MODEL FRAMEWORK FOR SEGREGATION

Guidelines for managing municipal solid waste through segregation, reuse and recycling

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Preface

Municipal solid waste (MSW) continues to be a severe problem in India due to poor management. From collection of waste to its disposal, cities are struggling to implement an affordable and sustainable model of management. On top of this, the amount of waste generated is increasing every day. Urban India alone generates a colossal 1.5 lakh metric tonne of MSW daily. Given that urban population is growing at an annual rate of 3–3.5 per cent, the yearly increase in the overall quantity of solid waste comes to about 5 per cent.

It is well understood that segregation at source lies at the heart of good waste management. Segregation improves collection and processing efficiency. But ensuring segregation at source requires better infrastructure and strict compliance systems. Municipalities will need to put in place processes ensuring segregated waste is transported and processed properly. They will also have to come out with bye-laws that support segregation.

Centre for Science and Environment (CSE) has been working with cities to document, promote and implement source-segregation model of waste management. We have understood that cities need to develop models which are primarily based on maximum waste recycling and reuse and are least dependent on landfills. This *Model Framework for Segregation* has been developed based on our work and learnings in Muzaffarpur, Bihar to implement a decentralized solid waste management model in the city based on segregation at source.

The model framework highlights the importance of a three-way segregation system with cent per cent collection and transportation of segregated waste. The model encourages the adoption of decentralized waste management—composting or biomethanization of wet waste, recycling of dry waste, co-processing of non-recyclable waste with high calorific value and ensuring that only 5–10 per cent of the residual inert waste is sent to engineered landfills.

What we wish to achieve through this model is to work towards making solid waste management financially self-sufficient and work towards zero landfill cities. The model framework can be directly adopted by other cities in the country with a relatively flat topography having a population between 0.1–0.5 million. However, for hilly areas, some aspects of this framework will have to be tweaked to meet the local needs.

We recognize that there is still a lot that needs to go into adopting sustainable waste management regimes in our cities and we shall continue to provide updates on the topic in our future studies.

Chandra Bhushan

1. The model

In the last two years, a paradigm shift has taken place in the approach to municipal solid waste (MSW) management in the country. The previous approach was built around efforts to collect and transport 100 per cent of unsegregated waste and the need for sanitary landfills to dispose off that waste. Segregation of waste at source and processing of segregated waste was considered impractical. MSW management in cities was judged on the basis of the presence or absence of sanitary landfill sites. In fact, the main compliance condition for a local body under the Municipal Solid Wastes (Management & Handling) Rules, 2000 was the construction of sanitary landfill sites.

The Solid Waste Management (SWM) Rules of 2016, however, direct that landfills should only be used for 'non-usable, non-recyclable, non-biodegradable, non-combustible and non-reactive inert waste, and pre-processing rejects and residues from waste processing facilities'. The Rules further state that 'every effort shall be made to recycle or reuse the rejects to achieve the desired objective of zero waste going to [a] landfill.' This is an important departure. But how will these Rules be enforced?

Segregation at source to manage solid waste has become an accepted paradigm in the last two years. Reports like *Not in My Backyard: Solid Waste Management in Indian Cities* have played an important role in pushing forward the idea of decentralized solid waste management based on segregation at source. Government of India has launched a campaign on segregation. But what is an effective model of segregation and how can it be operationalized?

CSE is working closely with many cities and documenting the 'segregation model' of solid waste management. It is directly providing support to the Muzaffarpur Municipal Corporation (MMC) to implement a decentralized solid waste management programme based on segregation at source. The model that CSE is proposing hereinafter is based on the learnings from Muzaffarpur.

The segregation model

The model is based on the following principles:

1. 100 per cent segregation of waste at household level into dry, wet and domestic hazardous waste.
2. 100 per cent segregation of waste by commercial entities.
3. One-time distribution of a pair of bins to households to incentivize segregation.
4. One-time distribution of bags to shops to store dry waste. Other commercial establishments like hotels, restaurants, clinics, offices etc. to buy their own bins.
5. Redesigning of waste collection vehicles to collect and transport segregated waste.
6. Provision of litter bins and containers at commercial and other public places.

