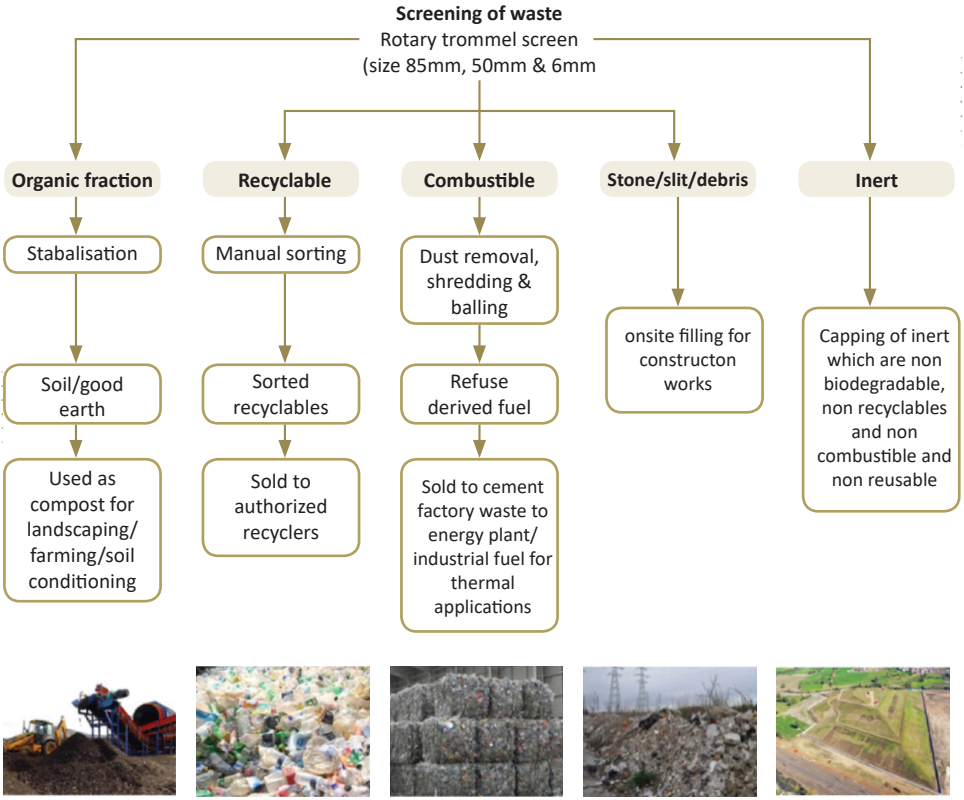


Figure 57 Screening process of bio-stabilized waste

12.5 Human resources and machinery or equipment requirement for the processing of legacy waste

Unit operation	Scope of Work	Human Resource Required	Equipment's or Machinery Requirement
Preoperational period	1. Analysis of waste To be remedied 2. Baseline study of heavy metals in surface and subsurface soils and water	1. Technical staff 2. Drone or total station operator 3. Onsite reporter for data collection	1. Drones or total station 2. Setting up small scale lab for testing
Excavation	1. Excavation of legacy waste as per phasing 2. Formation of windrows 3. Leachate can be dried of through solar exposure	1. JCB operator 2. Drivers 3. Helper for the formation of windrows 4. Onsite supervisor	1. Loaders and excavators 2. Dumpers 3. Tractor tiller 4. Shovels 5. PPE kits 6. Fire safety equipment
Stabilization of legacy waste	1. Spraying bio cultures and herbal sanitizer on waste at a set frequency 2. Handpicking of bulk waste (Recyclables) 3. Windrow turning 4. Monitoring of leachate generation and collection system	1. Bio culture and herbal sanitizer spray operator 2. Waste pickers for collection of bulk waste or recycler 3. Windrow turner or JCB operator 4. Onsite supervisor	1. Spray (Bio culture, Herbal Sanitizer) 2. Water tankers 3. Dumpers 4. Windrow Turner 5. Temporary leachate collection system 6. Shredder if required 7. PPE kits 8. Fire safety equipment
Screening of stabilized waste	1. Screening of stabilized waste 2. Collection and packing of the material 3. Transfer to the storage of the segregated waste	1. Trommel operator 2. Engineer 3. Labors (waste pickers) to collect the waste from trommel 4. LMV drivers 5. Onsite supervisor	1. Trommel with conveyor belt 2. Air density separator 3. Ballastic separator 4. Magnetic separator 5. Dumpers 6. Water tankers 7. PPE kits
Processing on segregated waste	1. RDF conversion 2. C& D waste processing 3. Volume reduction wherever possible 4. Packing and transferring processed waste 5. Transfer of inert to SLF and other recyclables to the storage facili	1. RDF plant operator 2. C and D waste shredder operator 3. Bailer and shredder operator 4. Packing of processed waste 5. LMV drivers 6. Onsite supervisor	1. RDF plant 2. Shredders (optional) 3. Baling machines (optional) 4. Packing materials 5. Fork lifts 6. Dumpers 7. PPE kits
Storage of the segregated waste	1. Store all the segregated waste 2. Keep track of the recyclables sold and stored 3. Maintenance of the Storage Space	1. Labors for unloading of segregated waste 2. Weighbridge operator 3. Keeping the record for inflow and outflow 4. Onsite supervisors 5. Housekeeping 6. Security guard	1. Weighbridge 2. Forklifts 3. PPE kits 4. Fire safety equipment

Scientific landfill	1. Quantification of inert (non-biodegradable, non-recyclable, non-reusable, and non-combustible) 2. Designing of SLF 3. Construction of SLF 4. Monitoring of SLF 5. Closure of SLF	1. Technical staff 2. Engineers 3. Onsite supervisors 4. LMV drivers	1. Loaders and excavators 2. JCB 3. Construction of SLF
During the project and post-treatment management	1. Analysis of remedied waste 2. Quantified data of all segregated waste and inert waste 3. Testing of soil, water, and air	1. Technical staff 2. Monitoring Staff	

Table 54 Indicative human resources and machinery requirement for the processing of legacy waste

