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Handbook on
Solid Waste Management
for urban local bodies of West Bengal



Urban Development &
Municipal Affairs Department,
Government of West Bengal.

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DISCLAIMER

This handbook is intended to help ULBs of West Bengal to develop capacity and awareness for effective municipal solid waste management. While every effort has been made to ensure the correctness of data/information used in this handbook, neither the authors nor SUDA accept any legal liability for the accuracy or inferences drawn from the material contained therein or for any consequences arising from the use of this material.

MESSAGE



With rapid pace of urbanisation, Solid Waste Management in urban area is one of the biggest challenges for urban governments. According to a CPCB report, in 2016, India produced some 52 million tonnes of waste each year, or roughly 14.4 lakh tonnes per day, of which only 23% is processed. By and large, in cities and towns, about half of the solid wastes generated are collected, transported and disposed of, giving rise to insanitary conditions and diseases, especially among the urban poor who constitute about 35% of the urban population. The average annual increase in waste generation in our country is around 5% .

Solid Waste Management is one of the obligatory functions of the Urban Local Bodies. Efficient garbage collection, transportation and disposal in scientific manner are its principal components. ULBs generally engage a large number of personnel to discharge this function and a substantial portion of their annual budget is spent only on garbage collection, transportation and disposal. To add to the list of problems, ULBs often have financial constraint and little technical capacity to face this challenge.

Government of West Bengal has devoted its full attention towards proper implementation of Solid Waste Management as per Solid Waste Management Rules,2016. Emphasis has been given on proper orientation of peoples' representatives and officials so that solid waste is managed and disposed as per best practices and not dumped at the dumpsites, as was done earlier. Door to door collection from households and segregation of wastes in to bio degradable and recyclable are two primary features of scientific solid waste management. State Urban Development Agency (SUDA), under Urban Development & Municipal Affairs Department has been sincerely making every possible effort to translate this idea into practice. Many ULBs have so far responded well. But we have miles to go. Initiatives have already been taken to supply utility articles needed for Solid Waste Management like tipper, bins, uniform and security gadgets for rag pickers etc. Transaction Advisers and Agencies for preparation of Micro Plan have already been engaged for assisting ULBs for implementing Scientific Solid Waste Management Plan which ultimately aims towards zero residue and revenue generation from waste processing activity. Capacity building component has been emphasised and resource personnel are being sent to different parts of the country for learning best practices. As per instruction of National Green Tribunal, eight cities and towns have been selected as model ULBs and they are rapidly implementing the components. Similarly, in 40 Ganga Towns of our state, we have put enormous emphasis on ghat cleaning, setting up of screens at nallahs draining into the river, removal of Garbage vantage points from the vicinity of ghats. Major IEC activities have been undertaken so that citizens may be associated with this effort and they own the programme. In a nutshell, it may be said that work is going on in full swing and effort will be accelerated in the coming days.

This literature will help ULBs in understanding the perspective in a more meaningful way and thus help in proper planning and execution of Solid Waste Management. We have to keep in mind that in spite of the major overhaul in the legislative framework with the introduction of Solid Waste Management Rules, 2016, Plastic Waste Management Rules,2016 etc. long ways are to be traversed as it demands change in the behavioural pattern of every citizen. I strongly believe, that if we can show earnestness and sincerity, our efforts will be crowned with dazzling success.

Date : 14.08.2019
(Place : Kolkata)

(FIRHAD HAKIM)
Minister-in-Charge
Urban Development and
Municipal Affairs Department
Government of West Bengal

FOREWORD



West Bengal is one of the fastest urbanising states in India. While this throws up several opportunities for the citizens, this also poses a big challenge for urban governments since most urban governments are constrained by inadequacy of capacity and resources. In West Bengal, the government in the Urban Development and Municipal Affairs Department is seized of meeting these challenges especially in the areas of provision of urban infrastructure. Among all the obligations of urban governments, the one which is most challenging to address, is perhaps management of solid waste.

In West Bengal the State Urban Development Agency (SUDA) and ULBs are currently grappling with the implementation of Solid Waste Management Rules, 2016. Unlike many other urban services, which are provided unilaterally by the respective urban local body, management of solid waste involves participation of citizens on an equal footing as that of the urban local body. Change of long held habits and attitudes towards disposal of solid waste, segregation of waste into bio-degradable (Kitchen/wet), and recyclables (plastic, glass, paper, metals etc.), a rational and economic method of collection of this waste, their transportation, temporary storage and their ultimate disposal are technically and managerially complex processes involving not only the municipal agencies, and specialized agencies but even the common man.

This compilation provides, in one place, a collection of various rules governing solid waste and some important orders of the National Green Tribunal (NGT). This handbook also contains a few technical guidelines of SWM and best practices and some instructions issued by this department. It also presents a few pictures from some Urban Local Bodies (ULBs) and a report on up to date progress. This compilation is made for municipal functionaries, public managers in the district administration, peoples' representatives in urban areas, agencies involved with different aspects of solid waste management and even the common public. The soft copy of the compilation will be available in the official website: www.wburbanservices.gov.in. We are printing a limited number of copies for ready reference of municipal functionaries functionaries as environmentally conscious department, As an public managers.

Date : 14.08.2019
(Place : Kolkata)

(Subrata Gupta)
Principal Secretary
Urban Development and
Municipal Affairs Department
Government of West Bengal

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Background and need for proper solid waste management at city level

In India, rapid population growth and expansion of developmental activities have both greatly aggravated resource depletion and degradation of the environment. In India (as elsewhere), development has caused rural-urban migration, urban poverty, and the unsustainable consumption of resources, with increased emission levels of greenhouse gases and other pollution which is caused by Municipal Solid Waste (MSW). The urban population in India is expected to increase to 4O% from the current 31% of the total Indian population by the year 2030. India generates over 1,43,449 metric tons of municipal solid waste (MSW) per day as per CPCB report, 2014-2015. The per capita waste generation in cities varies from 0.2 kg to 0.6 kg per day based on the size of the population. To further add to the problem, the total no. of towns (statutory and census) in the country have also increased from 5,161 in 2001 to 7,936 in 2011, thus increasing the no. of municipal waste generation by 2,775 within a decade. It is estimated that if the waste is not disposed of in a more systematic manner, more than 1,400 km^2 of land, which is equivalent to the size of the city of Delhi, would be required in the country by the year 2047 for its disposal.

Solid Waste Management (SWM) is a state subject and it is the responsibility of the state government to ensure that appropriate solid waste management practices are introduced in all the cities and towns in the state. However, SWM is a municipal function and it is the urban local bodies (ULB) that are directly responsible for it. The ULBs are required to plan, design, operate, and maintain the SWM in their respective cities/towns. India's 4378 municipalities spend a lot of money handling waste. Between 10% to 50% of the municipal budget is allocated for SWM and between 30% to 50% of the total staff are typically engaged in SWM. This critical service, if performed poorly, results in deterioration of health, sanitation and environmental degradation. Incorrect choice of technology, lack of public participation, financial constraints, institutional weakness, are factors that prevent a ULB from providing satisfactory service. The ULBs need both support and guidance to manage the solid waste in a scientific and cost effective manner.

As per census of India, in 1951, India had urban growth of 17.29%, which increased up to 31.16% in 2011. Due to urbanization and change in lifestyle, India has had to deal with increased solid waste generation. Dealing with waste has now become a global issue, which poses a threat to public health, environment and economy. Due to increasing population, India's basic necessities have sometimes been ignored. Greater focus on providing water, electricity, food for growing population, sometimes leads to negligence of services like waste management. Solid waste management is one of the 18 functions that comes under the purview of urban local bodies.

The management of municipal solid waste is one of the main functions of all Urban Local Bodies and all the ULBs are facing challenges in managing the chain of Municipal Solid Waste from door to door Collection, source segregation, secondary storage, secondary transportation, processing and finally scientific disposal. Segregation at source and storage is severely lacking and the biodegradable and non-biodegradable wastes are disposed of at common landfills. Urban Local Bodies (ULBs) are unable to provide effective services. Most ULBS spend nearly 60%-70% of their total overall budgetary allocation on collection, another 20%-30% on transportation, and often less than 10% on the treatment and final disposal of MSW. Transfer stations and formal recycling facilities do not exist in most parts of the country and the vehicles that collect waste from the communal bins also take it directly to unscientific disposal sites. Open, uncontrolled and poorly managed landfills are a common sight across many large urban centres. These open landfills or dump-yards pose severe environmental risks such as leachate generation, fires or emission of greenhouse gases, and hazards to public health through disease vectors such as flies & rodents. The state of MSW management is even more dismal in smaller towns and rural areas.

The rapid development and increased waste generation is demanding for a renewed attention to the increasing problem of municipal solid waste management. Therefore, it is imperative to derive a vision and policy to structure the solid waste management system in a sustainable manner. This handbook will guide the local authorities in the state to implement waste management in the future in compliance with the regulatory framework of India.

Issues and challenges faced by urban local bodies in implementing effective SWM plan

Process and Implementation: The predominant issue is lack of systematic door to door collection and the difficulty in extending door to door collection to the entire city.

Social and behavioural: These include the attitude towards waste management. The most important concern flagged by ULBs is that of lack of awareness among people regarding source segregation. Another issue includes the lack of IEC and dissemination of knowledge by ULBs and the government.

Infrastructure related: This includes non-availability of land for SWM, poor maintenance of existing infrastructure and lack of vehicles for collection and transportation of waste.

Administrative issues and challenges: Lack of public accountability, communication gap between various ULB departments, and lack of proper institutional structure are highlighted as major bottlenecks.

Planning and policy related issues: Lack of long term waste management plans are also considered as concerns. Inadequate management of waste from religious premises, festival sites, slaughter houses, gardens and horticultural parks and lack of mechanism for incentive based user charge collection emerge as other issues. The absence of buy back policies of ULBs to purchase products from recycling plants like C&D waste management plant, paper recycling plants and composting plants are also few concerns.

Other related issues and challenges: Lack of knowledge and skilled expertise in selection and implementation of appropriate technology based on the size of the city or town, quantity and composition of waste generated and cost effectiveness are areas of concern.

Human Resources Management: Lack of capacity building of ULB staff, proper training of existing staff and shortage of manpower are other issues. These result in loss of motivation for the workers, which further reflect in the quality of their work. Absence of health facilities for workers is another concern flagged by ULBs.

Present status of Solid Waste Management in Urban West Bengal

Present Status of Urban West Bengal on Solid Waste Management

Urban Scenario in West Bengal (As per Census 2011)

- Total Statutory Towns : 125 (2938 wards)
- Total Census Towns : 781
- Total Urban Population : 29093002
- Total Population of Statutory Towns : 21112134
- Total Population of Census Towns : 7980868
- Total Urban Households : 6611583

URBAN SCENARIO OF THE STATE OF WEST BENGAL

- Urbanization index 31.8% as against all India as 31.4%
- Urban population increased from 14.43 m on 1981 →18.7 m in 1991 →22.5 m in 2001 – 29.1 in 2011 and likely to reach 38 m 2021
- Decadal Growth of urban population
  - *1961-1971:28.4%*
  - *1971-1981:31.7%*
  - *1981-1991: 28.9%*
  - *1991-2001: 20.3%*
  - *2001-2011 : 29.6%*
- Percentage of Urban population to Total Population: 31.8% in 2011 living in 2.93% of the geographical area of State
- Highest Urban population density in the Country

Actions taken so far by the state government in UD &MA department and ULBs on solid waste management

- Policy and Strategy on Solid Waste Management and Plastic Waste Management for urban areas of West Bengal published.
- Amendment in the West Bengal Municipal Act for banning plastic bags of below 50 microns has been made.
- Amendments in the West Bengal Municipal Act, the West Bengal Municipal Corporation Act, the HMC Act and the KMC Act by way of imposing fine on occurrence of littering have been made.
- In compliance of the direction of Hon'ble NGT vide OA No. 606/2018 dated 2nd April2019,the State Government vide Notification No 40-JS(SM)/UD &MA/2019/SUDA-332/2019 dated 25.04.2019 has notified Asansol MC, Durgapur MC and Bidhannagar MC as Model cities and Uttarpara-Kotrang, Rishra, Baidyabati, Kalyani and Haldia as model towns
- Initial thrust has been given on 8 model cities, 42 Ganga towns and 13 towns situated under 17 polluted river stretches across the State.
- In compliance of clause No 20 of O.A no 606/2018 dated 02.04.2019 of Hon'ble NGT, Principal Secretary, UD& MA Department held ameeting with all District Magistrates on03.07.2019 for formation of Special Task Force at District level and provided direction regarding the issues to be monitored with the ULBs on SWM. This has been followed up with a detailed DO letter to all District Magistrates. Special Task Force,accordingly have been formed in all Districts and District Magistrates are regularly reviewing the progress ULB wise.
- All ULBs have formed ULB level Task Force for monitoring the SWM activities of ULBs.
- 78 ULBs banned plastic bags of below 50 microns.
- Transaction Advisors have been appointed for Assisting the State Government for Planning of Scientific Solid Waste Management through Cluster Approach and Bid Process Management selection of O & M Agency/s in 8 clusters with 40 ULBs.
- Micro Planning organizations have been empanelled for Scientific Micro-Planning and Assessment on Solid Waste Management at ULB level as per SWM Rules 2016 for ULBs.
- Ganga towns have taken several initiatives for prevention of pollution in Ganga
  - Installation of Screens in drains discharging pollutants to river Ganga.
  - Regular cleaning of ghats and placed two coloured bins in every ghats for segregated waste disposal and collection regularly.
  - Cleaning of Garbage Vulnerable points besides river banks.
  - Several IEC activities and capacity building of rag pickers and conservancy workers.

- As per clause no 24 of SWM Rules,2016,all 125 ULBs of West Bengal have submitted their annual report in Form IV and compiled report has been sent to West Bengal Pollution Control Board (WBPCB).
- Bulk generators of solid waste operating within these Model Cities/towns have been identified and they have been issued notice for strict observance of waste disposal procedure.Target has been set up to sensitize them and set up waste processing unit at source immediately.
- All 125 ULBs have been communicated for compliance of clause no 22 of SWM Rules,2016 that indicates project implementation timeline.
- Model cities have prepared their time bound action plan for SWM and initiated several activities.
- Intensive IEC campaign has been planned.IEC materials have been developed by reputed agencies and after formal launching of the content,all ULBs will be provided fund for extensive campaign with these materials.Slogan,Cartoon and Logo competition has been announced. This competition has been advertised in all leading newspaper inviting wide participation by citizens.
- Designed capacity building training programmes for rag pickers and conservancy workers.
- Exposure visit organized for the State Government and ULB level Officials at Indore MC, Mumbai MC and Pune MC.
- An exposure workshop arranged for the ULBs/ Development authorities in presence Dr.AsadWarshi, Hon'ble Member, National Apex Committee of Solid Waste Management under Hon'ble NGT.