7. Daily collection of segregated dry and wet waste by waste collectors.
8. Weekly collection of hazardous waste from households and commercial establishments.
9. Disposal of bio-medical and hazardous waste through authorized entities.
10. Decentralized processing of wet and dry waste.
11. Channelization of dry waste, after sorting, to authorized recyclers.
12. Ownership of dry waste to be vested in waste collectors. Money earned from selling dry waste to be distributed to waste collectors.
13. Composting or biomethanization of wet waste. Money earned from gas and compost to be used for the operation and maintenance of the solid waste management system.
14. User fees for collection, transportation and processing of waste. Penalty for littering and non-segregation of waste at source.
15. Implementation of the Plastic Waste Management Rules, 2016, especially the provision of Extended Producers' Responsibility (EPR) along with Solid Waste Management (SWM) Rules of 2016. Under this scheme, producers, importers and brand owners of multi-layered plastic sachets, pouches or packaging material support municipal corporations in implementation of the segregation model and take credit for the amount of plastic waste collected and recycled within their municipal limits.
16. A three-year propagation cycle to institutionalize segregation at source and implement the model.
17. Enactment of municipal bye-laws to implement the above model.

The major advantages of this model are:

1. Reduced dependence on land for disposal of waste. The space required for the landfills is reduced by 90 per cent.
2. Reduced cost of collection and transportation. Upto 40–50 per cent of municipal funds allocated for solid waste management are spent on salary of staff and contractual workers, 20–40 per cent on collection and transportation, and only 5 per cent on disposal. By adopting this model, the cost of collection and transportation will be reduced by at least 50 per cent, as waste will be treated much closer to the source.
3. Additional resources will be generated from composting and recycling, as more than 90 per cent of waste can be recycled and reused. This means an additional income for a large set of people (such as waste collectors, informal workers and recyclers) in the chain.
4. The environmental costs incurred due to pollution of land, water and air from unsanitary landfills will also be reduced drastically.

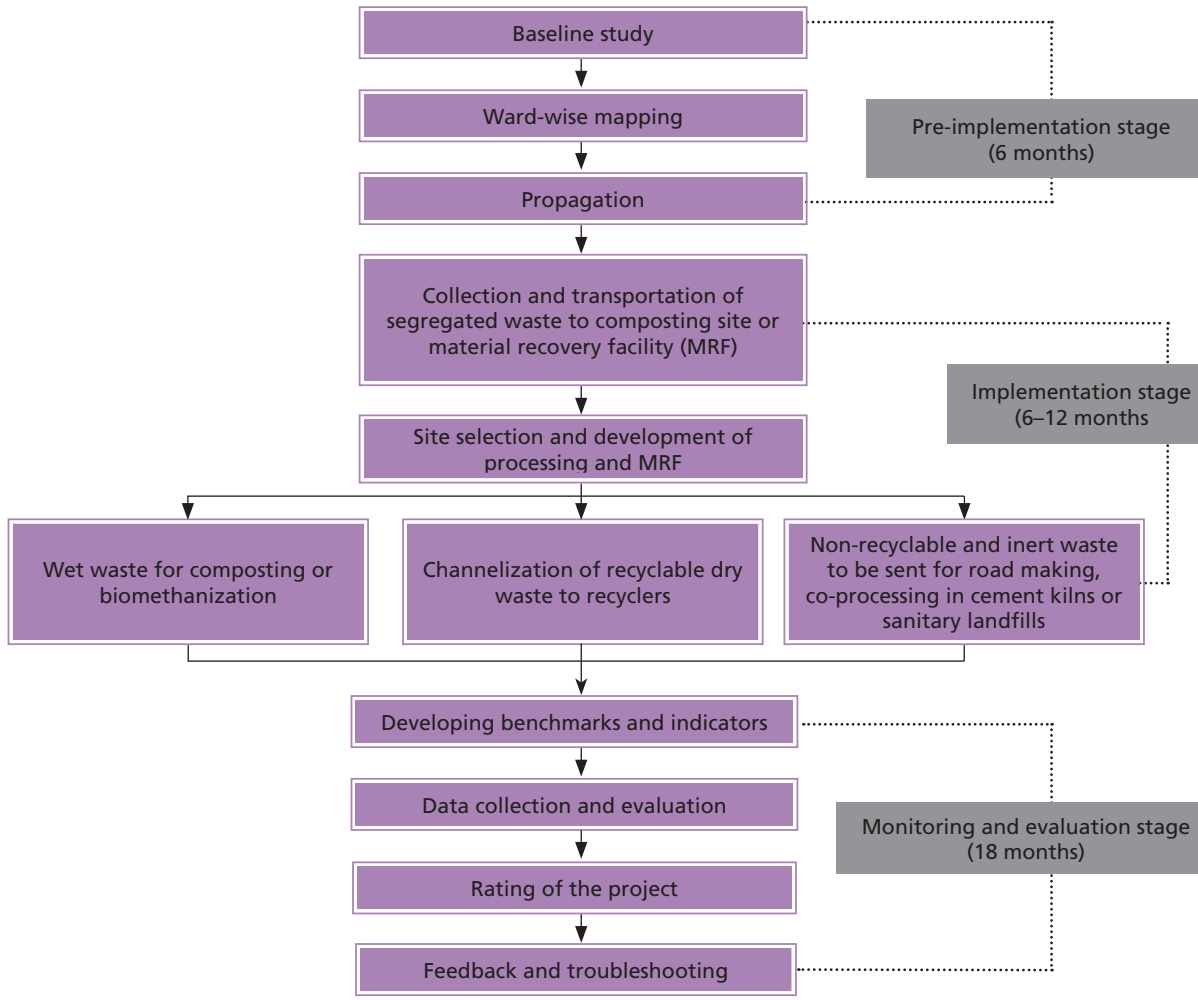
The above model is highly cost-effective and environmentally sustainable. It creates a large number of well-paying jobs. Informal waste collectors are brought into the net and provided with decent earnings and dignity. The operation and maintenance cost of the system is more or less paid for by user charges and sale of gas and compost.