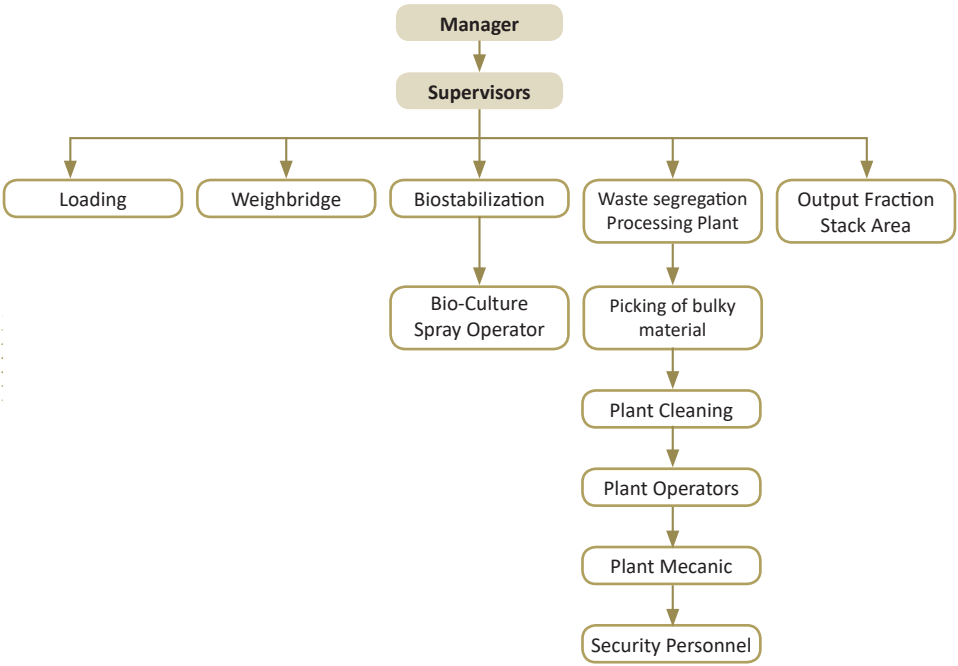


Figure 58 Indicative Human resource requirement

The major equipment that is deployed in the processes like excavation, shredding, screening, air classification and ferrous separation. As per suitability and requirement, appropriate choices of equipment should be made.



A. Screening equipment

b. Trommels

Screen sizes commonly used are one or more of the following: 150 mm. 80 to 100 mm, 24 to 50mm, 12-16 mm and 4-6. Trommel screens are more effective than vibrating screens for dumpsite reclamation.

b. Air Density Separator

Utilized to separate light materials from heavier materials through the use of an air stream of sufficient velocity to carry away the lighter materials



c. Ballistic Separators

separate stones and soil and humus

d. Magnetic Separator

E. Handling Equipment

6. Loaders (Front Load) and Excavators
7. Dumpers
8. Forklifts,
9. Elevator and conveyor Belt
10. Water tankers
11. Shredders (optional)
12. Baling Machines (optional)



C. Other Equipment

4. Odor control sprayers
5. Total station and drones







Notes

Chapter 13:

Construction and Demolition Waste Management

Key Highlights of this Topic

- What is circularity
- Linear and Circular value chain of waste
- Waste reduction at source
- Challenges in Linear economy
- Opportunities in implementing circularity in Waste Management
- Ideal Scenario for a city

About the topic

- This topic helps to understand importance of circularities and upcoming opportunities for sustainable waste management through implementation of circularity

13.1 Introduction

13.1.1 Circularity in waste management value chain:

Circularity is essential for urban local bodies as it offers a holistic approach to resource management, waste reduction, economic development, climate resilience, community engagement, and long-term sustainability. By integrating circular principles into urban planning and governance, local authorities can create more resilient, equitable, and sustainable cities.

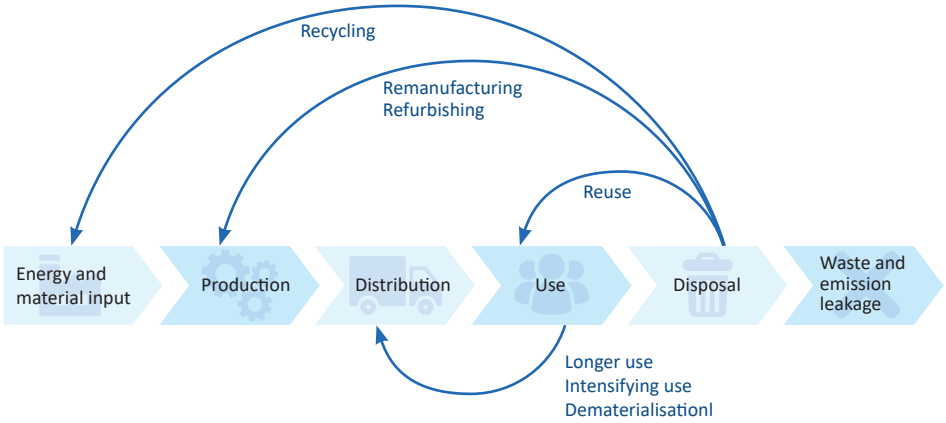


Figure 59 Circularity in waste management value chain

13.1.2 Linear and Circular value chain of waste:

a. Linear value chain

In a linear value chain, the main stakeholder responsible for waste management is considered as urban local body.

City administration collects, transports, processes, and disposes of the waste by using its own systems.



Figure 60 Linear value chain

b. Circular value chain

In the circular value chain various stakeholders are involved in waste management right from the informal sector, BWGs, at source/community level waste management, active citizens to ULB.

Load on centralized waste management system is comparatively low and also its helps to channel waste to recycling.

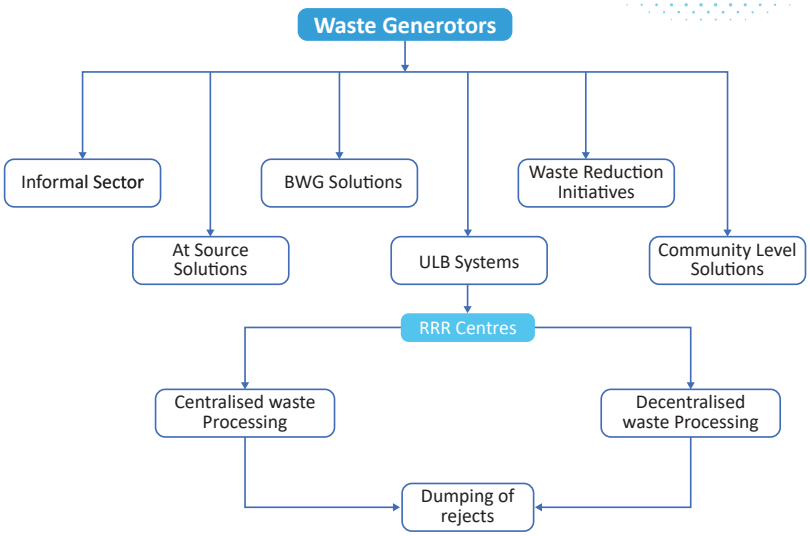


Figure 61 Circular value chain

13.3 Waste reduction at source

Considering society or community of 100 households lets understand what are the possible optionsfor waste reduction at source

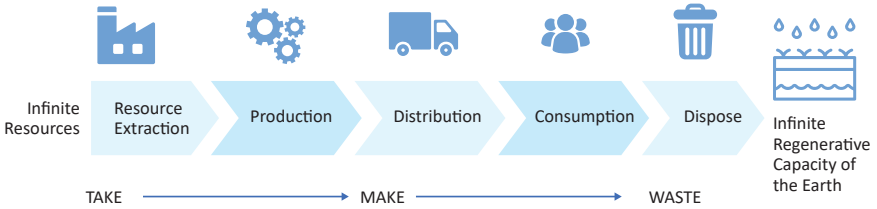


Figure 62 Practicing waste reduction at source

Inerts - Silt, ceramics, contaminated material, other material that cannot be recycled
Other Material - Glass, Metal, Tyre, Thermocole

Linear Economy

By 2050 material extraction and use is expected to double relative to 2015 levels, threatening a total breakdown of Earth's life support systems, which are already at a breaking point.