Status of Solid Waste Management of 125 ULBs of West Bengal

SL No	Particulars/Activities	Status
1	Total No. of Urban Local Bodies	125
2	No. of Wards	2938
3	Population (2011 census)	20905615
4	Waste Generation (TPD)	13709.41
5	Biodegradable waste (TPD)	7612.62 (55.53%)
6	Non Biodegradable/ Recyclable waste (TPD)	4423.90 (32.27%)
7	Inert waste (TPD)	1672.50 (12.20%)
8	Door to door Collection of Waste	2073 Wards (70.56%)
9	Waste Segregation at source	276 Wards (9.39%)
10	Waste Processing Unit	23 ULBs (Existing: 13 ULBs Under Construction: 10 ULBs)
11	Dumping Ground exists	98 ULBs (2240.86 Acres land)
12	Land Available for Sanitary landfill site	48 ULBs
13	Daily sweeping of road	118 ULBs
14	Daily sweeping of Market and places of importance	119 ULBs
15	Notices issued against polluters littering and fines are imposed	17 ULBs
16	Notices Issued for Plastic Ban	77 ULBs
17	Fine Imposed on Plastic Ban	29 ULBs

Legal Framework : Solid Waste Management (SWM) Rules, 2016

Unscientific disposal of municipal solid waste has serious consequences on the environment as well as human health. To tackle these problems, the Ministry of Environment, Forests & Climate Change (MoEF&CC), Government of India issued the Municipal Solid Waste (Management & Handling) Rules, 2OOO. These rules laid out a series of guidelines for scientific processing and disposal of waste. Thereafter, 16 years later, the rules were revised in 2016 by the MoEF&CC, thus releasing the latest Solid Waste Management (SWM) Rules in 2016, to regulate effective collection and disposal of municipal solid waste in India. Under these rules, responsibility of management of solid waste has been entrusted with Urban Development Departments and Urban Local Bodies. All municipal corporations have been directed to prepare a Solid Waste Management Plan and delineate duties of waste generators and authorities as well as specific parameters for composting, incineration and landfilling. This state policy on solid waste management shall comply with the SWM Rules, 2016.

These rules are applicable to

(i) Every urban local body (Mega city to Panchayat level)

(ii) Outgrowths in urban agglomerations

(iii) census towns as declared by the Registrar General and Census Commissioner of India

(iv) notified areas

(v) notified industrial townships

(vi) areas under the control of Indian Railways

(vii) (airports/ airbases

(viii) Ports and harbours

(ix) defence establishments

(x) special economic zones

(xi) State and Central government organisations

(xii) places of pilgrims

(xiii) religious and historical importance as may be notified by respective State government from time to time and

(xiv) every domestic, institutional, commercial and any other non residential solid waste generator situated in the areas.

Key aspects of the Solid Waste Management Rules, 2016

- The Rules are now applicable beyond Municipal areas and extend to urban agglomerations, census towns, notified industrial townships, areas under the control of Indian Railways, airports, airbase, Port and harbour, defence establishments, special economic zones, State and Central government organizations, places of pilgrims, religious & historical importance.
- Segregation of waste at source has been mandated to channelize the waste to wealth by recovery, reuse and recycle.
- Responsibilities of Generators have been introduced to segregate waste in to three streams, Wet (Biodegradable), Dry (Plastic, Paper, metal, wood, etc.) and domestic hazardous wastes (diapers, napkins, empty containers of cleaning agents, mosquito repellents, etc.) and handover segregated wastes to authorized rag-pickers or waste collectors or local bodies.
- Integration of waste pickers/ ragpickers and waste dealers/ Kabadiwalas in the formal system should be done by State Governments, and Self Help Group, or any other group to be formed.
- No person should throw, burn, or bury the solid waste generated by him, on streets, open public spaces outside his premises, or in the drain, or water bodies.
- Generator will have to pay 'User Fee' to waste collector and pay 'Spot Fine' for Littering and Non-segregation.
- Used sanitary waste like diapers, sanitary pads should be wrapped securely in pouches provided by manufacturers or brand owners of these products or in a suitable wrapping material and shall place the same in the bin meant for dry waste / non- bio-degradable waste.
- The concept of partnership has been introduced. Bulk and institutional generators, market associations, event organizers and hotels and restaurants have been made directly responsible for segregation and sorting the waste and manage in partnership with local bodies.
- All hotels and restaurants should segregate biodegradable waste and set up a system of collection or follow the system of collection set up by local body to ensure that such food waste is utilized for composting / biomethanation.

- All resident welfare and market associations, gated communities and institutions with an area >5,000 sq. m should segregate waste at source into valuable dry waste like plastic, tin, glass, paper, etc. and handover recyclable material to either the authorized waste pickers or the authorized recyclers, or to the urban local body.
- The bio-degradable waste should be processed, treated and disposed of through composting or bio-methanation within the premises as far as possible. The residual waste shall be given to the waste collectors or agency as directed by the local authority.
- New townships and group housing societies have been made responsible to develop in-house waste handling, and processing arrangements for bio-degradable waste.
- Every street vendor should keep suitable containers for storage of waste generated during the course of his activity such as food waste, disposable plates, cups, cans, wrappers, coconut shells, leftover food, vegetables, fruits etc. and deposit such waste at waste storage depot or container or vehicle as notified by the local authority.
- The developers of Special Economic Zone, industrial estate, industrial park to earmark at least 5% of the total area of the plot or minimum 5 plots/ sheds for recovery and recycling facility.
- All manufacturers of disposable products such as tin, glass, plastics packaging etc. or brand owners who introduce such products in the market shall provide necessary financial assistance to local authorities for the establishment of waste management system.
- All such brand owners who sell or market their products in such packaging material which are non-biodegradable should put in place a system to collect back the packaging waste generated due to their production.
- Manufacturers or brand owners or marketing companies of sanitary napkins and diapers should explore the possibility of using all recyclable materials in their products or they shall provide a pouch or wrapper for disposal of each napkin or diapers along with the packet of their sanitary products.
- All such manufacturers, brand owners or marketing companies should educate the masses for wrapping and disposal of their products.
- All industrial units using fuel and located within 100 km from a solid waste based RDF plant shall make arrangements within six months from the date of notification of these rules to replace at least 5 % of their fuel requirement by RDF so produced.
- Non-recyclable waste having calorific value of 1500 K/cal/kg or more shall not be disposed of on landfills and shall only be utilized for generating energy either or through refuse derived fuel or by giving away as feed stock for preparing refuse derived fuel.

- High calorific wastes shall be used for co-processing in cement or thermal power plants.
- Construction and demolition waste should be stored, separately disposed off, as per the Construction and Demolition Waste Management Rules, 2016
- Horticulture waste and garden waste generated from his premises should be disposed as per the directions of local authority.
- An event, or gathering organiser of more than 100 persons at any licensed/ unlicensed place, should ensure segregation of waste at source and handing over of segregated waste to waste collector or agency, as specified by local authority.
- Special provision for management of solid waste in hilly areas:- Construction of landfill on the hill shall be avoided. A transfer station at a suitable enclosed location shall be setup to collect residual waste from the processing facility and inert waste. Suitable land shall be identified in the plain areas, down the hill, within 25 kilometers for setting up sanitary landfill. The residual waste from the transfer station shall be disposed off at this sanitary landfill. In case of non-availability of such land, efforts shall be made to set up regional sanitary landfill for the inert and residual waste.

Policies and Strategies: West Bengal

Provision made in the Municipal and Corporation Acts of West Bengal on Solid Waste Management

West Bengal Municipal Act, 1993

1. Section 63 (2): Obligatory function of the Municipalities/ Notified Area Authorities
   (a) Collection, removal disposal and disposal of solid wastes including filth, rubbish and other obnoxious or polluted matters
   (b) Disposal of solid and liquid wastes consisting with efforts to cause recovery and reuse of all that can be salvaged.
2. Section 95B: Levy of special conservancy charge.-
   The Board of Councilors may levy a special conservancy charge for providing municipal services in connection with removal of solid wastes.
3. Section 260 to 273: The act describes the functions of the Municipalities/ Notified Area Authorities in relation to solid wastes.

Kolkata Municipal Corporation Act, 1980

1. Section 29 ©: Obligatory function of Kolkata Municipal Corporation
   The scavenging, removal and disposal of filth, rubbish and other obnoxious or polluted matters.
2. Section 210B: Levy of special conservancy charge.-
   The Corporation may levy a special conservancy charge on the commercial and industrial establishments for providing municipal services in connection with removal of solid waste.
3. Section 322 to 342: The act describes the functions of Kolkata Municipal Corporation in relation to solid wastes

Howrah Municipal Corporation Act, 1980

1. Section 114A: Levy of special conservancy charge.-
   The Corporation may levy a special conservancy charge on the commercial and industrial establishments for providing municipal services in connection with removal of solid waste.
2. Section 188-188O: The act describes the functions of Howrah Municipal Corporation in relation to solid wastes

West Bengal Municipal Corporation Act, 2006

1. Section 97 (2): Obligatory function of Other Municipal Corporations

   (a) Scavenging, removal and disposal of filth, rubbish and other obnoxious or polluted matters.

2. Section 105: Levy of special conservancy charge.-

   The Corporation may levy a special conservancy charge for providing municipal services in connection with the removal of solid waste.

3. Section 300-300 (O): The act describes the functions of Other Municipal Corporations in relation to solid wastes

Amendment made in the Municipal and Corporation Acts of West Bengal on Solid Waste Management

Provision on imposition of prohibition against use of thin plastic carry bags and similar other materials:

A. Section 340 of the West Bengal Municipal Act, 1993 (West. Ben. Act XXII of 1993). Prohibition against defiling of water of public and private tanks and uses, and throwing of plastic in the public streets and tanks, whether private or public.—No person shall—

(*a*) bathe in, or in any manner defile, water in any place set apart by the Municipality or by the owner thereof for drinking only; or

(*b*) deposit any offensive or deleterious matter in the dry bed of any place set apart as aforesaid for drinking purpose; or

(*c*) wash clothes in any place set apart as aforesaid for drinking or bathing purpose; or

(*d*) wash any animal or any cooking utensils or wool, skins or other foul or offensive substance or deposit any offensive or deleterious matter in any place set apart as aforesaid for bathing purpose or washing clothes; or

(*e*) cause or suffer to drain into or upon any place set apart as aforesaid for drinking, or bathing purpose or washing clothes or cause or suffer anything to be brought thereinto or do anything whereby the water may be fouled or corrupted; or

(*f*) use, sale and distribute plastic within the municipal area or throw plastic in the public streets, drain and tanks, whether private or public and defile water of public and private tanks.

Note.—For the purpose of this section "plastic" means virgin and recycled plastic carry bags, cups and any other materials made of plastic of prescribed size and thickness as may be notified by the competent authority from time to time.

B. Section 96N of the West Bengal Municipal Corporation Act, 2006(West Ben. Act XXXIX of 2006.). Prohibition against defiling of water of public and private tanks and uses, and throwing of plastic in the public streets and tanks, whether private or public.—No person shall—

(*a*) bathe in, or in any manner defile, water in any place set apart by the Corporation or by the owner thereof for drinking only; or

(b) deposit any offensive or deleterious matter in the dry bed of any place set apart as aforesaid for drinking purpose; or

(c) wash clothes in any place set apart as aforesaid for drinking or bathing purpose; or

(d) wash any animal or any cooking utensils or wool, skins or other foul or offensive substance or deposit any offensive or deleterious matter in any place set apart as aforesaid for bathing purpose or washing clothes; or

(e) cause or suffer to drain into or upon any place set apart as aforesaid for drinking, or bathing purpose or washing clothes or cause or suffer anything to be brought thereinto or do anything whereby the water may be fouled or corrupted; or

(f) use, sale and distribute plastic within the municipal area or throw plastic in the public streets, drain and tanks, whether private or public and defile water of public and private tanks.

Note.—For the purpose of this section "plastic" means virgin and recycled plastic carry bags, cups and any other materials made of plastic of prescribed size and thickness as may be notified by the competent authority from time to time.

C. In Kolkata Municipal Corporation Act, 1980, though specific provision has not been made, but the following sections in chapter XX empowers the Corporation to initiate necessary action in the matter.

336. Prohibition against deposit of solid wastes.—

(1) No person shall deposit or cause or permit to be deposited or throw upon or along any public street, public place, land belonging to the Corporation or any unoccupied land or on the bank of a water-course any solid waste except in accordance with the provisions of this Act.

(2) Without prejudice to the generality of the foregoing provision, no person shall deposit or cause or permit to be deposited any building rubbish in or along any street, public place or land except in conformity with the conditions of prior permission from the Municipal Commissioner :

Provided that no permission shall be given until an advance payment of a fee for the removal by the employees or contractors of the Corporation of such rubbish has been made in accordance with such rates as may be determined by the Mayor-in-Council from time to time :

Provided further that if the Municipal Commissioner thinks fit, he may, for reasons to be recorded, refuse to give such permission.

337. Presumption as to offender.— If any rubbish, offensive matter, trade refuse, special waste, hazardous waste or excrementitious and polluted matter accumulating on any premises is deposited in any place in contravention of the provisions of this Act, it shall be presumed, unless the contrary is proved, that such contravention has been committed by the occupier of such premises.

338. Depositing or throwing any solid waste in contravention of the provisions of this Act.— Whoever deposits or throws or causes or permits to be deposited or thrown any solid waste on any place in contravention of the provisions of this Act shall, subject to such regulations as may be made in this behalf, be punishable with fine *which shall not be less than rupees five thousand and which may extend to rupees one lakh* for each such offence.

D. In Howrah Municipal Corporation Act, 1980, though specific provision has not been made, but the following sections in chapter XIV empowers the Corporation to initiate necessary action in the matter.

188I. Prohibition against deposit of solid wastes.—

(1) No person shall deposit or cause or permit to be deposited or throw upon or along any public street, public place, land belonging to the Corporation or any unoccupied land or on the bank of a water-course any solid waste except in accordance with the provisions of this Act.

(2) Without prejudice to the generality of the foregoing provision, no person shall deposit or cause or permit to be deposited any building rubbish in or along any street, public place or land except in conformity with the conditions of prior permission from the Commissioner :

Provided that no permission shall be given until an advance payment of a fee for the removal by the employees or contractors of the Corporation of such rubbish has been made in accordance with such rates as may be determined by the Corporation from time to time.

Provided further that if the Commissioner thinks fit, he may, for reasons to be recorded, refuse to give such permission.

188J. Presumption as to offender.— If any rubbish, offensive matter, trade refuse, special waste, hazardous waste or excrementitiously and polluted matter accumulating on any premises is deposited in any place in contravention of the provisions of this Act, it shall be presumed, unless the contrary is proved, that such contravention has been committed by the occupier of such premises.

188K. Depositing or throwing any solid waste in contravention of the provisions of this Act.— Whoever deposits or throws or causes or permits to be deposited or thrown any solid waste on any place in

contravention of the provisions of this Act shall, subject to such regulations as may be made in this behalf, be punishable with fine *which shall not be less than rupees five thousand and which may extend to rupees one lakh for each such offence.*

Solid Waste Management Strategy of the State: It encompasses four fundamental principles:

- Reinforcement of the three 'R's – Reduce, Reuse and Recycle
- Clubbing or grouping of certain functions within the solid waste management value chain so that municipalities can share resources, leading to lower costs and an increased scale of economy
- Waste management is a service, and therefore needs being professionally managed; such expertise can come from private sector as well as civil society or community based organisations, and there is no one model that fits all such situations.
- The generation of waste has negative externalities, and therefore the 'polluter pays' principle must apply.

Hon'ble NGT Order O.A. No. 606/2018 dated 16.01.2019

- Clause No. VI (35) : A Special Task Force in every district having four members one each nominated by District Magistrate, Superintendent of Police, Regional Officer of the State Pollution Control Board in concerned District and one person to be nominated by the Chairman of District Legal service authority for monitoring and awareness about the SWM Rules, 2016.