This is a uniquely Indian model of solid waste management—frugal and generating wealth from waste.

2. Implementing segregation

In order to develop a zero-landfill model for a city, a systematic approach is necessary. Figure 1: *Step-wise adoption of a decentralized waste management plan by a city* illustrates the approach for making a decentralized waste management plan. Broadly, the plan is divided into three phases—pre-implementation stage, implementation stage, and monitoring and evaluation stage. A decentralized waste management system can be set up in three years, with the pre-implementation stage requiring six months, implementation stage six–12 months, and monitoring and evaluation stage requiring 18 months.

Figure 1: Step-wise adoption of a decentralized waste management plan by a city



Source: CSE, 2017

2.1 Baseline study

A baseline study involves inventorization and gathering relevant background data of the city. This information helps in the preparation of an effective solid waste management plan.

The following information is required:

a) What is the population of the city?
b) How is the city's administration organized—ward-, circle- or sector-wise?
c) How many households, commercial establishments, schools, institutions (government and private), industrial areas etc. does the city have?
d) How much municipal solid waste (MSW) does the city generate—overall and per capita?
e) What is the composition of the generated MSW? What are the percentages of wet, recyclable, domestic hazardous and inert wastes?
f) What are the existing processing and disposal mechanisms for MSW?
g) Does the city have bye-laws on solid waste management? If yes, what is the implementation status of the bye-laws?
h) What is the existing infrastructure and manpower capacity for solid waste management?
i) Is there scope for any partnerships that can be worked out with corporates and NGOs for provision of resources and handholding?

2.2 Ward mapping

A city is usually divided into zones or circles, which are further divided into wards. For the execution of a decentralized waste management plan, mapping of wards is imperative. Mapping of a single ward is done based on the following parameters:

a) Approximate total area
b) Number of households, and commercial and industrial entities
c) Number of waste collectors
d) Number of collection vehicles—tippers, pushcarts and tricycles
e) Routes of each collection vehicle moving within the ward with details of number of households covered per tipper, pushcart or tricycle
f) Number of scrap vendors
g) Availability of space for decentralized treatment such as composting or biomethanization
h) Number of litter spots in each ward

2.3 Propagation

Table 1: Resource requirement for propagation lists the resources required for effective propagation of a decentralized waste management plan in a city.