Circular Economy

With a circular economy, we can fulfil people's needs* with just 70% of the materials we currently use-within the safe limits of the planet.

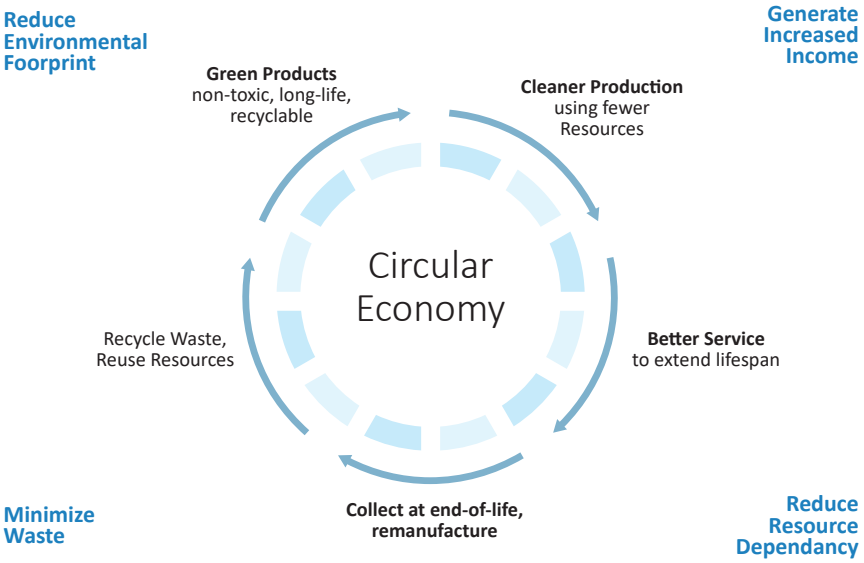


Figure 63 Challenges in circular Economy

13.6 Opportunities in Implementing Circularity in waste

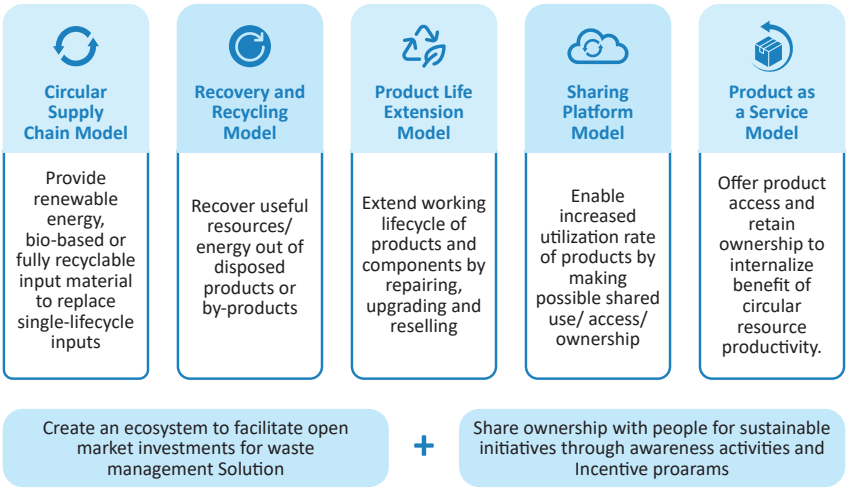


Figure 64 Opportunities in Circular Economy

13.6.1 Opportunities in wet and dry waste management

Wet Waste	Dry waste	Other Wastes
Options • Home Composting • At source Composting • Biogas	**Options** • Material Recovery Centre • Recycling industry • Preprocessing and product development from recyclables	**Options** • RRR Centrel • Reuse and Repurpose set up
Implementation • Enforcement for BWGs • Incentives for promotion • Facilitation for ease of business	**Implementation** • Traceability of waste • Facilitation to invite waste related business into the city	**Implementation** • Setting up recycling centers • Facilitating supply chains for upcycling and recycling industries
Economics • Service charge based operations by private companies • CSR based funding towards community level solutions • Enforcing fines to BWGs	**Economics** • Complimenting enforcement and collection systems run by ULBs to have segregated waste collection • Incentivizing waste segregation through private partnerships • Incentivizing waste reduction/ at source management through tax rebates • Competitive spirit to acknowledge the doers	