Hon'ble NGT Order O.A. No. 606/2018 dated 02.04.2019

- Clause No. II (19) : The District Magistrate should hold monthly meetings as per Rule 12 (duties of District Magistrate) of SWM Rules, 2016 and submit reports to the Urban Development & Municipal Affairs Department with a copy to the State Level Committee under Hon'ble NGT.

Hon'ble NGT Order O.A. No. 606/2018 dated 02.04.2019

- Clause No. IV (39) :

i. Steps for compliance of Rules 22 (time frame for implementation) and 24 (submission of annual report in form iv) of SWM Rules be now taken within six weeks to the extent not yet taken. Similar steps be taken with regard to Bio-Medical Waste Management Rules and Plastic Waste Management Rules.

ii. Atleast three major cities and as many major towns as possible in the State and atleast three Panchayats in every District may be notified on the website within two weeks from today as model cities/towns/villages which will be made fully compliant within next six months.

iii. The remaining cities, towns and Village Panchayats of the State may be made fully compliant in respect of environmental norms within one year.

iv. A quarterly report be furnished by the Chief Secretary, every three months. First such report shall be furnished by July 10, 2019.

Municipal Solid Waste Management Planning

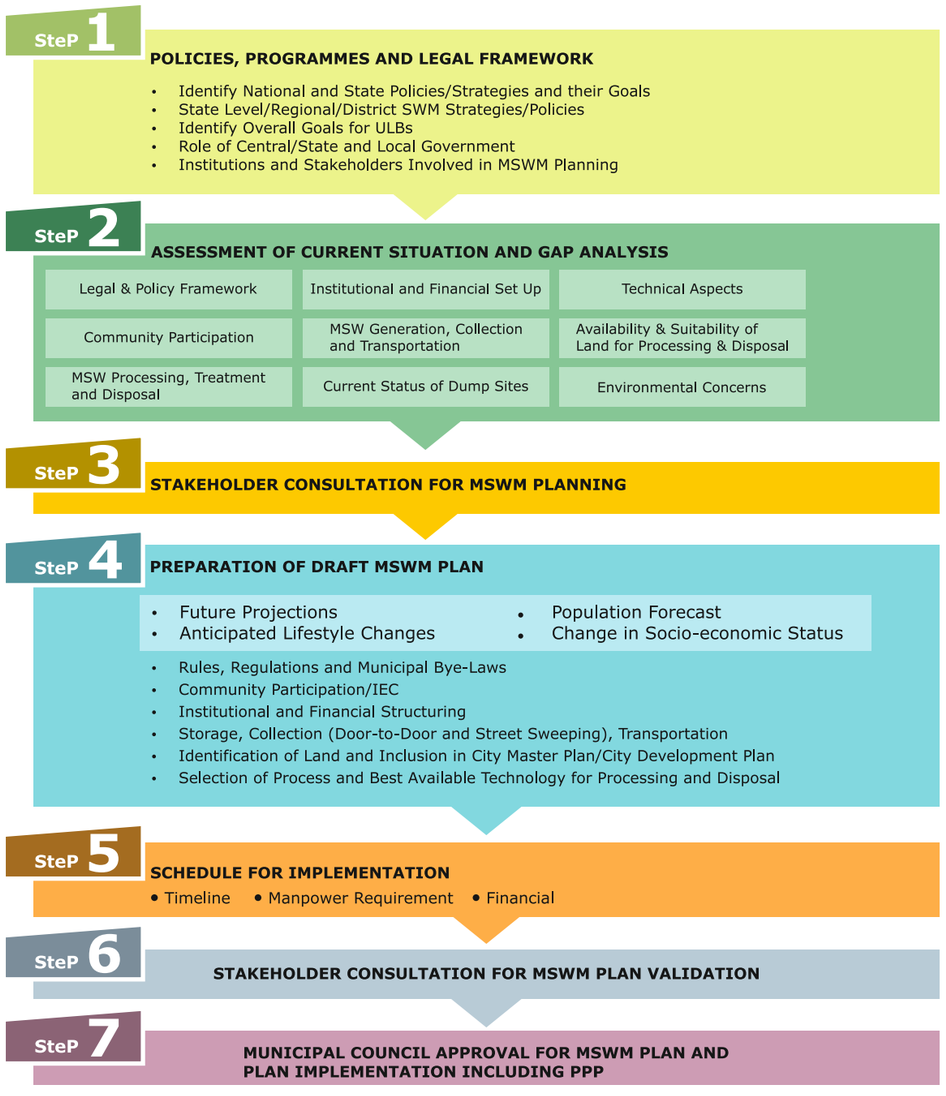


Fig 1 - The seven-step approach

Future Projection: Estimating future waste generation quantities and composition is critical for developing MSW Management plan. Planning horizons for MSW processing, treatment, or disposal projects typically extend to 20–30 years, depending on the nature of the facility. Forecasting future MSW generation is dependent on various factors, such as

- future population forecasts;
- anticipated lifestyle changes;
- change in socio-economic profile of the ULB.

Integrated Solid Waste Management Plan

The Integrated Solid Waste Management (ISWM) proposes a waste management hierarchy with the aim to reduce the amount of waste being disposed, while maximizing resource conservation and resource efficiency. The urban local bodies have to integrate the ISWM in the overall municipal solid waste management plan of their city/town.

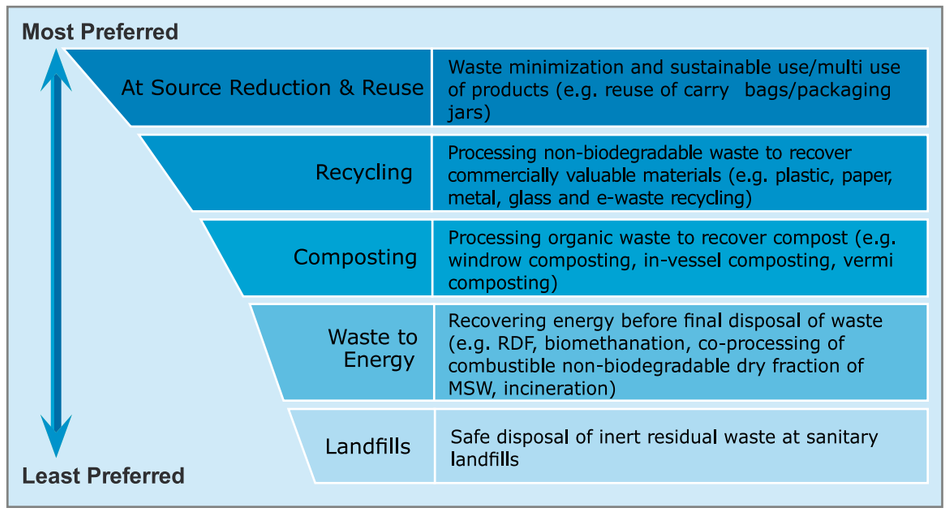


Figure 2: Integrated Solid Waste Management System Hierarchy

The two models suggested to be considered for the operationalization of municipal solid waste management plan are:

1. Centralised method: This method involves collection of municipal waste from all over the local area and by means of landfilling, dump outside the city/nagar panchayat limits. This process looks at door-to-door collection of solid waste by waste pickers who hand over to the collection team who then discard the collected waste in the landfill. The waste pickers are employees of the Municipal Corporation or Nagar Panchayat. The collection team is generally contracted out by a tendering process.

Advantages : include (i) economies of scale, (ii) single monitoring point, and (iii) high-end technology and environmental controls.

Limitations : include (i) larger tract of land, (ii) fund limitations, (iii) limited experience of ULBs in managing large contracts, and (iv) high potential for environmental failure of systems where environmental controls are not in place or monitored.

2. De-centralized method: This is a model seen in a few places like Suryapet in Andhra Pradesh and Bangalore in Karnataka. The waste is collected ward-wise and is segregated at source into bio-degradable and non-biodegradable. The biodegradable waste is composted at a nearby facility by different methods of aerobic and anaerobic composting. The non-biodegradable waste is further categorised into paper, plastic, metal and other waste and then further collected by recyclers for up-cycling or downcycling of products

   Advantages : (1) It allows for lower level of mechanisation than the centralised solutions and provide job opportunities for informal workers and small entrepreneurs (2) it can be tailor made for the local waste stream, climate, social, and economic conditions (3) It reduces the cost incurred for the collection, transportation, and disposal of waste by the ULBs.

   Limitations: (1) difficulty in obtaining land in many urban areas; (2) difficulty in maintaining scientific and hygienic conditions due to (3) lack of sufficient space and training and capacity of workers; (4) uncertain quality of end products; and difficulty in ensuring economic viability of the system, especially when qualified staff is required.

The integrated waste management plan may be developed by considering several factors such as future population and waste generation projections, applicable laws and policies, institutional and financial structuring, inclusive and equitable community involvement, technical considerations in collection and transportation, availability of land, and best suited technologies for handling waste generated in the ULB, based on the ISWM hierarchy. Linkages with the city sanitation plans and National Urban Sanitation Policy (NUSP) is required.

Waste Minimisation, Segregation, Collection and Transportation

The most preferred option for waste management in the ISWM hierarchy is to prevent the generation of waste at various stages including in the design, production, packaging, use, and reuse of products. Waste prevention helps to reduce handling, treatment, and disposal costs and various environmental impacts such as leachate, air emissions, and generation of greenhouse gases(GHG). Minimisation of waste generation at source and reuse of products are the most preferred waste prevention strategies.

The SWM Rules, 2016 defines segregation as sorting and separate storage of various components of solid waste namely biodegradable wastes including agriculture and dairy waste, non-biodegradable wastes including recyclable waste, non- recyclable combustible waste, sanitary waste and non-recyclable inert waste, domestic hazardous wastes, and construction and demolition wastes.

Segregating waste at source ensures that waste is less contaminated and can be collected and transported for further processing. Segregation of waste also optimises waste processing and treatment technologies. It results in high proportion of segregated material that could be reused and recycled, leading to less consumption of virgin material. Bins for storage of bio-degradable wastes shall be painted green, those for storage of recyclable wastes shall be printed blue and those for storage of other wastes shall be printed black.

BASIC SEGREGATION					
Wet waste (green bin)	Dry waste (Blue bin)				Domestic Hazardous7
	With further sub-segregation BASIC+				
Food wastes of all kinds, cooked and uncooked, including eggshells and bones, flower, fruit and waste including juice, vegetable peels and household garden/plant wastes. Soiled tissues, food wrappers, paper towels; fish and meat	Paper cardboard and cartons	Containers & packaging of all kinds excluding those containing hazardous materials Compound packaging (tetrapak, blisters etc.) Plastics	Rags Rubber Wood Discarded clothing Furniture	Metals Glass (all kinds) Inerts House sweepings and inerts (not garden, yard or street sweepings)	E-waste* Hazardous wastes** Household medical waste*** Batteries from flashlights and button cells. Lights bulbs, tube lights and Compact Fluorescent Lamps (CFL) Car batteries, oil filters and car care products and consumables

* E-waste: Printer & printer cartridges, electronic parts and equipment and others

** Hazardous wastes: Chemicals and solvents and their empty containers, paints, oil, lubricants, glues, thinners and their empty containers, insecticides, pesticides and herbicides and their empty containers, photographic chemicals, bleaches and household kitchen & drain cleaning agents

*** Household Medical Waste: Thermometers and other mercury containing products, discarded medicines, injection needles and syringes after destroying them both, sanitary wastes and diapers (should be collected daily)

Table 1 : Indicative list of segregation of household waste

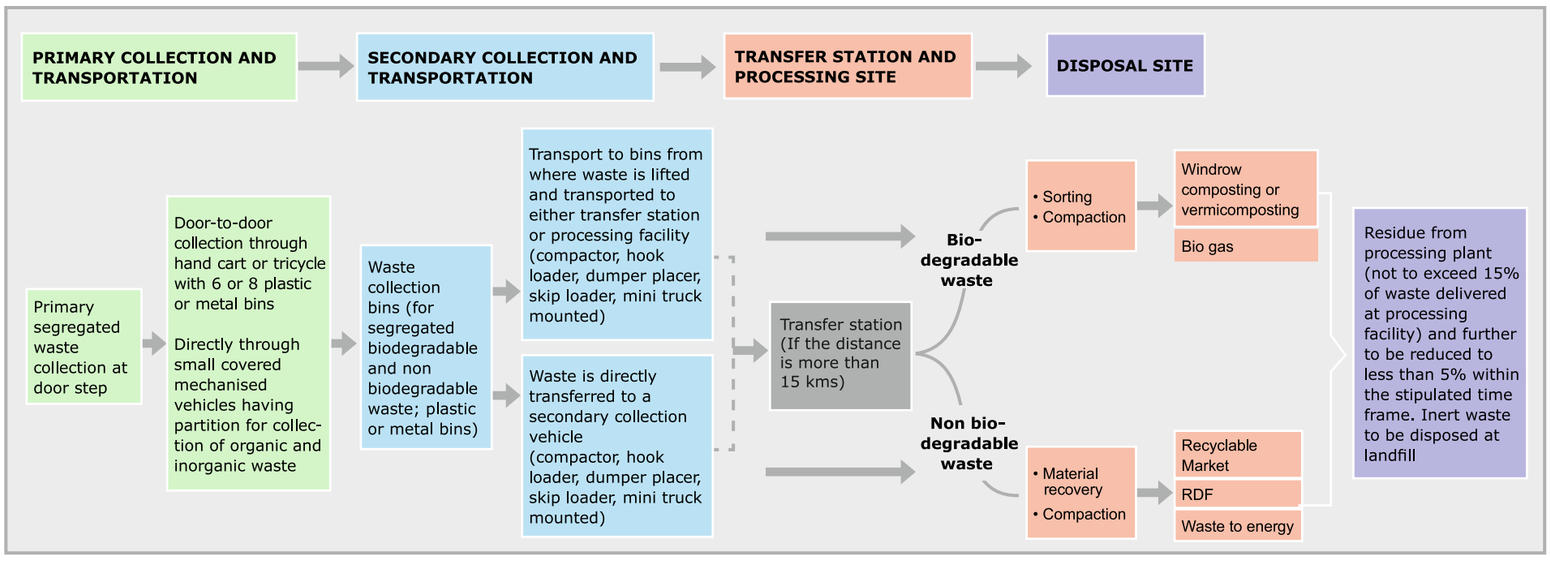
Door-to-door collection of segregated waste is mandatory as per SWM Rules, 2016. Collection of segregated waste (wet waste, dry recyclables, and domestic hazardous waste), sanitary, horticulture, construction & demolition from residential, commercial, and institutional areas is to be planned by ULBs. Frequency of waste collection is dependent on the quantum of waste generated by each of these groups and the level of segregation of waste. While residential waste is to be collected daily, waste from market area, commercial establishments and institutions may be collected twice a day. The quantum of waste generated and collected also determines the mode of transportation used to collect waste at doorstep. Segregated containers are required for collection of different fractions (wet, dry and domestic hazardous); at a minimum, ULBs shall collect wet and dry waste separately.



Waste collected from doorstep may either be stored in a secondary collection point or transferred directly to secondary collection vehicles (bin-less cities). The feasibility of choosing between secondary storage or direct transfer to secondary collection vehicles is to be ascertained based on the availability of secondary collection vehicles, extent of collection area, and timing of collection. Where waste from all residential areas is collected during morning hours and transferred directly from primary collection vehicles to secondary collection vehicles, the requirement for secondary collection vehicles will be much higher as compared to staggered timings of collection. Wet, dry and domestic hazardous waste should be transported in segregated manner. ULBs should ensure that source segregated waste is collected and also transported separately.