Table 1: Resource requirement for propagation

Resources required for propagation	Role and responsibility
Volunteers	Hiring and training volunteers from the city for sensitizing households with minimum requirement as follows: • Educational qualification 10+2 or higher, should be a resident of the city, aged between 18–30 years, proficient in the local language(s), with good communication skills. See *Annexure 1* for form on recruitment of volunteers. • As a thumb rule, for a city of one lakh households, 100 volunteers are required during the propagation and during the implementation phase for a period. • During the second year of implementation and for the monitoring and evaluation phase, 20 volunteers are required for supervision.
Stickers for marking households	• Households that have received bins and have committed to segregation need to be marked to keep a track on the percentage of segregation.
Information, education and communication (IEC) material	• Material such as pamphlets, hoardings and multimedia can be utilized to create awareness on segregation of waste and its importance amongst citizens. See *Annexure 2*.
Three kinds of bins	• One set of three standardized bins (one each green and blue, the third either black or red, each with a capacity of 20 litres) can be given to households, and a bag to commercial establishments (because commercial establishments largely produce dry waste) to aid them in the process of segregation. • Households must compulsorily segregate waste into wet (biodegradable waste such as cooked food waste, fruit and vegetable peels), dry (paper, plastic, metal, glass etc.), and domestic hazardous waste (discarded paint drums, pesticide cans, CFL bulbs, tubelights, expired medicine, broken mercury thermometers, used batteries, needles and syringes, and contaminated gauges etc.) and must put the segregated waste into green, blue and black/red bins respectively. Commercial establishments can put their dry waste separately in a bag provided to them. • Wet and dry waste can be handed over to the waste collector every day. Most types of hazardous waste can be handed over to waste collectors once a week, except sanitary waste, which is difficult to store and can be wrapped properly with paper and handed over to collectors every day.
Record books	The record book shall have the following details: • How many households are segregating • A daily entry with details of the quantity of segregated dry waste brought to the franchise (local scrap dealer) by the waste collector. • Amount of money made by each waste collector from sale of dry waste. • Amount of recyclable waste sent for recycling by the franchise on a weekly or monthly basis. • Amount of non-recyclable waste stored on a monthly basis (to be sent for co-processing). • Amount of wet waste collected each day. • Amount of wet waste sent for composting or biomethanization. • Amount of compost produced each month. • Amount of compost sold every month.

Source: CSE, 2017

The steps involved in propagation are as follows:

2.3.1 Launch of door-to-door propagation in each ward

i) Local authorities to conduct an inaugural programme to launch door-to-door propagation in each ward with the participation of the elected board (such as mayor or deputy mayor), municipal commissioner, ward councilor etc.
ii) Local authorities to put up hoardings in the city requesting citizens to join the cleanliness initiative being undertaken.
iii) Volunteers to conduct street plays to generate further awareness and motivation amongst residents to participate in making their city cleaner.
iv) Use of local media (newspaper, local news channel or city cable) to spread awareness about the programme.

2.3.2 Door-to-door propagation through volunteers

a) After the launch of the segregation programme in a ward, volunteers to distribute a pair of bins to each household, along with a pamphlet explaining how to segregate at source.
ii) Volunteers to fill up household record-keeping forms (see *Annexure 3*) for each household and obtain ID proof of the householder, tax receipts, etc.
iii) A sticker to be put on the entrance of every house as a mark that the household has received bins and has committed to segregate.

2.3.3 Training of waste collectors for collection of segregated waste

i) Waste collectors to be trained by a local NGO or authority to collect and transport segregated waste in collection vehicles.
ii) Collectors to be given personal protective equipment (PPE) such as gloves and appropriate tools for ensuring their safety while handling MSW.
iii) Incentives to be given to collectors for collection of segregated waste by allowing them additional income from selling the segregated dry waste to the nearest scrapdealers (franchise).