Source: Circular Economy in Solid and Liquid Waste

Figure 65 Opportunities in implementing circularity in waste

13.6.1 Opportunities in wet and dry waste management

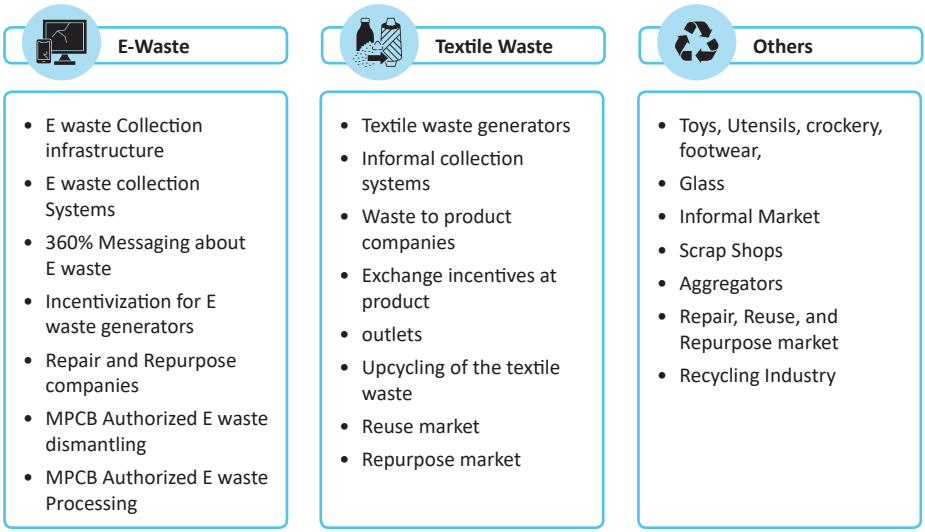


Figure 66 Opportunities in implementing circularity in other types of waste

13.7 Ideal scenario for city

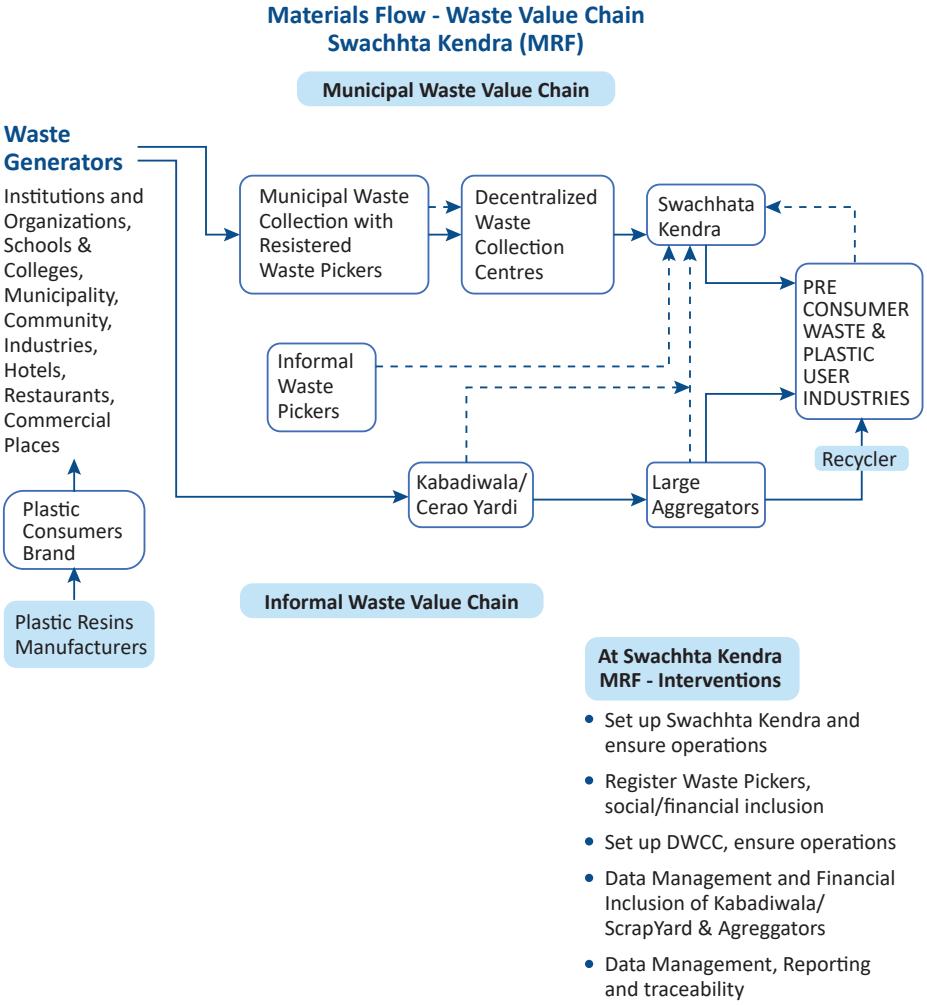


Figure 67 Ideal scenario for city

Notes

Chapter 14:

Introduction to Sanitation and Technology Selection

Key Highlights of this Topic

- Overview of Sanitation value chain
- On-site and off-site sewage management systems
- Brief about technologies
- Matrix for selection of Technology

About the topic

- This topic help to select suitable technology for the treatment of used water based on existing drainage system, land and fund availability, requirements for discharge standards and limitations

Summary:

	1	2	3	4	5	6	7	8
Process	ASP	EA	MBR	MBBR	SBR	UASB	WSP	CW
Effluent Quality	G	VG	VG	VG	VG	A	A	P
Coliform Removal	G	G	VG	VG	VG	A	P	P
Nitrification Denitrification	P	P	P	P	VG	P	P	P
Phosphorus Removal	P	P	P	P	VG	P	P	P
Process Reliability	VG	VG	G	P	G	G	P	P
Land Use	G	A	VG	G	VG	G	P	P
Ease of Operation	G	VG	P	VG	G	A	A	A
Ease of Maintenance	G	VG	P	P	G	VG	VG	P
Energy Recovery	VG	P	P	A	P	G	P	P
Electrical Demand	A	P	P	P	A	A	VG	VG
Capital Cost	A	G	P	A	A	A	G	G
Track Record	VG	G	P	G	G	G	A	P
Typical Capacity Range (MLD)	AF	SF	SF	SF	AF	AF	AF	AF

Source: Guidelines for Decentralized Wastewater Management Prepared by MoUD Centre of Excellence, Indian Institute of Technology Madras - Chennai, India for Ministry of Urban Development, Government of India

Abbreviations-

ASP-Activated Sludge; EA-Extended Aeration; MBR-Membrane Bio Reactor; MBBR-Moving Bed Biofilm Reactor; SBR-Sequencing Batch Reactor; UASB-Up flow Anaerobic Sludge Blanket; WSP-Waste Stabilization Pond; CW-Constructed Wetlands; VG-Very Good; G-Good; A-Average; P-Poor.