The establishment of intermediate transfer stations is determined by the distance between secondary waste collection points and the final treatment and disposal point. If the distance from the city jurisdiction to the final treatment and disposal points exceeds 15 km, transfer stations may be established. The choice of secondary collection vehicles is to be synchronised with the design of secondary collection bins and storage containers in the transfer station. Compactors may be used to haul waste from transfer stations to the waste disposal site.

Figure 3: Flow Chart for Household Waste Collection, Transportation and Disposal[10]

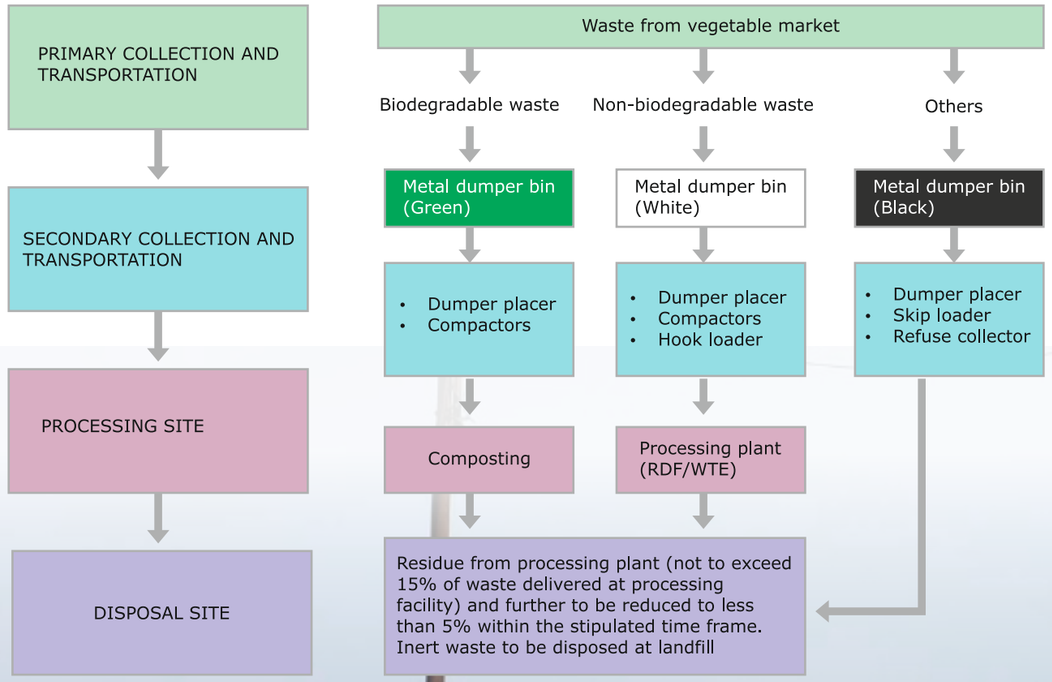


- The compactor is an appropriate vehicle for collecting biodegradable and recyclable component of MSW
- Skip loaders/ Hook loaders are preferred for collecting inert waste or Construction and Demolition waste
- Waste may be transferred to the transfer station if the processing site is located at least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

Towards Bin less city: To avoid littering

Direct transfer of waste from the primary collection point to secondary collection vehicles promotes a bin-less arrangement for waste collection and Transportation. Issues related to placement of bins, littering around bins, non-lifting of bins as per schedule, and continuous movement of fleet to lift bins and replace them are avoided. However, such systems are successful only when there is sufficient fleet of secondary collection vehicles to synchronise with primary collection and where good coordination systems exist. Without adequate management controls, such systems may fail, resulting in littering. It is also advisable to place backup collection bins in commercial or high footfall areas to cater to unexpected waste generation. Kochi and Nashik Municipal Corporations have successfully implemented bin-less systems in the cities, based on synchronised collection and transportation systems.

Figure 4: Flow Chart for Collection, Transportation and Disposal of Vegetable Market Waste





Information, Education, and Communication activities for awareness generation to ensure efficient segregation, collection and transportation

As mentioned, SWM Rules, 2016 mandates ULBs to create public awareness through information, education, and communication (IEC) campaign to educate the waste generators on MSWM activities. Some of the action points for awareness generation are the following:

- Ensure active participation of the community in reducing overall quantities of waste. The different waste reduction strategies, such as take-back, deposit–refund system, etc. will be successful only if the community is ready to adopt the change.
- Promote source reduction programmes in the community and encourage handover of recyclable material to sustainable recycling facilities through informal sector, NGOs, CBOs, etc.
- Campaign for reducing the use of specific non-recyclable, non-reusable,or toxic material. Practice and promote material substitution where possible.
- Generate awareness among people to avoid littering. Sensitise citizens to segregate waste at their premises into biodegradable, dry, and special waste and hand over the segregated waste to the collectors. Involvement of RWAs, CBOs, NGOs, SHGs, and market associations is imperative to ensure the success of source segregation.
- Ensure awareness on existing recyclable collection systems, including dedicated collection points. Enforce extended producer responsibility (EPR) initiatives.
- Hold regular meetings among the ULB staff and representatives of RWAs, market associations, NGOs, SHGs, and other stakeholders to ensure successful uptake of such programs.
- Ensure active participation of the community for successful implementation of primary and secondary collection systems.
- Involve community in designing the primary collection system, e.g.,in determining waste collection system and timings.
- Generate awareness on bye-laws on waste collection and management system as well as user charges levied on different waste fractions.



Treatment and disposal options for solid waste

The ULBs shall make a well-informed decision while selecting treatment technologies and shall contract private partners on a tipping fee basis. The policy follows the SWM Rules, 2016 and maintains that all Class I cities in the state shall have both compost plants and landfill sites, while other cities or towns with a population of less than 1 lakh shall have only suitable engineered landfill sites. The various technologies for treatment and disposal of municipal solid waste management are based on the following principles:

Thermal treatment: Incineration is the combustion of waste in the presence of oxygen, so that the waste is converted into carbon dioxide, water vapour and ash. Also labelled Waste to Energy (WtE) method, it is a means of recovering energy from the waste. It's advantages include waste volume reduction, cutback on transportation costs and reduction of greenhouse gas emissions. However, when garbage is burned, pollutants, such as mercury, lead, dioxins may be released into the atmosphere, and cause health issues.

Pyrolysis and gasification: In this method, thermal processing is in complete absence of oxygen or with less amount of air.

Biological treatment methods: This involves using micro-organisms to decompose the biodegradable components of waste. The 2 types of processes: Aerobic: This needs the presence of oxygen and includes windrow composting, aerated static pile composting & in-vessel composting, vermi-culture etc. Anaerobic digestion: Takes place in the absence of oxygen.

Landfills and open dumping: Sanitary landfills are the controlled disposal of waste on land in such a way that contact between waste and the environment is significantly reduced and the waste is concentrated in a well-defined area. Dumps are open areas where waste is dumped exposing it to natural elements, stray animals and birds. With the absence of any kind of monitoring and no leachate collection system, this leads to the contamination of both land and water resource

Choosing Appropriate Technology

The choice of technologies for processing, treatment, and disposal of SWM in a ULB should be guided by the ISWM hierarchy.

Collection of segregated waste improves the performance of processing and treatment facilities. The first preference should always be given to segregating recyclables for further reuse or recycling. Access to appropriate recycling industries is essential for safeguarding public health and environment.

Organic waste may be composted aerobically or used for generating energy through anaerobic decomposition processes.





High calorific value material should be further segregated and may be used for co-processing in cement plants or as fuel in appropriately designed and environmentally controlled industrial boilers.

Different waste to energy technologies are available for varying quantities of waste generation. The technologies should be carefully assessed and chosen as per the characteristics and quantities of waste generated specific to each ULB.

Incinerator plants should be planned for only in those ULBs where a minimum of 1,000 TPD of mixed waste can be supplied daily to the plant, after ensuring implementation of higher order technologies in the ISWM hierarchy.

Process and environmental controls and monitoring of the entire system are critical for the environmentally sustainable functioning of these plants. Technologies which are still under development, like pyrolysis, gasification, and bioreactor landfills, should not be attempted, unless their commercial application is proven in India.

Table 2: Indicative Criteria for Selection of Appropriate Technology or Combination of Technologies[28]

CRITERIA	WINDROW COMPOSTING	VERMICULTURE	BIOMETHANATION	RDF	INCINERATION	INTEGRATED SYSTEM (COMPOSTING + RDF)	SANITARY LANDFILL
TECHNICAL CRITERIA							
Facility 29,30 Location	To be located as per the buffer zone criteria mentioned below.	To be located as per the buffer zone criteria mentioned below.	To be located as per the buffer zone criteria mentioned below.	To be locate as per the buffer zone criteria mentioned below.	To be located as per the buffer zone criteria mentioned below.	To be located as per the buffer zone criteria mentioned below.	Landfill sites must be located at least 500 m away from residential areas and should abide by the criteria mentioned in MSW Rules and state level guidelines.
Buffer Zone (No Development Zone)	500 m for facilities dealing with 100 TPD or more of MSW 400 m for facilities dealing with 75–100 TPD of MSW 300 m for facilities dealing with 50–75 TPD of MSW 200 m for facilities dealing with 10–50 TPD of MSW No buffer zone for facilities dealing upto 5 TPD of MSW No buffer zone for decentralised plants handling less than 1 TPD of MSW (but adequate environmental controls are required)						

- Adopted from various sources (JnNURM, World Bank, Task Force Report on Waste to Energy, Planning Commission of India – 2014).
- Site selection criteria specified by the EIA Notification 2006 and its amendments shall be considered.
- CPCB Guidance on Criteria for Site Selection for Landfills shall also be considered.

Indicative Criteria for Selection of Appropriate Technology or Combination of Technologies [contd.]

CRITERIA	WINDROW COMPOSTING	VERMICULTURE	BIOMETHANATION	RDF	INCINERATION	INTEGRATED SYSTEM (COMPOSTING + RDF)	SANITARY LANDFILL
Natural environment	Composting in coastal/high rainfall areas should have a shed to prevent waste from becoming excessively wet and thereby to control leachate generation.	Composting in coastal/high rainfall areas should have a shed to prevent waste from becoming excessively wet and thereby to control leachate generation.					Should be avoided in marshy land and in conditions where the ground water table is 2 m from the base of the liner. In marshy land, apart from ground and surface water contamination potential, there could be huge risks due to structural safety of the landfill (slippage and complete breakdown).
Land Requirement	For 300 TPD of segregated/pre-sorted MSW: 5 ha of land including buffer zone is required.	For 20 TPD of segregated/pre-sorted: 1.25 ha.	For 300 TPD of segregated/pre-sorted MSW: 2.5 ha of land is required.	For 300 TPD of segregated/ pre-sorted MSW: 2 ha of land is required.	For 1000 TPD of mixed waste: 5 ha of land including buffer zone	For 300 TPD of segregated/ presorted MSW: 6 ha of land (Note: Many of the processing units are shared).	For 300 TPD of MSW: 30 ha of land is required for 20 years.
Waste Quantity which can be managed by a single facility.	500 TPD	1 TPD to 20 TPD. Higher capacities can also be planned if adequate land is available along with other necessary arrangements.	1 TPD at small scale to 500 TPD at larger scale	100 TPD of segregated waste and above	1000 TPD and above of mixed waste (smaller plants are not techno economically viable, given the cost of required environmental control equipment and boiler technology	500 TPD and above (economically sustainable above 500 TPD plant size)	100 TPD inert and above. Smaller landfills are not techno economically viable
Requirement for Segregation prior to technology	High	Very high	Very high	High	High – Feed stock should be free from inerts and low on moisture content	Moderate because both dry and wet fractions are utilized	Only inert waste may be placed in landfills as per SWM Rules
Rejects	About 30% including inerts if only composting is done.[36] 15%* rejects with RDF, if located in the same plant	About 30% including inerts*	About 30% from mixed waste*	Around 30% from mixed waste**	Around 15%**	Approximately 15-20%***	No rejects
Potential for Direct Energy Recovery	No	No	Yes	No (feed stock for energy recovery)	Yes	Yes	Not as per SWM Rules

- In cases of an integrated facility of composting and RDF, 15% rejects from mixed waste stream is expected
- Rejects from mixed waste fundamentally depends on the presence of non- biodegradable material which are taken out during pre-sorting stage
- For incoming mixed waste for RDF & Incineration Non combustible material is taken out during the sorting stage
- Process rejects from segregated waste should be less than 10%

Indicative Criteria for Selection of Appropriate TechAQnologyQ or Combination of Technologies [contd.]

CRITERIA	WINDROW COMPOSTING	VERMICULTURE	BIOMETHANATION	RDF	INCINERATION	INTEGRATED SYSTEM (COM-POSTING + RDF)	SANITARY LANDFILL
Technology Maturity	Windrow composting technique is well established	Community scale projects are successful	Feasibility for biodegradable waste is proven. In case of mixed waste, appropriate presorting has to be carried out.	Quality of RDF should be based on end use, no clear consensus on quality requirements. Burning of RDF below 850°C for less than 2 seconds residence time can pose serious problems of health and environment. Rules regulating characteristics of RDF and guidelines for appropriate use not prescribed by concerned authority.	Technology is available. However constraints of low calorific value, high moisture content and high proportion of inert waste should be considered while undertaking the project commercially.	Composting and RDF combined facility is an upcoming phenomenon. Utilisation of rejects from compost plants as input material for RDF production and sale. Rejects from integrated system are 15-20% as opposed to 30-40% from individual system.	Sanitary landfill is a proven method for safe disposal of waste, practiced world over. However it has environmental implications and efforts have to be made to minimize waste going to landfills. MSW Rules only permit inert wastes to be landfilled.
FINANCIAL CRITERIA							
Indicative Capital Investment[87]	Typically 15-20 Cr for 500 TPD plant	1 Cr. per 20 TPD	Typically 75-80 Cr for 500 TPD plant	Typically 17-20 Cr for 500 TPD plant	Very high capital, operating and maintenance costs. 15 Cr. per MW power production	Typically 25-30 Cr for 500 TPD plant) without a mechanical Hot Air Generator (HAG) for drying However, moisture can be reduced by bio-drying with much less cost but slightly reduced efficiency.	High
Market for product/ By-Product	Quality compost compliant with FCO 2013 has a good market. IPNM Task Force (vetted by Supreme Court, 1 Sep 2006) has recommended co-marketing of 3-4 bags of compost with 6-7 bags of inorganic fertiliser.	Good market potential in Urban and Rural areas. However it is not adequately explored for bulk marketing.	So far, there is no appropriate system for pricing biogas. The system of pricing according to kerosene equivalent puts biogas at a disadvantage. At present, there is lot of interest in conversion of biogas into automotive fuel by stripping CO_2 In this case, equivalent pricing with power/CNG again puts biogas at a disadvantage because of scale of economy.	Good market potential for RDF. In small cities, RDF plants only become feeders of RDF to large RDF based power plants and cement plants.	Good potential of energy generation if power purchase agreements are made reflecting true cost of production including O&M costs	Quality compost compliant with FCO 2009 has a good market. Good market potential for RDF. In small cities, RDF plants only become feeders of RDF to large RDF based power plants and cement plants.	No potential, since it is stipulated by the SWM Rules that only inert wastes are to be disposed in landfills

- Toolkit for Solid Waste Management (2012), Jawaharlal Nehru National Urban Renewal Mission, Ministry of Urban Development, Government of India. http://jnnurm.nic.in/wp-content/uploads/2012/11/SWM-toolkit.pdf

Indicative Criteria for Selection of Appropriate Technology or Combination of Technologies [contd.]