2.3.4 Regular follow-up

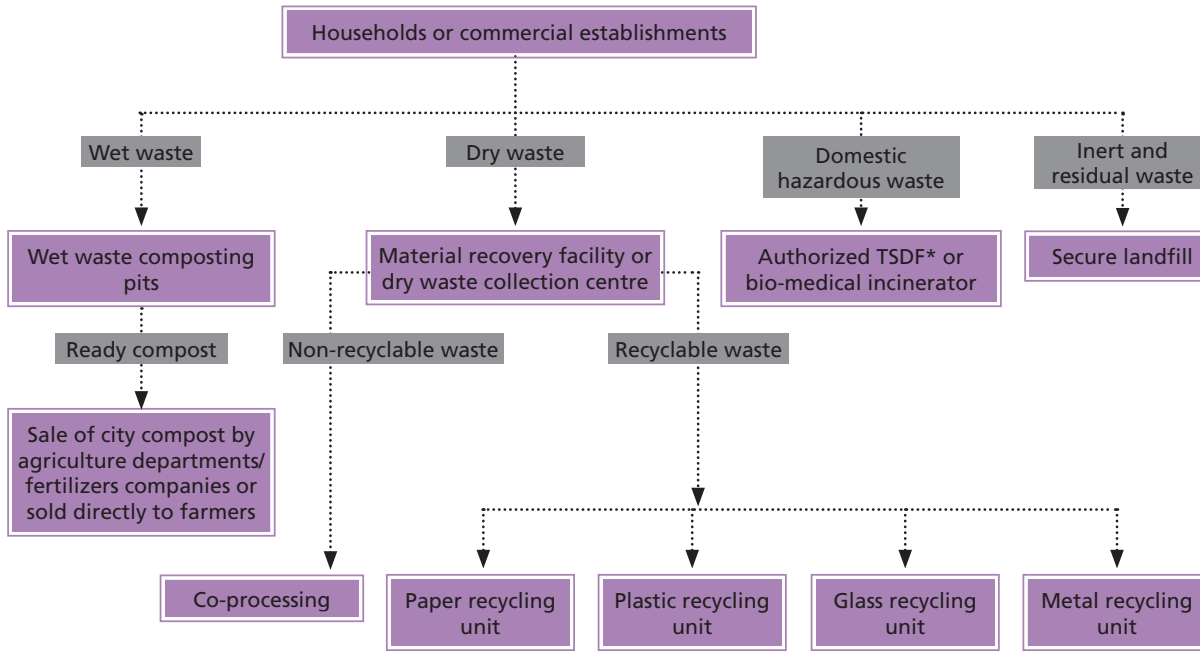
i) Once door-to-door collection of segregated waste begins, volunteers to keep regular track of the percentage of segregation in each ward.
ii) Volunteers to assist households in case they face any issues or challenges with regard to segregation.

2.4 Collection and transportation of segregated waste

Local authorities must ensure provision of appropriate infrastructure to support collection of segregated waste from households and commercial areas. As a thumb rule, a ward with 1,500–3,000 households will require six–eight waste collectors, one tipper and five tricycles or pushcarts to ensure effective collection of segregated waste. See *Annexure 4* for sample tenders for procuring tricycles and tippers.

Waste collectors can either use the whistle-blow method in door-to-door collection of segregated waste or the public address method (in which a vehicle comes to a convenient designated place in the locality for collection of segregated

Figure 2: Collection and transportation of segregated waste



**TSDF: Treatment, storage and disposal facilities*
Source: CSE, 2017

waste from households). Segregated waste is transported to the local material recovery facility (MRF) or processing facility where wet waste can be further processed and dry waste segregated and channelized for recycling. *Figure 2: Collection and transportation of segregated waste* depicts the methodology for collection and transportation of segregated waste from households and commercial areas.

Decentralized waste management, i.e., treating MSW closer to the source, is the most viable option for processing. In case of wet waste, technologies such as composting or biomethanization can be opted for. In case of dry waste, the collectors shall be incentivized to hand over waste to a local franchise. For instance, in Muzaffarpur, Bihar, the local franchise takes dry waste at a rate of ₹3 per kg from the waste collectors. However, the rates may vary from city to city. In case of hazardous waste, authorized treatment, storage and disposal facilities or bio-medical waste incinerators can be utilized. Non-recyclable waste can be sent for co-processing to cement plants. Only the inert fraction should be disposed of in a landfill.

2.5 Site selection and development of processing or MRF facility

Municipal corporations need to select sites for building compost pits or setting up biomethanization plants or MRFs. The sites need to be built as close to the source as possible to ensure decentralized transportation and processing. The sites need to have a covered shed.

Benchmarks for an MRF: An area of approximately 5,000 square feet will be required for five wards with 1,500–3,000 households each.

Benchmarks for composting area: Assuming one ward has 2,000 households and each household generates one kg waste per day, with wet waste percentage being 50–60 per cent:

a) Wet waste generated per ward per day = 2,000 x 1 x 0.6 = 1,200 kg
b) Assuming the wet waste density of around 400 kg per m^3

Volume of waste generated per day per ward = 1,200 kg / 400 kg per m^3 = 3 m^3.

A compost pit with dimensions 7 feet x 4.5 feet x 4.5 feet has a volume of ~ 4 m^3

This wet waste quickly loses moisture and reduces to about one-third of its original volume.

c) It takes two months for waste to turn into compost, so the waste in the first pit will become compost in 60 days, after which the pit can be emptied and readied to receive more waste.