Table 55 Selection of Waste Water Treatment Technologies

14.1 Introduction to Sanitation:

14.1.1 Sources of liquid waste

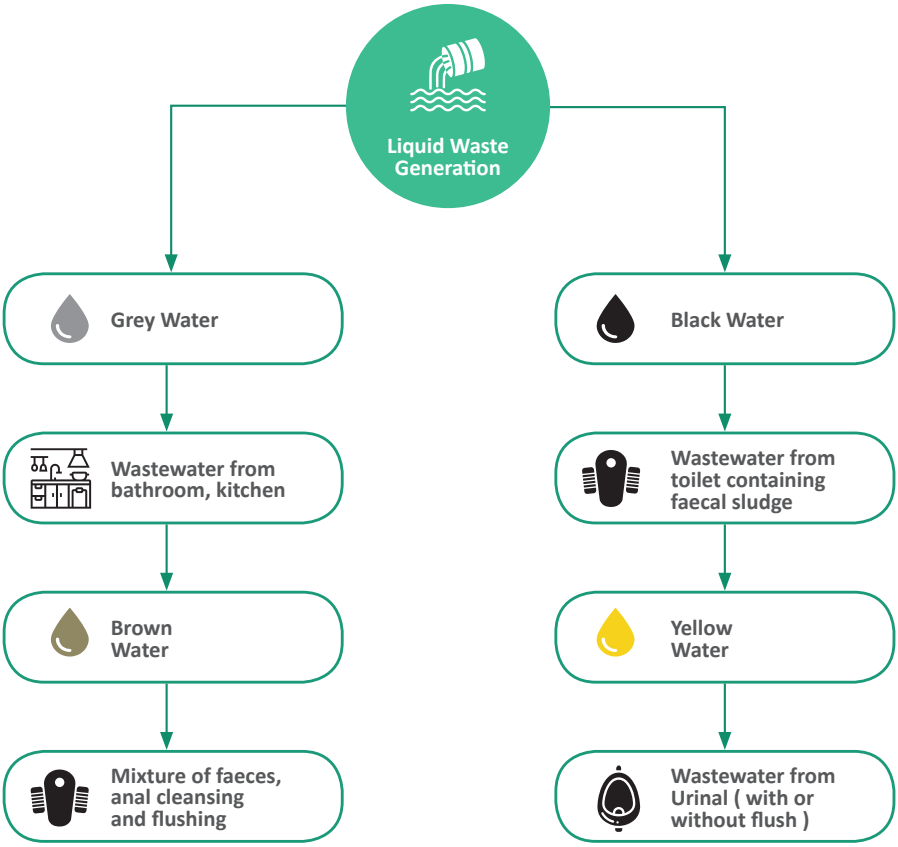


Figure 68 Sources of waste water

14.1.2 Overview of Sanitation Value Chain

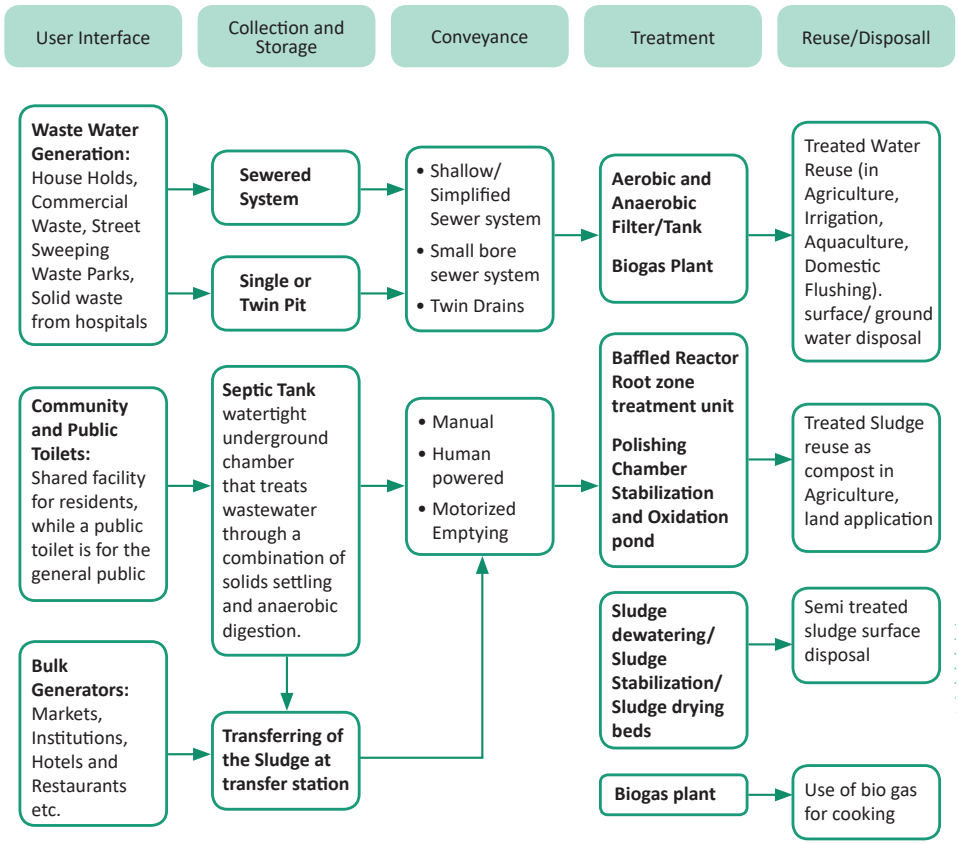


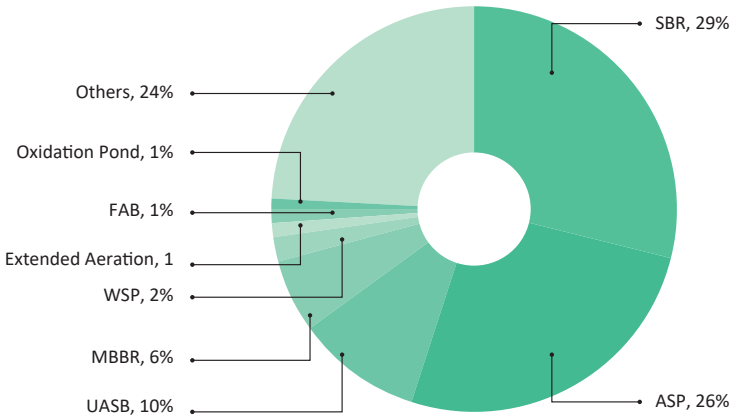
Figure 69 Overview of Sanitation Value Chain

14.1.3 Technologies for used water management

Nature-based Treatment Technologies			
1	Waste Stabilization Pond (WSP)	2	Root Zone/Constructed WetLand
Conventional/Mechanized Technology			
1	Aerated Lagoon	5	Trickling Filter
2	Activated Sludge Process (ASP)	6	Moving Bed Biofilm Reactor (MBBR)
3	Extended Aeration (EA)	7	Up-flow Anaerobic Sludge Blanket (UASB)
4	Sequencing Batch Reactor (SBR)		
Combination of UASB/ABR technologies for higher rate of removal			
1	UASB/ABR + Polishing Pond	4	UASB/ABR + Activated Sludge Process
2	UASB/ABR + Land disposal	5	Decentralized Treatment System (DTS)
3	UASB/ABR + Trickling Filter		

Table 56 Technologies for used water management

As per CPCB Report 2021, various technologies are employed for the treatment of domestic wastewater. It is observed that Sequential Batch Reactor (SBR) and Activated Sludge Process (ASP) are the most prevailing technologies adopted by ULBs, especially in larger ones.



14.1.4 On-site and off-site sewage management systems

On-Site Sewage Management Systems	Off-site Sewage Management Systems
Conventional Septic tank	Waste Stabilization Ponds (WSP)
Up-Flow Anaerobic Filter	Phytorid Processes/ Constructed Wetland
	Upflow anaerobic sludge blanket (UASB)
Package septic tank-Contact aeration type system	Activated Sludge Process (ASP)
Bio-Digester	Extended Aeration Process (EAP)
	Moving Bed Biological Reactor (MBBR)/Fluidized Aerated Bed (FAB)
	Sequencing Batch Reactor (SBR)
	Membrane Bioreactors (MBR)

Low Cost | Medium Cost | HIgh Cost

Table 57 On-site and off-site sewage management systems

14. 2 Brief of technologies

A. Nature-based treatment technologies

2. Waste Stabilization Pond:

They are normally connected in series to provide a two- or three-stage treatment process as mentioned below:

I. Anaerobic ponds:

- comparatively small and deep (3–4 m) as there is no need for aeration.
- They receive raw sewage, which is treated by anaerobic bacteria, while sludge that builds up in the bottom of the pond is digested by anaerobic microorganisms.