CRITERIA	WINDROW COMPOSTING	VERMICULTURE	BIOMETHANATION	RDF	INCINERATION	INTEGRATED SYSTEM (COMPOSTING + RDF)	SANITARY LANDFILL
MANAGERIAL CRITERIA							
Labour Requirement	Labour intensive	Labour intensive	Less labour intensive	Labour intensive (based on current practice).	Non labour intensive but requires considerable technical capacity,	Labour intensive but requires considerable technical capacity.	Only inert wastes are to be deposited in sanitary landfills. Labour intensive but requires considerable technical expertise as well.
Predominant skills for Operation and Management.	Technically qualified and experienced, and semi-skilled staff..	Technically qualifiedand experienced, and Semi-skilled staff [38].	Technically qualified and experienced staff.	Technically qualified and experienced staff.	Technically qualified and experienced staff.	Technically qualified and experienced staff and semi-skilled.	Technically qualified and experienced, and semi-skilled staff.
ENVIRONMENTALCRITERIA							
Concerns for toxicity of product	The final product is generally applied to soil and used as manure. Can contaminate the food chain if compost is not meeting FCO norms.	The product is generally safe as worms cannot endure significant contamination of raw materials. FCO Standards are to be met with	The final product is generally applied to soil as a soil conditioner. Can contaminate the food chain if compost is not meeting FCO norms.	-	-	The final product is generally applied to soil and used as manure. Can contaminate the food chain if compost is not meeting FCO norms.	-
Leachate Pollution	Potential exists. Varies with the climate of area and seasonal variation. In relatively dry seasons, leachate can be recirculated into the windrow to contain loss of nutrients and also pollution potential. In high rainfall areas, the windrows need to be covered either temporarily or permanently to control leachate generation. However, the design of the shed should be such that good natural ventilation is maintained.	Insignificant quantities at low waste volumes per vermi-pit.	High if not treated appropriately	Low	High potential of leachate at the receiving pit.	Potential exists for compost Varies with the climate of area and seasonal variation. In relatively dry seasons, leachate can be recirculated into the windrow to contain loss of nutrients and also pollution potential. In high rainfall areas, the windrows need to be covered either temporarily or permanently to control leachate generation. However, the design of the shed should be such that good natural ventilation is maintained.	Polluted surface runoff during wet weather, groundwater contamination due to leachate infiltration Moderate to high depending upon the leachate recycling and control systems. Leachate management during monsoons requires special attention

38 On-site training is required for unskilled labour, as a minimum requirement for efficient operation

Figure 13: Indicative Criteria for Selection of Appropriate Technology or Combination of Technologies [contd.]

CRITERIA	WINDROW COMPOSTING	VERMICULTURE	BIOMETHANATION	RDF	INCINERATION	INTEGRATED SYSTEM (COMPOSTING + RDF)	SANITARY LANDFILL
Atmospheric pollution	Low (dust, aerosol etc.). Odour issues.	Low. Odour issues.	Low. Leakage of biogas. Odour issues.	Low to moderate (dust, aerosols). Very high if RDF is not burnt at required temperature. Odour issues.	Very high if emissions not managed properly. Fly ash should be disposed safely in an engineered landfill. (Emissions due to incomplete combustion of municipal refuse contain a number of toxic compounds, dioxins and furans, requiring appropriate emissions control systems)	Moderate, require appropriate emission control systems (Air emission include acid gases, dioxins and furans).	Air pollution and problems of odour and methane emissions if not managed properly.
Other	Fire and safety issues to be taken care of	Fire and safety issues to be taken care of	Fire and safety issues to be taken care of	Presence of inappropriate material in the RDF (chlorinated plastics). Fire and safety issues to be taken care of.	Disposal of bottom ash/ slag. Fire and safety issues to be taken care of.	Presence of inappropriate material in the RDF (chlorinated plastics). Fire and safety issues to be taken care of.	Spontaneous ignition due to possible methane concentration. Fire and safety issues to be taken care of.

- Actual planning and implementation will also depend on engineering and installation of plants



In cases of an integrated facility of composting and RDF, 15% rejects from mixed waste stream is expected. Rejects from mixed waste fundamentally depends on the presence of non- biodegradable material which are taken out during pre-sorting stage. For incoming mixed waste for RDF & Incineration Non-combustible material is taken out during the sorting stage. Process rejects from segregated waste should be less than 10%

Plastic Waste Management

The disposal of plastic waste is legislated under the Plastic Waste Management Rules, 2016. These rules specify the responsibilities of urban local bodies (ULBs) for managing plastic waste. However, most of the discarded plastics find their way into the municipal waste streams.

Following the integrated solid waste management (ISWM) hierarchy, reuse and recycling of plastic waste are the preferred methods for managing plastic wastes after reduction. However, as mentioned, plastics cannot be recycled indefinitely; each recycling cycle reduces the strength and utility of the plastic. Plastic waste chokes the urban drainage system, causing urban flooding in many instances. Immediate action on appropriate management (focusing on minimisation) and disposal of these wastes is required. Plastic waste is accepted as fuel in cement kilns; residence times and temperatures are adequate to preempt the production of dioxins and furans. In cineration of plastic wastes for energy recovery may also be considered under strictly controlled and monitored conditions. Reusing plastic waste to form polymer blended bitumen roads are an accepted method for final disposal of plastics in India. Landfilling of plastics should be avoided.



Figure 14:

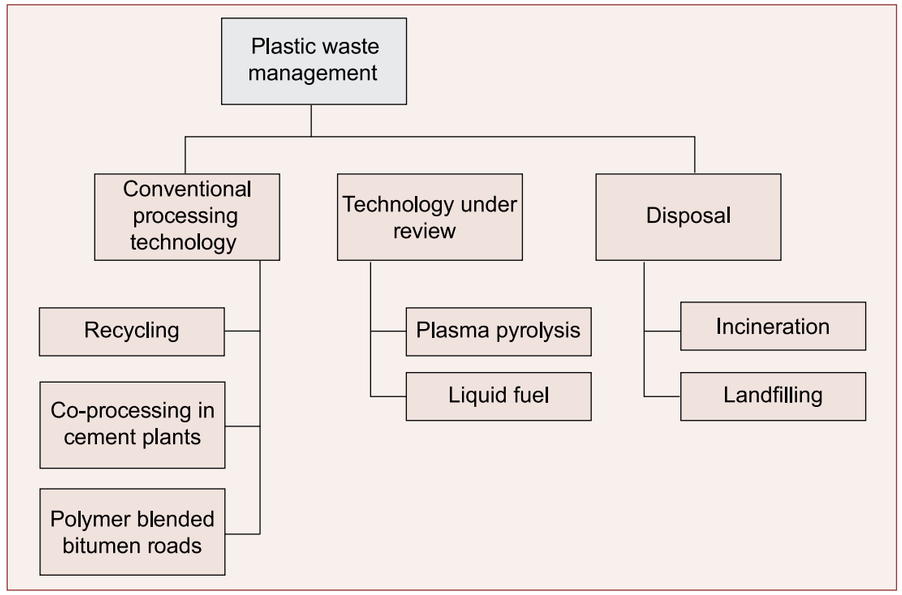
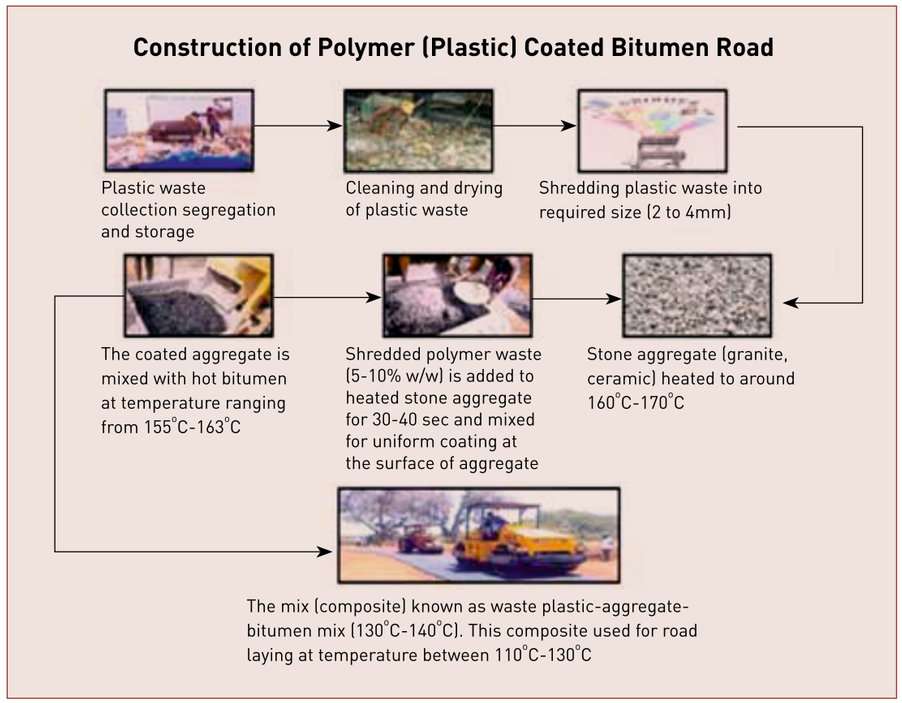


Figure 15:



Construction and Demolition Waste Management

With the growing importance of construction and demolition waste, the Government of India has deemed it appropriate to formulate a separate regulation for construction and demolition waste namely Construction and Demolition Waste Rules, 2016 describing the roles and responsibilities of the different stakeholders as well as the compliance criteria for the management of the construction and demolition waste. According to the rules, construction and demolition waste "means the waste comprising of building materials, debris and rubble resulting from construction, remodeling, repair and demolition of any civil structure. C&D waste includes bricks, tiles, stone, soil, rubble, plaster, drywall or gypsum board, wood, plumbing fixtures, non-hazardous insulating material, plastics, wall paper, glass, metal (e.g., steel, aluminum), asphalt, etc. However, C&D waste does not include any hazardous waste as defined under the Hazardous and Other Wastes (Management and Trans boundary Movement).

Schedule I of the construction and demolition waste management rules, specifies the management of construction and demolition waste. It details out guidance on storage, collection, transportation, processing, and disposal and also the use of the recycled products. Reuse, processing, and recycling have been emphasized. Large generators have to be incentivized for setting up in-situ processing facility. For large facilities, say for million plus cities, processing should be done through appropriate technology which minimizes process residues for landfilling, e.g., "wet" process, which can retrieve sand grade material (4.75 mm to 75 μ) from soil and other fine inert material. Schedule II provides for further use of processed C&D products inoperation of sanitary landfill. It must be clarified that while processed C&D waste shall be utilized in sanitary landfill for MSW of the city or region, residues from C&D waste processing or recycling industries shall be landfilled in the sanitary landfill for MSW.

Indicative List of Statutory Clearances or Acts and Non-statutory Approvals required by all Municipal Solid Waste Management Processing Treatment, and Disposal Facilities

Statutory Clearances

Environmental Clearances: Water (Prevention and Control of Pollution) Act, 1974; Water (Prevention and Control of Pollution) Cess Act, 1977; Air (Prevention and Control of Pollution) Act, 1981; Environment (Protection) Act, 1986, and Rules; Environmental Impact Assessment Notification, 2006

Clearance from the State Pollution Control Board

Clearance from the Airport Authority

Fertilizer Control Order Clearance for compost based plants

Land use from the Revenue Authority

State Electricity Authority Clearance for providing grid connectivity

Public Liability Insurance Act, 1991 and Rules, 1991

Industries (Development and Regulation) Act, 1951

Factories Act, 1948

Motor Vehicles Act, 1938, amended in 1988 and Rules,1989

Petroleum Act,1934

Energy Conservation Act,2001

Non-statutory Approvals

Proof of Possession of Site

Bank Loan Sanction Letter and Agreement

Bank Appraisal Note

Water Supply Agreement

Power Purchase Agreement

Municipal Solid Waste Supply Agreement with Municipal Authority

Sanitary Landfilling

In line with the Solid Waste Management (SWM) Rules, 2016, sanitary landfills minimize the harmful impact of solid waste on the environment through the use of the following mechanisms:

a) reduction of groundwater contamination through leachate collection and treatment;

b) control of surface water contamination through runoff;

c) reduction of air contamination due to gases, litter, dust, or bad odour;

d) control of other problems due to rodents, pests, fire, bird menace, slope failure, erosion, etc.

Waste categories suitable for sanitary landfills are the following:

i non-biodegradable and inert waste by nature or through pretreatment;

ii. commingled waste (mixed waste) not found suitable for waste processing;

iii. pre-processing and post-processing rejects from waste processing sites; and

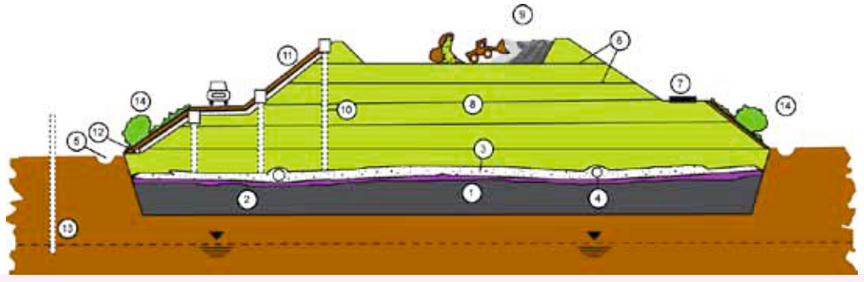
iv. non-hazardous waste not being processed or recycled.

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

(i) biodegradable waste or garden waste,

(ii) dry recyclables, and

(iii) hazardous waste or industrial waste (to be disposed in hazardous waste sites with special containment).