II. Facultative ponds:

- Shallower (1.5–2 m) with a larger surface area than anaerobic ponds.
- They consist of an aerobic zone close to the surface and a deeper, anaerobic zone

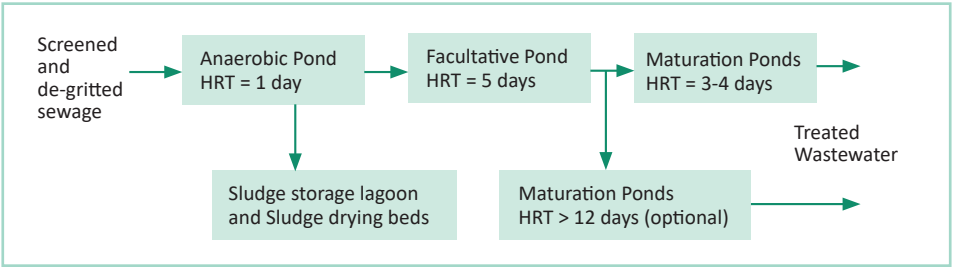
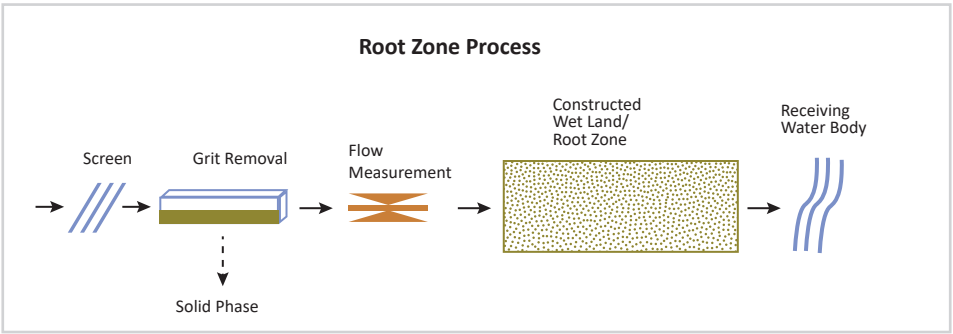


Figure 70 Flow Diagram for Waste Stabilization Pond

2. Root Zone or Constructed Wetland

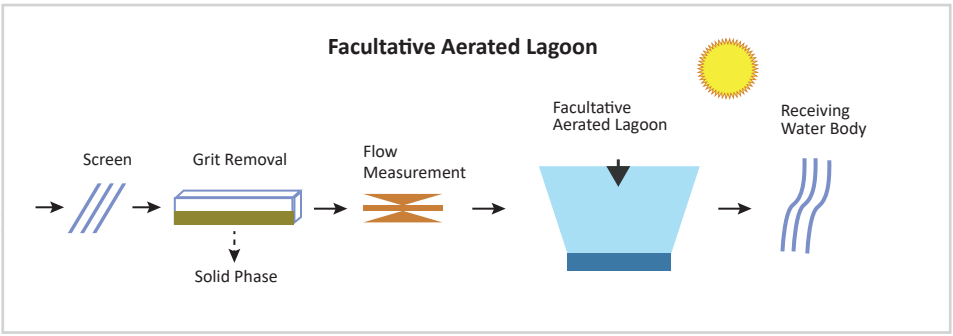
- Constructed filtration systems planted with wetland vegetation like cattails (Typha species), reeds (Phragmites species), bulrushes (Scirpus species), sedges (Carex species), Canna indica etc. with defined filter material and direction of wastewater flow.
- It is based on slow filtration of pre-treated wastewater
- The filter environment must fulfill the pre-defined requirements in terms of hydraulic conductivity and load of wastewater by pollution, flow rate, frost penetration, or the possibility to bind phosphorus and heavy metals



B. Mechanized Treatment Technologies:

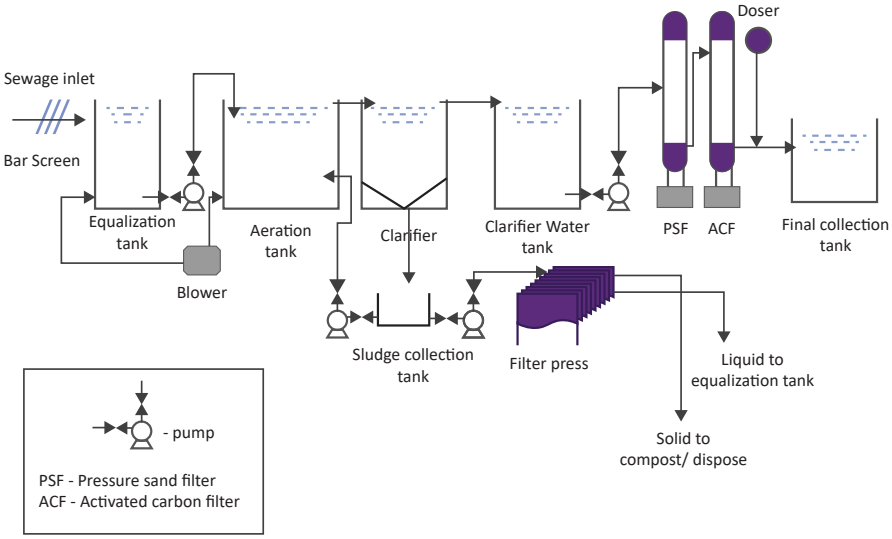
3. Aerated Lagoon:

- Lagoons are generally rectangular, though it is not particularly essential. Natural land contours may be followed to the extent possible to save on earthwork.
- Lagoon units may be built with different length-width ratios and arrangement of internal baffles to promote desired mixing conditions.
- Lagoons may also be provided as two or three stage systems with the subsequent units placed at a lower level than the first if desired



2. Activated Sludge Process:

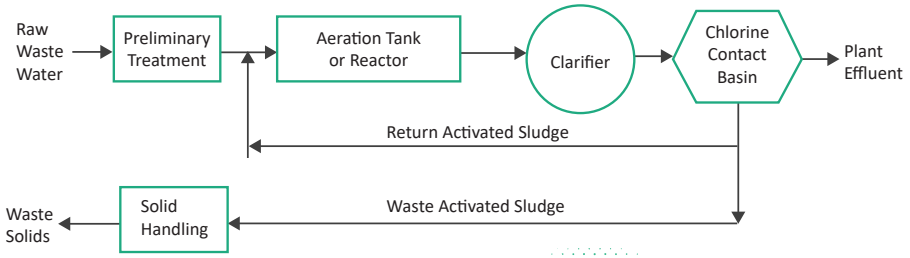
- In principle all ASPs consist of three main components: an aeration tank, which serves as bioreactor; a settling tank ("final clarifier")
- Sewage and return activated sludge (RAS) enter together or separately into the reactor and leave as mixed liquor. This mixed liquor flows into the clarifier where it can settle and the treated effluent separates from the activated sludge.
- The settled activated sludge is recycled to the aeration tank and a portion wasted out of the system as waste activated sludge (WAS).



3. Extended Aeration:

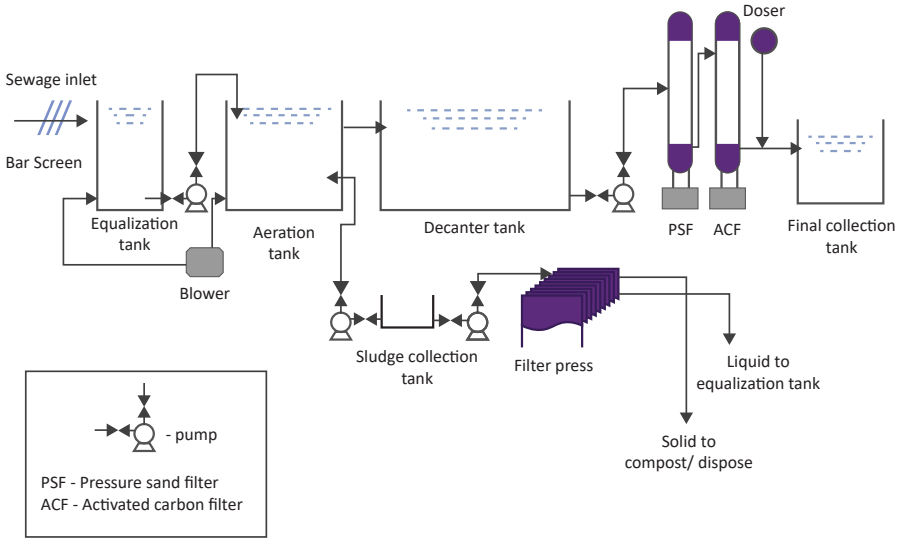
- The extended aeration process is one of the modifications of the ASP.
- It is a complete mix system and provides biological treatment for the removal of biodegradable organic wastes under aerobic conditions.
- Air may be supplied by mechanical or diffused aeration to provide the oxygen required to sustain the aerobic biological process.

Extended Aeration Schematic



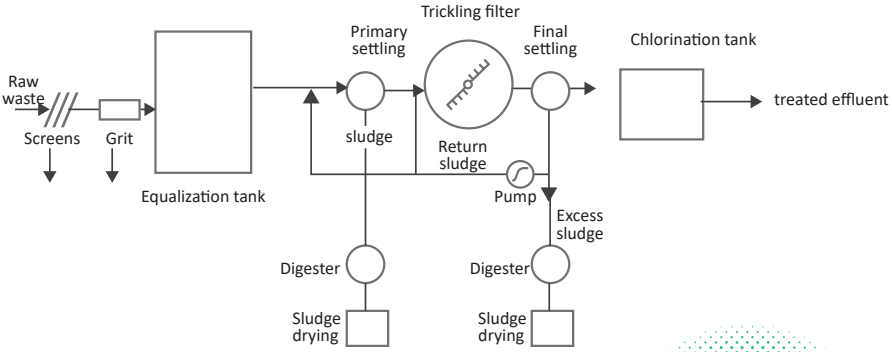
4. Sequencing Batch Reactors:

- The Sequencing Batch Reactor (SBR) is an Activated Sludge Process designed to operate under non steady state conditions.
- An SBR operates in a true batch mode with aeration and sludge settlement both occurring in the same tank. The wastewater is added to a single "batch" reactor, treated to remove undesirable components, and then discharged. They are suitable for treatment applications characterized by low or intermittent flow conditions. These systems have a relatively small footprint, they are useful for areas where the available land is limited.



5. Trickling Filter:

- The Trickling Filters can treat domestic blackwater or brown water, greywater, or any other biodegradable effluent. Trickling filters can be built in almost all environments, but special adaptations for cold climates are required.
- Compared to other technologies like waste stabilization ponds, trickling filters are compact, although they are still best suited for peri-urban or large rural settlements.



6. Moving Bed Biofilm Reactor:

- MBBR is a highly effective biological water treatment process that is based on a combination of biofilm media and conventional activated sludge processes.
- Moving Bed Biofilm reactor (MBBR) processes improve reliability, simplify operation, and require less space than other traditional wastewater treatment systems like ASP and are tolerant of both load swings and temporary load deprivation.
- This compact treatment system is effective in the removal of BOD as well as nitrogen and phosphorus while facilitating effective solids separation.

7. Upflow Anaerobic Sludge Blanket:

- UASB is a methane-producing digester, which is based on an anaerobic process. In the UASB reactor, the sewage flows upwards through a layer of sludge. At the top of the reactor, phase separation between gas-solid-liquid takes place. Any biomass leaving the reaction zone is directly recirculated from the settling zone.
- Wastewater flows upwards through the blanket and is processed by the anaerobic microorganisms. The upward flow combined with the settling action of gravity suspends the blanket with the aid of flocculants. Provision of feed inlet pipe in a UASB reactor in such a way that 1 feed inlet/sqm area of UASB subject to a minimum of 1 feed inlet pipe for 2 sqm of the floor area of UASB