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

Fig 5: Sanitary Landfilling

Site Selection for Sanitary Landfilling



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

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

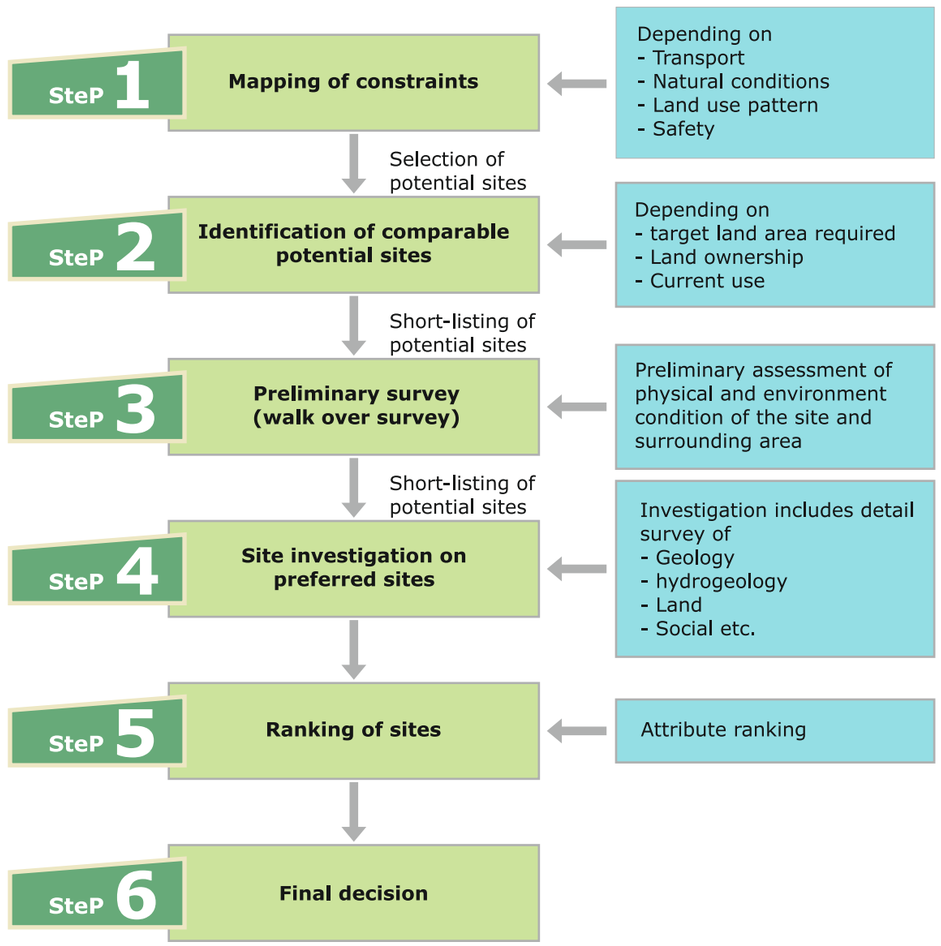


Figure 6: Site Selection criteria for Sanitary Landfilling

Legacy Waste Management

Recently, Hon'ble NGT raised concerns over incremental growth of Municipal Solid Waste (MSW), these MSW dumps are converting into virtual mountains. Hon'ble NGT further directed that every city/town should adhere to clause 'J' of Schedule–I of SWM Rules, 2016. Finally, Hon'ble NGT directed CPCB to propose Standard Operating Processing (SOP) for implementation of Bio-mining and Bio-remediation of legacy solid waste. Under upstream EPR, Producers, Importers and Brand Owners will have to Eco-Design their product packaging and design it considering its collection, recovery and end-of-life sustainable disposal to avoid formation of future legacy wastes.

As per the rules, local authorities and Panchayats shall investigate and analyse all old open dumpsites and existing operational dumpsites for their potential of bio-mining and bio-remediation and wheresoever feasible, take necessary actions to bio-mine or bio-remediate the sites; in absence of the potential of bio-mining and bio-remediation of dumpsite, it shall be scientifically capped as per landfill capping norms to prevent further damage to the environment.

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

(i) Reduction of waste by bio-mining and waste processing followed by placement of residues in new landfills or capping as in (ii) below.

(ii) Capping with solid waste cover or solid waste cover enhanced with geomembrane to enable collection and flaring / utilisation of greenhouse gases.

(iii) Capping as in (ii) above with additional measures (in alluvial and other coarse grained soils) such as cut-off walls and extraction wells for pumping and treating contaminated ground water.

(iv) Any other method suitable for reducing environmental impact to acceptable level

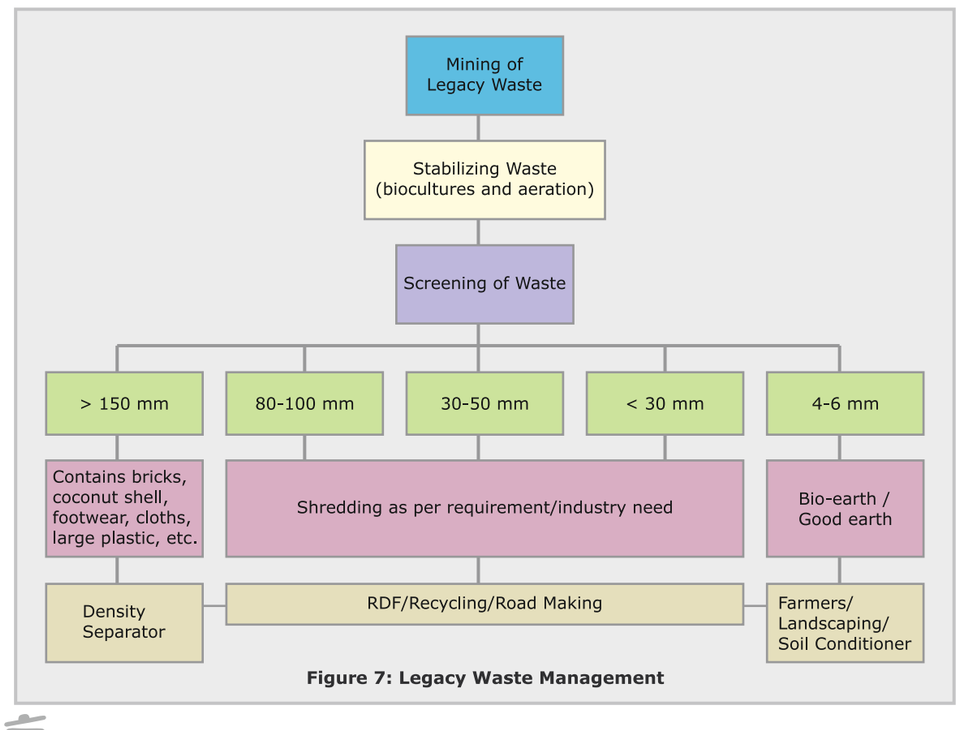


Figure 7: Legacy Waste Management

The dumping of mixed MSW begins in low-lying areas without any prior water proofing layers to protect groundwater or prevent landfill gas migration. Capping of unlined dumps is in fact dangerous as it makes the waste even more airless, generating more leachate and also more methane and landfill gas, which leaks out below the edges of the capping. This created a disaster at the Mindspace IT complex, constructed next to a capped landfill at Malad in Mumbai. The landfill gases entered the Mindspace basement where the central air-conditioning circulated it to every floor in the building, causing regular frequent failure of every type of electronic equipment. Capping should only be considered for the maximum 10% residual rejects after bio-mining (screening) of stabilized waste. The SWM Rules 2016 in Rule 15 permit it only where bio-mining and bio-remediation is not possible. Perhaps the only places where this is not possible are in steep inaccessible ravines and narrow valleys in mountainous regions. Thus, capping of dumpsites is not advisable. However, if any scientific landfill site for municipal waste is present which has been constructed as per the norms and guidelines of MoEF&CC and has been filled to its maximum level, possibility of capping can be explored.

Legacy Waste has several ill-effects like generation of greenhouse gases, pollution of the entire ecosystem around the dump site, posing risk of uncontrollable fire, etc. Thus, it is very critical to start working on clearing it today and ensuring that fresh waste is also handled accordingly. This will also improve the morale of the ULB and its residents.

It is the responsibility of ULB to ensure that remediation of dumpsite is done inhouse or by engaging a competent agency. ULB will have to pay an agency the expenditure for remediation of legacy waste as one cannot forecast the chance of recovering recyclables from the highly contaminated waste nor forecast revenue from selling of recyclables so as to financially sustain the entire model. However, a clause can be made by ULB during appointing agency that the revenue generated by selling any recoverable material shall be transferred back to ULB. This can make the executing agency a technology and manpower partner in the project, who is paid for a management cost. ULB can either go with the 5 models explained for bio-remediation and bio-mining of legacy waste, or make its own cost-effective, space effective and sustainable option, introduce new technology or install various other machinery/equipment based on the practical circumstances of legacy waste. Various types of waste will be recovered from legacy waste like dry waste, soil conditioner, hazardous waste, bio-medical waste, construction and debris waste, e-waste, etc. All these wastes should be disposed of as per the norms and guidelines issued by MoEF&CC under respective waste management and handling rules under the Environment (Protection) Act 1986.

Financial and Contracting mode for implementation of MSWM plan

The planning for an advanced MSWM system should be based on accurate financial calculations, taking into consideration all relevant costs including hidden costs and revenues. The financial implication should be inbuilt in the sild waste management plan of municipality. A full cost account is suggested to be considered for narrowing down to the total cost involvement in the implementation of the plan. The elements of the full cost accounting to be considered are

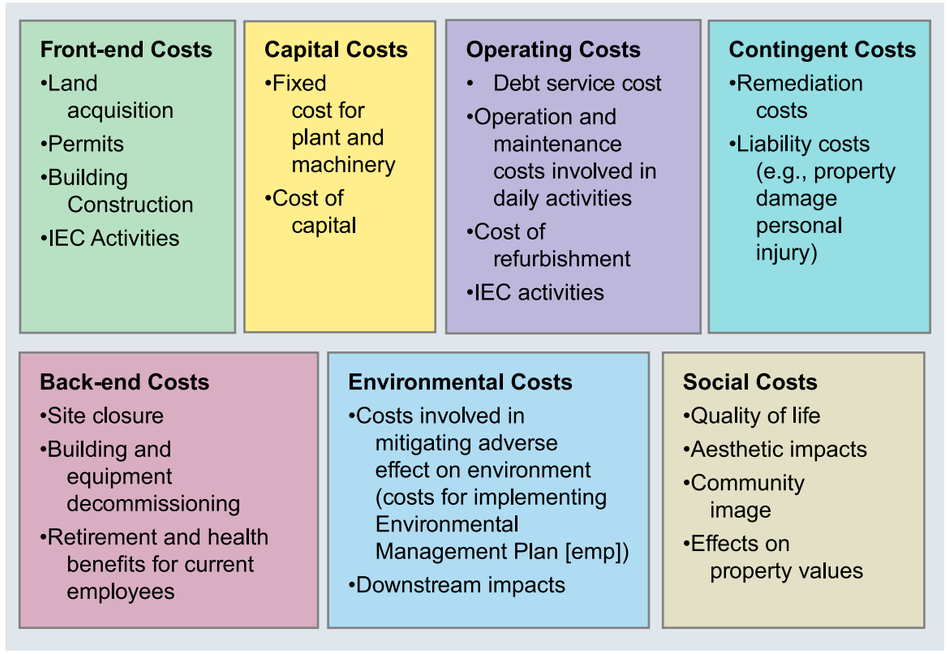


Figure 8: Elements of Full Cost Accounting

Identification of Sources for Finance

The extent of service provision by the ULBs is determined largely by the availability and allocation of finances to different services and functions. ULBs are empowered to derive their income from several sources such as taxes, fines, penalties, and remunerative enterprises. Apart from the above-mentioned sources, ULBs also depend on grants and loans to meet their financial needs. The traditional sources of financing MSWM activities include:

1. Local taxes, e.g., property tax, water tax, conservancy tax, development fee, etc.
2. User charges
3. Rents from properties, license fees, and other non-tax revenues
4. Grants from state and central government, e.g., Swachh Bharat Mission, state finance commission grants
5. loans from capital market, government, and financial institutions, e.g., Housing and Urban Development Corporation (HUDCO) and National Bank for Agriculture and Rural Development (NABARD)
6. loans from international agencies, e.g., Asian Development Bank (ADB), Japan Bank for International Cooperation (JBIC), German Development Bank (KfW) and the World Bank
7. Public private partnerships
8. Municipal bonds or debentures
9. revenue from sale of products from waste processing plants (if owned by the ULB)
10. tipping fees from the private operator

Depending on the nature of activities to be tendered out, one of severalmodels of contracting may be adopted. A transparent bidding process and performance benchmarks combined with stringent monitoring ensures the success of PPP projects. Not all contracting models are suitable for each of the SWM operations. Municipal authorities may adopt one or more of the following contracting models:

Table : Key Characteristics of Contracts in Municipal Solid Waste Sector

MSW MANAGEMENT & OPERATION	CHARACTERISTICS	RELEVANT CONTRACT MODELS	IMPLEMENTING ULB
Collection and Transportation	• Large and diverse workforce, vehicles and equipment • Intensive logistics • Citizen interface • Investment ranges widely depending on scope of work	Service contracts; Management contracts; Concession contracts	Bangalore, Surat, Chennai, Ahmedabad, etc.
Street sweeping	• Labour intensive • Minimal investment in tool and equipment • Limited technical skills • Logistics intensive	Service contracts	Delhi, Hyderabad, Chennai, Rajkot, Surat etc.
Transport	• Capital intensive • Fleet management skills	Concession contracts	Bangalore, Delhi, Chennai, Surat, Ahmedabad, etc.
Processing / disposal	• Capitalintensive • Technicallyskilledstafing required • Experienceoftechnology deployed	Concession contracts (Design Build Operate [DBO], Build Own Operate (BOO), Design Build Own Operate Transfer (DBOOT)	Surat, Pune, Delhi, Hyderabad, Coimbatore, etc.

- Draft National Public Private Partnership Policy, Government of India (2011).
- Subject to compliance with Contract Labour Regulation Act (CLRA) (1996).

Other Stakeholders involvement in SWM chain

Corporate / brands involvement under Extended Producer Responsibility

Extended producer responsibility (EPR) is a policy approach wherein a producer is held responsible for the post-consumer stage of a product, typically for defined tasks of separate collection (e.g., for e-waste or hazardous waste components), reuse (e.g., disposal-refund systems for bottles), recycling (e.g., for used cars), and storage and treatment (e.g.,forbatteries). EPR programs are commonly made mandatory through legislation, but can also be adopted voluntarily (i.e., retail take-backprograms). National and state level involvement is necessary to ensure that EPR initiatives are successfully implemented. However, ULBs should also encourage local level initiatives based on the principles of EPR.



A sample model of container deposit scheme to promote recycling

Integration of the Informal Sector

In India the informal sector, comprising of the kabadi system and waste pickers, plays a significant role in collection and processing of recyclable material. There is a significant thrust in various national and state level policies to recognise, identify, and integrate informal sector workers into formal waste management processes and initiatives. Creation of livelihoods, social acceptance, and security for informal sector workers and regularising the recycling sector are all benefits of integrating the informal sector. This may be done effectively by organising them into self-help groups (SHGs) or cooperatives, to capacitate them to work as entrepreneurs in a business entity. In the future, they may own small recycling facilities which are managed scientifically and hygienically.

Management Activities

Door-to-door collection

Sorting of recyclable waste

Collection and segregation of recyclable material

Manual sorting at the conveyor belt in a material recovery facility

Setup and management of recyclable or reusable waste take-back or buy-backfacilities supported by adequate and appropriate skill enhancement arranged for bythe urban local body (ULB) or other concerned departments

Waste sorters in processing facilities (e.g., at the sorting conveyor)

As per SWM Rules, 2016 ULBs are directed to:

- Establish a system to recognise organisations of waste pickers or informal waste collectors and promote and establish a system for integration of these authorised waste-pickers and waste collectors to facilitate their participation in solid waste management including door to door collection ofwaste;
- Facilitate formation of Self Help Groups, provide identity cards and thereafter encourage integration in solid waste management including door to door collection of waste;
- Setup material recovery facilities or secondary storage facilities with sufficient space for sorting of recyclable materials to enable informal or authorised waste pickers and waste collectors to separate recyclables from the waste and provide easy access to waste pickers and recyclers for collection of segregated recyclable waste such as paper, plastic, metal, glass, textile from the source of generation or from material recovery facilities.