14.3 Criteria for Selection of Technology

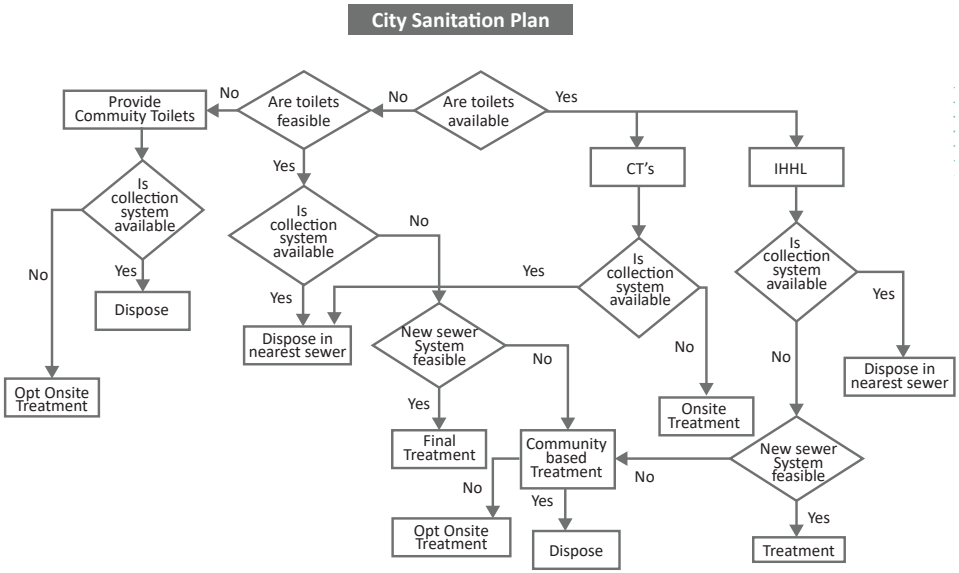


Figure 71 Decision making map for selection of technology

14.4 Matrix for selection of technologies

PART 1

Parameters	WSP	RZP	Aerated Lagoon	Activated Sludge Process (ASP)
Land Requirement (Ha/ MLD)	0.5 – 1.0	0.6 – 1.5	0.27- 0.4	0.15 - 0.25
Energy Requirement (kWh/ML treated)	Negligible	Negligible	15-20	180 to 225
Capital Cost (Lakh/ MLD)	30 to 60	30-150	40 to 60	80- 170
O &M Cost (lakh/year/ MLD)	0.6 to 2.5	1.2 - 3	1.5to 3.0	6to 10
Effluent Quality				
BOD removal efficiency	80-95%	80-95%	80-90%	75-90%
COD:	85-90%	85-90%	85-90%	75-90%
TSS:		80-95%	95%	95%
Advantage	• Simple to construct, operate and maintain • Low O &M cost • Extremely robust and can withstand hydraulic and organic shock loads	Construction does not need expensive materials • Operation and maintenance of the system is easy	• Relatively simple construction, O & M • Lower land requirements than the facultative and anaerobic-facultative pond systems • Satisfactory resistance to load variations	• Less land requirement and low installation cost in comparison to mechanized treatment systems
Disadvantage	• Land requirements still high • Relatively high energy requirements • Need for periodic (some years interval) removal of sludge from aerated pond	• Land availability is a constraint. • Optimizations of parameters become difficult when different wastewater get mixed together • Regular maintenance required	• Land requirements still high • Relatively high energy requirements • Need for periodic (some years interval) removal of sludge from aerated pond	• Difficulty in sludge removal and disposal. • High operational costs

Limitations	Pond systems should preferably be commissioned at the beginning of the hot season to establish as quickly as possible the necessary microbial populations to effect waste stabilization.	Primary treatment - Check sludge levels in primary treatment and de-sludge as necessary to maintain treatment performance and avoid sludge drift into wetland.		Higher cost is for treatment plants including sludge treatment like anaerobic digestion or for small capacity plants without sludge treatment.
Plant examples	• Fatehgarh: 2.7 MLD (1993) • Goniana: 3 MLD (2012)	Kalyan Dombivali Municipal Corporation (Manda Titwala) – 2 MLD Dharamshala, H.P.- 180 KLD	Sadalaga, Chikkodi (Karnataka): AL 3.72 MLD (2018) and 15 MLD (2004)	• Bangalore Urban, Yelahanka: 10 MLD (year 2003) • Nashik (at Panchak): 7.5 MLD (Year 2004)
Sludge generated (Per year for 1 MLD)	32	Cleaning-once in a 10 yr	70	108
Suitability	Any town with temp>20° C Population< 20K	Suitable for all location and weather condition with a moderate to high temperature		

PART 2

Parameters	Extended Aeration	Sequencing Batch Reactors	Trickling Filter	Moving Bed Biofilm Reactor	Up flow Anaerobic Sludge Blanket
Land Requirement (Ha/MLD)	0.15 - 0.25	0.10– 0.15	0.25– 0.50	0.04 - 0.05	0.2 - 0.3
Energy Requirement (kWh/ML treated)	180 to 225	150 to 200	150-180	200 to 250	10 to 15
Capital Cost (Lakh/MLD)	90 to 200	150 to 300	50 to 80	170 to 23022	40- 60
O &M Cost (lakh/year/ MLD)	7 to 12	10 to 20	2 to 5	8 to 12	2.0 - 3.5
Effluent Quality					
BOD removal efficiency	75-90%	75-90%	75-90%	80-90%	50-70%
COD:	85-90%	85-90%	85-90%	85-90%	85-90%
TSS:	95%	95%	95%	95%	95%

Aadvantage	• Variant with Highest BOD removal efficiency • Consistent Nitrification	• High BOD removal efficiency • Low land requirement • High degree of coliform removal • Process Control – SBR has inbuilt process control. Depending on the BOD load, it adjusts the DO supply.	• Low energy requirement compared to ASP • Low land requirement • Simple mechanical equipment	• Resistant to shock loads • Work quickly with Low Hydraulic retention time	• Low land and energy consumption • Low construction and operational costs • Production of methane, a highly calorific fuel gas
Disadvantage	• Increased energy consumption compared to ASP • Skilled operators required • High investment and operational costs	• Comparatively high energy consumption • Highly skilled operators needed	• To improve effluent quality, a settling tank can be provided, • Sensitivity to low temperatures	• High operating cost due to large power requirements • Skilled manpower requirement • Reduce nutrient removal	• Longer start-up period. • Post-treatment required to achieve surface water discharge quality. • Efficient working only between the temperature 15° to 35° c
Limitations	Items requiring attention include – plant cleanliness, aeration equipment, air lift pumps, scum skimmer, etc.	• The precaution needed is to make sure that power supply is available continuously.		• Equipment - The electro-mechanical components such as blowers, aerators and pumps need to be checked on a weekly basis. • The overhauling needs to be done on an annual basis for detailed check up to avoid major break down.	Combination of Treatment processes to achieve surface water discharge quality: • UASB + Aerated biofilter • UASB + Overland flow (land disposal) • UASB + Anaerobic filter • UASB + Trickling filter • UASB + Physical-chemical treatment • UASB + Polishing Pond (facultative or maturation) • UASB + Activated sludge

Plant examples	• Pimpri Chinchwad (Chikhali Phase I): 16 MLD (1987) • Mangalore (panchady) 8.75 MLD (2011)	• Bangalore Urban, Halasuru: 2 MLD (year 2018) • Daman: 4.21 MLD (2018)	• Bangalore Urban V valley, 10 MLD, two stage TF (2009) • Nagpur, Sonegaon NIT, 0.3 MLD, Phytorid bed TF (2019)	• Sonepat: Kharkhoda 4.5 MLD (2013), Gohana 3 MLD (2015)	• Panipat (Jattal Road): 10 MLD (2000) • Karoli(Karauli): 5 MLD (2018)
Sludge generated (Per year for 1 MLD)	96	92	88	96	80
Suitability	Suitable for all location and weather condition with a moderate to high temperature				

Table 57 Matrix for selection of Technology