Monitoring and Evaluation of the MSWM Plan

Depending on the existing plans for the urban area and the size of the area that the MSWM plan is prepared for, it is desirable to review the plan once every 2–3 years, with the objective of continuous improvement towards meeting service delivery standards.The service level benchmarking (SLB) indicators stipulated by the Ministry of Urban Development(MoUD) are shown in following table:

Table 4: Service Level Benchmarks for Solid Waste Management

PERFORMANCE INDICATORS	UNIT	DEFINITION	MINIMUM FREQUENCY OF PERFORMANCE MEASUREMENT AND REPORTING	SMALLEST GEOGRAPHICAL AREA FOR MEASUREMENT
Extent of segregation of municipal solid waste	100%	Percentage of households and other establishments that segregate their garbage into wet and dry waste at the source.	Monitoring of performance – daily Reporting and Evaluation– monthly	Ward level
Extent of municipal solid waste recovery	80%	Percentage of municipal waste recovered or processed by the ULBs, households and informal sector	Monitoring of performance – daily Reporting and Evaluation: monthly	Ward level
Extent of scientific disposal of municipal solid waste	100%	Percentage of waste disposed at the landfill, which is designed, operated and maintained as per set standards	Monitoring of performance – daily Reporting and Evaluation – monthly	ULB level

Efficiency in redressal of customer complaints	80%	Percentage of complaints related to municipal waste management redressed within a given time period	Monitoring of performance – daily Reporting and Evaluation – monthly	Zone or ULB level
Extent of cost recovery in SWM services	100%	This indicator denotes the extent to which the ULB is able to recover all operating expenses relating to SWM services from operating revenues of sources related exclusively to SWM.	Monitoring of performance – quarterly Reporting and Evaluation – annually	ULB level
Efficiency in collection of SWM charges	90%	It is defined as current year revenues collected, expressed as a percentage of the total operating revenues, for the corresponding time period.	Monitoring of performance – quarterly Reporting and Evaluation – annually	ULB level

Training and Capacity Building

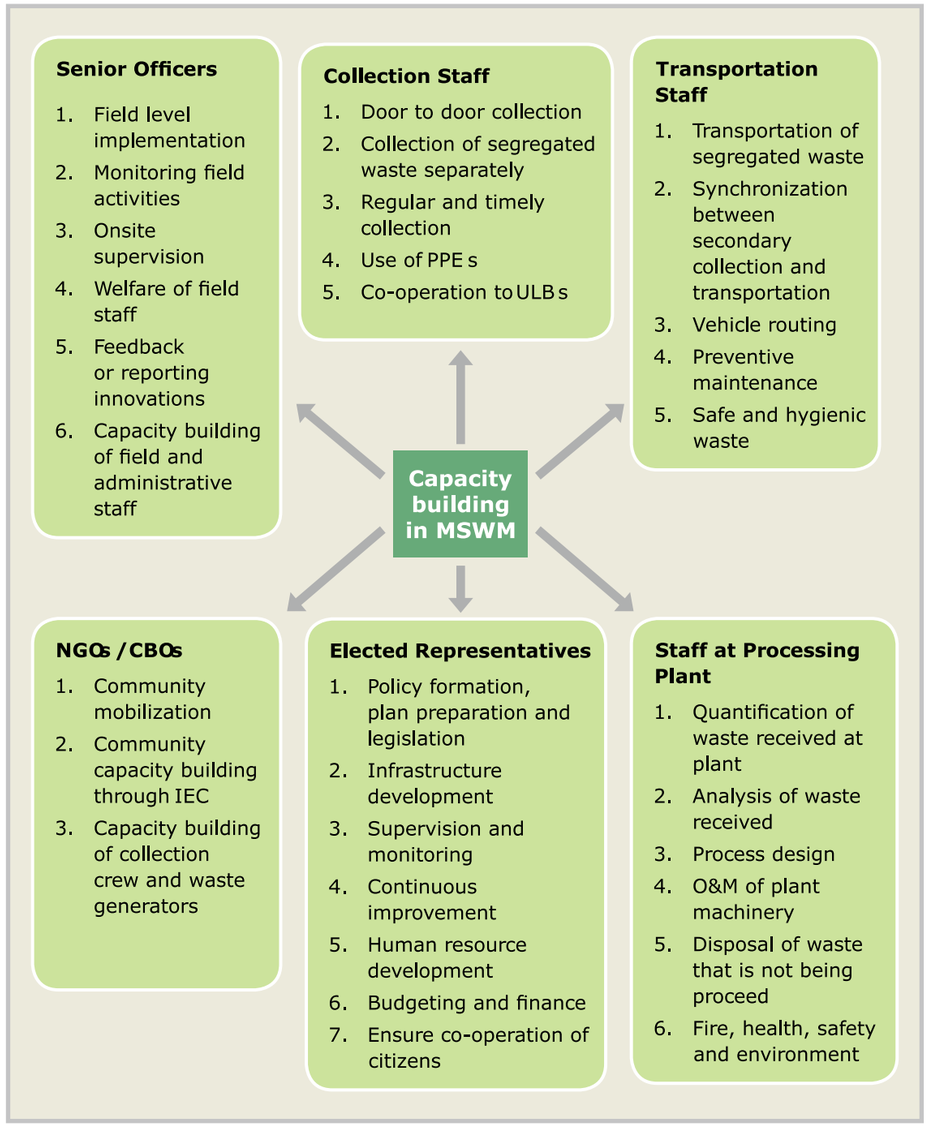


There is an urgent need to train and enhance the capacities of staff in MSWM activities. Professionalising the MSW sector will not only build the capacities of workers to perform more effectively and efficiently in the existing conditions but will also inculcate a sense of responsibility and pride towards their profession. Provision of hygienic and safe working conditions for workers and encouraging the use of personal protective equipment (PPE) should also be part of this effort. The positive impact of such actions on the well-being of all workers (specifically the women) is far-reaching. These efforts will also lead to an improvement in service delivery and hence better management of activities.



It is important that the approach to capacity building in MSWM should not only focus on technology but also on different aspects including governance, financing, planning, and improved service delivery. The various capacity building approaches that can be adopted for different stakeholders based on the ULB's requirement

Figure 9: Capacity Building Approaches for Different Stakeholders [13]



Special training: The following should also be trained:

(i) unqualified staff and sanitation workers

(ii) ground level staff like sanitary supervisors(or equivalent)

(iii) sanitary inspectors, junior engineers, senior officers and All staff should have enough know how of the solid waste management sector including instructing the sanitation workers. Best practices adopted by different cities in the state, country, and internationally should be made known to senior staff.

Refresher courses for supervisory staff: Refresher courses should be conducted to officers and supervisor staff once in every 5 years.

Study visits: Learning by seeing can be enhanced by visiting institutions where good practices are already established.

Professional growth opportunities : Adequate professional growth opportunities should be built into the MSWM hierarchy to encourage supervisory staff members to remain in the department and hence avoid attrition.

Case Studies

1 Gorai Dumping Ground, Mumbai : Scientific Landfill Closure and Methane Capture

Background: Closure and scientific capping of garbage dumpsite is essential for containing its pollution potential. Usually, old dumpsites are left withoutany remedial steps and allowed to degenerate over the years in terms of leachatepercolating down to groundwater, vector breeding, and air pollution. Some dumpsites have been covered with thin layer of soil and vegetation to beautify the area. However, generation of leachate continues. With ingress of rainwater, more leachate is formed. This goes on for years until the material in the landfill is stabilized, which may be 20–50years in warm climates.

The first known example of scientific capping of a garbage dumpsite in India happened in Mumbai at Gorai dumpsite. This is a specific example where an ongoing dumpsite was systematically closed and then capped. Normally, this procedure would be well suited for already closed dumpsite where dumping of fresh garbage has been stopped. Operational since 1972, Gorai dumpsite is in the western suburbs of Mumbai. The 19.6-hectare site is adjacent to Gorai creek and is very close to habitation. Approximately 2.34 million tons of waste up to an average height of 26 m was lying at the site, causing significant environmental damage to the creek and the neighborhood. The capacity of the dump was already exhausted. The creek waters had been polluted due to inflow of leachate, and the air quality had deteriorated from the frequent burning of garbage. The Municipal Corporation of Greater Mumbai (MCGM) took up this challenge and, with technical assistance of Infrastructure Leasing & Financial Services Ltd (IL&FS) (Environment Division), worked out a scientific plan for controlled closure and scientific capping based on detailed survey and consultation



Design Strategy and Action Plan

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

The scientific closure plan included the following components:

(I) fresh dumping stopped and relocation and slope reformation (1:3) of existing waste;

(ii) laying of construction and demolition (C&D) waste and compaction;

(iii) laying of liner system consisting of:

- (a) top vegetation layer;
- (b) 300 mm thick top soil layer;
- (c) geocomposite layer;
- (d) 1.5 mm geomembrane layer;
- (e) 200 g/m2 and 400 g/m2 geotextile; and
- (f) 300 mm thick drainage layer;

(iv) installation of landfill gas collection, venting, and flaring system;

(v) installation of LCS using perforated pipes along the periphery of the fill, followed by storage in a leachate tank and transportation to the nearest sewage treatment plant (STP);

(vi) sheet piling on the seaward side to prevent leachate from entering the creek;

(vii) surface water drainage for channeling storm water;

(viii) construction of bunds, access roads, and compound wall on the landward side of site;

(ix) landscaping and greenery, irrigation, and lighting of the area; and

(x) post-closure care for 15 years with close monitoring of the indicative parameters like leachate, watering and maintaining the greenery, checking leakage of landfill gas, checking subsidence of the cover layer, etc.

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

Outcome

The following are the outcomes of the project:

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

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

2 Jabalpur : Integration of Technology in Collection and Transportation

Solid waste management in Jabalpur come sunder the purview of the Jabalpur Municipal Corporation (JMC) which is responsible for providing municipal and civic services, which includes collection, segregation, transportation, treatment and disposal of solid waste generated in the city. Jabalpur today generates approximately 670 MT per day of garbage a day and all of it is collected from the source whether it is a household or commercial establishment. The total wet waste generation is approximately 410 MT per day and the dry waste generation is 260 MT per day. Jabalpur ensures 100% coverage of wards through its door to door collection system. JMC claims that 100% segregation at source is being practiced in the city (Source: Smart cities data, MOHUA website).

Most of the waste is sent to the waste to energy plant set up in the city, rest of the waste goes to the two landfill sites that the city presently has at Ranital and Kathonda. Jabalpur has setup a waste to energy plant at Kathonda for disposal of the solid waste collected from the 79 wards of Jabalpur Municipal Corporation. Essel Infra projects Ltd. has set up a 600 TPD processing plant for converting solid waste to energy at Jabalpur on BOT basis with concession for 20 years for electricity generation of 11.5 MW as of May 2016. The noteworthy initiative taken by the city is discussed as below:



JMC needed a way for refining the solid waste management services in Jabalpur city. For meeting this objective, JMC established a collection and transportation system in the year 2016 through private sector participation. To manage, maintain and monitor the door to door collection of waste and holistic view of waste from source to end was one of the major challenges faced by the city. The city required a system which can track, help to locate and monitor the door to door collection with RFID tags, semi underground bin management with BLS and the jobs carried out by the department such as Vehicle Tracking and Monitoring System (VTMS) using GPS and dashboards was an important requirement. In Jabalpur, about 670MT of solid waste is generated from both household and commercial sources. The waste generation rate in the municipality is expected to increase by 15% by the year 2020. The total number of vehicles available in the city are 240 tippers, 20 hopper trucks, 14 waste compactors, 4 cranes mounted waste transfer vehicles and 6 static compacters.

The collection and transportation of the waste in Jabalpur is undertaken through the following steps:

STEP 1 RFID tags for door-to door and community bins, to improve the customer experience

STEP 2 Bin Level Sensors(BLS) to increase the productivity

STEP 3 Weight collected waste at W2E plant to reduce the maintenance cost

STEP 4 Integration for VTMS, Weight

monitoring and GIS After the implementation of daily door to door garbage collection system in the morning hours, it has now become the practice of every citizen to store the household waste temporarily in dustbin till the door to door garbage collection vehicle arrives. This has made a good improvement in the overall scenario. A sense of good hygiene and awareness towards environment are visible. Door to door collection is adopted in the entire city, which has resulted in efficient collection of waste, reduction of littering, foul odour and unaesthetic appearance of bins. The innovative characteristics of the project:

Tech Mahindra has been given the responsibility to integrate the information technology for improving the collection and transportation in the city at an estimated cost of Rs. 6.94 crore. This has also helped in the monitoring of the system and rectifies the processes to reduce the operational cost. GPS has been deployed on vehicles that are involved in collection and transportation of waste and the realtime movement is monitored through a centralized control rooms. Such GPS enabled mapping tracks the vehicular movement as per the designated hours of operation. Furthermore, these GPS systems enable the identification of vehicles that have broken down during operations and hence enable the routing of stand-by vehicles or closest collection vehicles. RFID readers are installed at every household which gives information as to whether solid waste has been collected on time or not. 250 RFID readers have been deployed at various locations in the city. The monitoring system is being used in conjunction with Vehicle Tracking and Monitoring System (VTMS) solutions; this has resulted in ensuring complete coverage of door-to-door and community collection, management of refuse picking routes for SWM and monitoring and tracking the refuse weight by there fuse vehicle along the route; integration of refuse transfer station facilities with the centralized monitoring facility etc.

Recommendation

While the door to door collection and transportation system in the city is using RFID, BLS, etc. giving an impression of cleanliness in the city, but burning of mixed waste using waste incineration technology is against the SWM Rules 2016 compliance expectations. The SWM Rules 2016 clearly states that the wet waste should be segregated at source and composted, recyclables should be recycled and only no compostable, non-recyclable waste should be made into RDF and taken to RDF based incineration plants or cement kilns. The city needs to improve its waste management and treatment facilities.

3 Aurangabad: Mazhi City Taka Tak Campaign

Aurangabad Municipal Corporation (AMC) is divided into 9 zones each given around 9 to 13 wards. It currently generates about 400 Metric ton (MT) of municipal solid waste from about 0.25 to 0.3 million housing units. There is 100% door to door collection of waste in the city. Waste is collected three times a day. Around about 145 vehicles that includes tippers, trucks, tractors, JCB and loaders are used for the waste collection transportation and handling of solid waste. Around 1545 sanitary workers and 48 supervising members are engagedin solid waste management of the city. Waste is being segregated post collection near CentralNaka area of Aurangabad city. Overall 10% of disposed waste is being recycled currently and theremaining is being disposed of at the dumpsite at Naregaon. The AMC along with Civic ResponseTeam (CRT) is playing an import role of reducing the amount of waste going to landfill by applyingwaste segregation at various wards. AMC has been working on various latest methods to reducewaste reduction at source level which include encouragement by public awareness campaign andpenalties on citizens for unmindfully spreading solid waste."Mazhi City Taka Tak" Campaign. The AMC initiated the Mazhi City Taka Tak (MCTT) campaign, with residents, NGOs, corporatesectors and elected representatives thereby joining hands with the civic bodies focusing on a long-term policy on garbage collection system. The MCTT was launched on January 2016by the civic body in collaboration with Bajaj Private Limited, Confederation of IndianIndustry (CII) and Civic Response Team (CRT). 12 wards in 6 zones of Aurangabad were selected for this campaign.



Volunteers of the "Mazhi City Taka Tak" Campaign

The Civic Response Team (CRT) designed and conducted a comprehensive capacity building program on Solid Waste Management (SWM) for the Sanitation Department of Aurangabad Municipal Corporation (AMC). A total 18 wards, 2 from each zone, were selected based on the deliberation with the team. While selecting the wards equal importance was given to the amount of work carried out in that ward and the results obtained. Survey was conducted for households, Sanitary Inspectors, Jawans and Safai Karmacharis from each of these wards. Training not only covered the technical knowledge but also focused on the soft skills such as team work and effective communication.

Awareness programs were organized for the residents, to inform them regarding the new system and the segregation process. In the course of the campaign, AMC propagated the practice of door-to-door collection of segregated wet, dry and biomedical waste. Around 5580 gunny bags and over 10,000 Personal Protective Equipment (PPE) were distributed to the Safai Karmacharis to facilitate segregated collection. Efforts were made to compost and generate biogas out of the wet waste and recycle the dry waste. Instead of limiting the efforts to training residents on source segregation, residentsare encouraged to become active participants by monitoring the work in their areas, participating in/ organizing awareness drives/ events etc. The main forms of resident awareness and involvement included the following:

- Rallies with school children
- Events to reclaim old dumping points
- Awareness programs with "Mahila Mandals", society members, youth groups etc.
- Events led by local corporators to generate awareness
- Caller tunes with information regarding waste segregation
- Engagement of local artists and performers
- Presentation on home composting/ biogas by experts
- Events for appreciation of sanitation staff
- Print, audio and visual media.
- Development of audio materials to play on primary collection vehicles

AMC has also banned the use of plastic bags under 50 microns and started a cloth bag campaign where bags made of recycled cloth are being encouraged. The campaign has helped to get rid of over 740 dumping points from around 34wards, catering to over 70,000 households. In a bid to avoid more burden on Naregaon dumping ward, the citizens cooperated with the civic body in the Voluntary Garbage Disposal Scheme (VGDS). Efforts were made to stop littering on streets and burning of dry leaves. This has enabled the civic body in curbing transportation expenses to the dumpsite and saving Rs. 1.5 crore per month. Currently, 89.7% citizen store their household waste in segregated manner.

Recommendation

The IEC activity carried out has created a positive response about the management of solid waste in the city. The civic bodies along with the NGOs should try to replicate it in a phased-out manner at different wards to achieve Zero Waste Status.

4 Guwahati: Non-Recyclable Multilayered Plastic Waste Recycling

The solid waste management of Guwahati comes under the purview of Health and Sanitation Department of the municipal corporation. There is 100% doorto door collection in the city. The Guwahati Municipal Corporation (GMC)is divided into 31 wards and there is one NGO each assigned for the job of Primary Collection and Street Sweeping within the respective ward and for depositingthe waste so collected at the nearby secondary collection bin/s. The work of Primary Collection is being monitored by the Sanitary Supervisors of the ward. The NGOs are also mandated with the collection of monthly User Charges from the households and commercial establishments. The NGOs have a total manpower of 450 workers whooperate a total of 480 Tricycles and 64 Auto Tippers all around the city. The Secondary Collection and Transportation (C&T) is being handled by a fleet of modern compactors and tippers by GMC. This is looked after by Zonal engineers and Supervisors assisted by a fleet of hand carters and sweepers. There are two functional Transfer Stationsin Guwahati at RGB Road near Nursery, Ganeshguri and Bhangagarh. Approximately, 85-90 % waste is being transported daily to Boragaon landfill site which is spread over 48 acres of land.

Integrated Compost Plant

The Windrow composting plant has all required machinery to produce compost with the capacity of 200 MT per day. Presently this plant is not functional as the required segregated efficiently and produces low quality compost contaminated with plastics and heavy metals. The cost incurred for developing the facility was around Rs 5 crore.



Decentralized Waste Management at IAS Colony,Khanapara

The IAS Colony has recently taken up an initiative of zero waste campus with Environ a local NGO from Guwahati. The IAS colony has 60households and produces 70 kg of wet waste per day. The waste is segregated int he colony and is being used to make compost. part from this dry organic waste consisting of dried leaves, flowers and twigs are also used in the composting pile which is collected from the lawns and gardens of the campus. The project was setup with an aim of promoting community-based composting in Guwahati. The compost and leachate obtained is being used in the horticulture purposes within the premises itself.

After the success of the project similar initiatives have been started in different colonies of Guwahati to manage waste at source. Non-Recyclable Multilayered Plastic Waste Recycling Guwahati generates 37 MT of plastic waste every day- about 12.37 percent of the entire state's production. Taking the seriousness of the situation, three engineers Rupam Choudhury, David Pratim Gogoi, Mousum Talukdar from Assam Engineering College have setup Zerund Bricks Manufacturing Pvt. Ltd. at an initial capital expenditure of Rs 50 lakhs. The enterprise makes patented Plastic Embedded Light Weight Brick using the multilayered plastic waste derived from plastic carry bags, biscuits & chips packs and different wrappers from chocolate which create a lot of environmental problems. The enterprise helps in managing 600 kg per day of plastic waste by utilizing them to create the bricks.

As the brick is light-weight, total dead load of the structure reduces up to 40% in comparison to the red clay bricks, hence the cost of the whole structure decreases. The brick has been developed in larger size. The larger size reduces the total number of mortar joints in the walls which leads to the less consumption of cement and sand in the joints and hence cost of infrastructure development decreases.

Plastic Bottle recycling by “Green Recycling Industry”

“Green Recycling Industry” at Bongshar, Kamrup is the only Plastic Bottle recycling unit of Assam where 3MT waste Polyethylene terephthalate (PET) bottles are recycled for producing 'Hot Washed PET Flakes'. Mr. Ranendra Baishya is the proprietor of the unit. The Flakes and PET powders acts as the ingredient of different polyester garments and second grade PET bottles.

The waste plastic bottles are collected by the waste collectors and compressed into bales. The bales are then dispatched to the plant. After reaching the plant, sorting process is done and pet bottles are separated from other materials. It is recycled into a new form which is named as PET flakes. Later these flakes are transported to different facilities where it is transformed into different finished products.

Recommendation

Guwahati has been able to achieve 100% door to door collection through convergence with local NGO, the next step for the city should be towards source segregation and treatment of different waste streams in a scientific manner. The municipal corporation should try to revive the ISWM plant and promote household and community-based initiatives.

5 Ambikapur: A Swachh city

Ambikapur is a small city in Sarjuga district with a population of 1.12 lakhs.The city waste was dumped on the 16 acres dumping yard located 3.5 kmaway from the city. The launch of the Swachh Bharat Mission encouragedthe Ambikapur Municipal Corporation (AMC) to find ways to deal with itswaste. To tackle the daunting situation and manage the waste in an effective manner,the Solid and Liquid Resource Management (SLRM) project was started under theguidance of the district collector. This was assisted by C. Srinivasan of India Green Service, Vellore that paved the way for "Swachh Ambikapur" project. It is based on community-based model that employs women from Self Help Groups (SHGs) and creates livelihood opportunities. The primary objective was to put in place a systemfor door-to-door collection of solid waste from homes and commercial establishments in Ambikapur, and to practice scientific disposal of the waste. The efforts have shown positive results, the 16 acre-open dumpsite is now a sanitation awareness park, while the administration has removed the community dustbins that were once overflowing and Ambikapur has become a bin free city. The Ambikapur SLRM model shows that with proper management, we can protect our environment, improve livelihood opportunities for the deprived and live in a clean and healthy environment.



Stages of Project

1. Preparatory Stage: Leading citizens, businessmen, women groups, civic administration officials and others were called to attend a meeting of stakeholders. Mr. C. Srinivasan, of Indian Green Service, Vellore was engaged as a resource person to conceptualize the project, provide technical guidance and guide implementation.
2. Community Based Structure and Training: Six Hundred women were recruited for orientation and training related to segregation (organic/inorganic) at source and secondary segregation in the work-shed (SLRM Centre). The women were also trained in soft skills: the dynamics of working in a group as a team member, the importance of using mask, gloves, gum-boots and other safety gear, the importance of punctuality, the manner of dealing with hostile homes, personal hygiene.
3. Infrastructure: The SLRM Centre is the hub of the entire project. It is an industrial work-shed (approx. 1,500 sq. ft.) with an RCC structure and cement floor, built on an open area of land (approx. 3,000 – 5,000 sq. ft.), fenced on all sides, with a broad gate on the front side.
4. Information, Education and Communication (IEC): People from every household and commercial establishment were asked (in batches) to come to the designated spot at a designated hour to collect the red and green bins meant for segregation at source. Recognizing that children can be opinion-leaders at home, over twelve thousand and five hundred school kids were sensitized regarding the project and enlisted as volunteers to promote the initiative.
5. Monitoring: Special software was designed in-house and a desk was set up at the District Data Centre. CCTV cameras have been installed in every SLRM Centre. All seventeen Centres are visually monitored from a Central Data Centre.

Collection, Segregation and Transportation

AMC has taken the whole process of collection on a dashboard system online. It makes the monitoring of the whole activity easy and also makes the workers accountable for their attendance and performance. The door to door collection of waste is done by 447 women from Self Help Groups (SHGs) who are divided into 137 teams. For efficient collection of waste, the city is divided into 225 routes. The waste is collected in uniformly designed e-rickshaws with two separate compartments for wet and dry waste. The rickshaws have a special bell with a distinct ring that serves as a signal for people to dispose of their waste. The rickshaws are equipped with GPS trackers and all the sanitation workers have been provided with cell phones. This helps the workers to keep a track on the daily collection of garbage and also provides information regarding residents who fail to abide by the waste management code of conduct.

Solid and Liquid Resource Management

After the collection, the waste is brought to the 17 SLRM centres in the city. The centres are designed to ensure uniformity. It is an industrial work-shed (approx. 1,500 sq. ft.) with an RCC structure and cement floor, built on an open area of land (approx. 3,000 – 5,000 sq. ft.), fenced on all sides, with a broad gate on the front side. Each SLRM Centre is designed to ensure abundant light and ventilation, has a storeroom and a change room. The Centres have tap water connections and adequate number of tubs, forks, tarpaulin spread sheet and other accessories. The entrance gate is wide enough to allow easy entry to the vehicles that bring in the collected waste. Once the waste is brought to the SLRM centre, the organic waste is divided into seventeen categories and the inorganic waste in divided into twenty categories.

The food waste collected from the household is fed to cattle, ducks and hens at the centre. The other organic leftovers are used in bio digester to make biogas and slurry composted.Arranging for parcels of land within the city was a challenge. To overcome this, unauthorized occupation on government land were mapped and the occupiers were either evicted or rehabilitated elsewhere. Altogether, 6,986.63 sq. m of land valued at Rs 25 crore was freed by December 2015.

Tertiary Segregation Centre

From the SLRM centre the recyclable waste is taken to the tertiary centre located at erstwhile dumpsite, where it is further classified into 156 categories. The various resources recovered by the Tertiary Segregation Centre are deposited in a makeshift known as Treasury. Periodically when the resource grows into a substantial volume, it is sold through a transparent process.According to the data from the district

data centre, 127 MT of organic waste and 113MT of inorganic waste have been collected till date. The waste generated by the cityhas a resale value. For managing operations and maintenance of the project, a usercharge of Rs 50 is collected from houses, Rs 100 from shops, Rs 500 from hotels andRs 1000 from hostels and ashrams. The total income from the user charges rangesfrom Rs 12-15 lakh per month.

According to the November 2017 SLRM report, the municipal corporation had collected Rs 150.38 lakh as user charges, Rs 3 lakh from the sale of city compost and Rs 67.03 lakh from the sale of recyclable items between May 2015 and November 2017. In 2012, the annual expenditure of AMC for solid waste management was Rs 1.23 crores, and in 2017, after the implementation of SLRM project, it has reduced to Rs 37 lakhs. The SHGs are federated into a registered Society called "Swachh Ambikapur Mission Sahakari Samiti Maryadit". Ambikapur Municipal Corporation has an agreement with this Society. Each worker earns around Rs 5,000 per month. To encourage SLRM, the corporators of the wards have contributed Rs 1 lakh each for the proper operation and maintenance of the project. In addition to this, the 16-acre dumpsite has been remedied and converted into a sanitation awareness park.

Horticulture Waste Processing at Pushpvatika Sargawan

The horticulture waste processing facility at Pushpvatika Sargawan, Ambikapur was established in the year 2017. The facility receives wet waste and horticulture waste from the households and the parks of the city, which amounts to 150 kg on an average. Vermicomposting is employed to process the waste where each bed measures 3ft by 8ft.The composting facility has engaged2 staff members for supervision andmaintenance of the facility the capital costof the facility is approximately Rs.10,000/- and the operation and maintenance costof the facility is Rs. 2,000/- per month.

Key Highlights

- The sustained efforts have made Ambikapur a bin-free city devoid of dumpsites and landfills.
- 100% user charges collected from households and commercial establishments.
- AMC has also successfully reduced its cost of land acquisition by reclaiming encroached land worth Rs 25 Crore
- As a result of segregation at source, the corporation has earned Rs. 84.81 Lakhs from sale of recycled waste
- The SLRM model has also generated 623 green jobs without putting a financial burden on the state treasury.
- SHG members now have two sources of income, payment from AMC and thesale of recyclables
- As a result of decentralizing the waste management process, the transportationcost has gone down to Rs. 2.1 Lakhs (Oct 2017) from Rs. 7.32 Lakhs (June 2015)

Recommendation

As the households in the city follow source segregation, the next step for AMC should be towards promoting home composting or community composting. This would be helpful in reducing the transportation cost for municipal body for handling solid waste

Bibliography

Solid Waste Management Rules, 2016

Plastic Waste Management Rules, 2016 as amended 2018

Construction and Demolition Waste Management Rules, 2016, All India Institute of Local Self Government (2012).

Reference Material on Municipal Solid Waste Management for Urban Local Bodies – Processing Options. Part II. Mumbai: India.

Anthena Infonomics (2012). Public Private Partnership in Municipal Solid Waste Management- Potential and Strategies. India.

Central Pollution Control Board (2013). An Overview on Plastic Waste Management. New Delhi.

Central Pollution Control Board (2012). Status Report on Municipal Solid Waste Management. New Delhi.

Central Pollution Control Board (2003). Guidelines for the Selection of Site for Landfilling. New Delhi.

Ghosh, S., Ghosh, S. & Aich, A. (2011), Rebuilding C&D Waste Recycling Efforts in India. Waste Management World. New Delhi.

Mazumdar, N.B. (2007). Composting Municipal Solid Waste: The IndianScenario. International Journal of Environmental Technology andManagement, 7(3/4): 326-350.

Ministry of Urban Development (2016). Manual on Municipal Solid Waste Management. Central Public Health & Environment Engineering Organization: Government of India. New Delhi.

NIUA (2019) "SOLID WASTE MANAGEMENT INITIATIVES IN URBAN INDIA: A COMPENDIUM" Delhi, India

Assessment of Solid Waste Management for Aurangabad City- Challenges and Solution, International Journal of Innovative Research in Science, Engineering and Technology, Vol. 8, Issue 3, March 2019

Guidelines for Disposal of Legacy Waste (Old Municipal Solid Waste) CPCB, Feb 2019

IPCC Third Assessment Report, 2001

http://www.civicresponseteam.com/images/CRT_Newsletter_jan'16.pdf

http://plasticnews.aipma.net/pn/jun2016/mobile/index.html#p=63

http://www.civicresponseteam.com/BMCSC_Overview_IA.pdf

http://environ.org.in/abstracts-on-solid-waste-management/
http://www.zerund.com/about.html
https://gmc.assam.gov.in/frontimpotentdata/ngos-in-waste-management
http://www.uncrd.or.jp/content/documents/6501PS-1-P4.pdf
https://www.capam.org/knowledge/articles/2017/swachh_ambikapur.html
https://www.indiawaterportal.org/articles/waste-away-ambikapur-shows-way
https://www.youtube.com/watch?v=nq12b02Cq0g
https://www.youtube.com/watch?v=Nr3OjamdCSg
https://www.youtube.com/watch?v=WEMSuqpqkro