Therefore, enough pits for a 60-day cycle need to be constructed. Since three-fourths of a pit fills up in approximately one day, but the volume reduces to one-third in two-three days, number of pits required = One-third of volume of wet waste x 60 = 1/3 x 3/4 x 60 = 15 pits

d) Area required for one pit = 7 feet x 4.5 feet = 31.5 square feet
e) Area required for 15 composting pits for one ward = 31.5 square feet x 15 = 473 square feet

Thus, for five wards having 2,000 households each, an area of 2,365 square feet is required for composting wet waste, and if we account for the area needed for movement of vehicles and sanitation workers around the pits, approximately 4,000 sq ft will be sufficient. See *Annexure 5* for details on the composting process.

Create market linkages for compost: A city's compost should be tested as per the guidelines and directions of the fertilizer control order (FCO) by the agricultural department of the city. The compost can be marketed by the local authorities and sold to farmers and residents. The agriculture department can also promote the city's compost.

2.6 Developing benchmarks and indicators

The following indicators can be designed to determine the progress of the initiative:

i) Operational indicators

- Percentage of segregation
- Number of wards covered in a given time period
- Efficiency of collection (percentage)
- Availability of infrastructure to support segregation
- Production of compost or biogas
- Level of engagement by local residents

ii) Environmental indicators

- Cleanliness in wards
- Diversion of waste from landfills to processing centres
- Improvement in health and sanitation

iii) Financial indicators

- Time period in which the model will become self-sustainable
- Incentives to waste collectors
- Profits made by local authorities by selling city compost or biogas
- Efficiency of user fee collection (user fee will be charged based on bye-laws of the city (see *Annexure 6* for sample bye-laws).

iv) Social indicators

- Behavioural changes
- Has the project generated jobs in the city
- Improved livelihood support for the informal sector

2.7 Data collection and evaluation

Based on the aforementioned indicators, data has to be collected and a report card generated with information as given in *Table 2: Evaluation of performance*.

2.8 Rating the project

After completion of the implementation stage, local authorities need to collect data and rate the project as per the report card. This data can be collected on a quarterly- or a half yearly-basis. Based on the points allotted, if the city scores between 65 to 85 points, the project is successful. If it scores between 40 to 65 points, the project is partially successful, and if the score is less than 40 points, the city needs to rework on the implementation and improve upon the relevant parameters.

2.9 Feedback and troubleshooting

A regular feedback and grievance redressal mechanism needs to be created by the local authorities. A subjective feedback through filling of forms can be collected from stakeholders—citizens, sanitation workers, private partners etc. A monthly or quarterly review mechanism should also be created by the concerned state urban development department to review the progress of the work.

Table 2: Evaluation of performance

Operational performance		Environmental performance		Financial performance		Social performance	
Segregation efficiency	**Points**	**Dumpsites and litter spots removed**	**Points**	**Financial self-sufficiency+**	**Points**	**New jobs created**	**Points**
> 95 per cent	5	100 per cent	5	In 3 year	5	More than 100	5
80–95 per cent	4	80–99 per cent	4	In 3–5 year	3	50–99	3
60–79 per cent	3	60–79 per cent	3	> 5 years	1	Less than 50	1
40–59 per cent	2	40–59 per cent	2				
< 40 per cent	1	< 40 per cent	1				
Collection efficiency	**Points**	**Wet waste treatment**	**Points**	**Compost selling price (per kg)***	**Points**	**Income increment for waste collectors****	**Points**
100 per cent	5	> 90 per cent	5	More than ₹6	5	More than 20 per cent	5
80–99 per cent	4	80–90 per cent	4	₹3 to ₹6	3	10–20 per cent	3
60–79 per cent	3	60–79 per cent	3	Less than ₹3	1	Less than 10 per cent	1
40–59 per cent	2	40–59 per cent	2				
< 40 per cent	1	< 40 per cent	1				
Transportation efficiency	**Points**	**Dry waste recycling**	**Points**	**User fee collection**	**Points**	**Reduction in littering*****	**Points**
100 per cent	5	> 90 per cent	5	> 95 per cent	5	Completely eliminated	5
80–99 per cent	4	80–90 per cent	4	80–95 per cent	4	Significantly reduced	4
60–79 per cent	3	60 -79 per cent	3	60–79 per cent	3	Average reduction	3
40–59 per cent	2	40–59 per cent	2	40–59 per cent	2	No change	0
< 40 per cent	1	< 40 per cent	1	< 40 per cent	1		
		Perception of residents on cleanliness***	**Points**	**Reduction in fines for littering or not segregating**	**Points**	**Source composting or biomethanization**	**Points**
		Excellent	5	100 per cent	5	> 33 per cent	5
		Very good	4	80–99 per cent	4	20–33 per cent	3
		Good	3	60–79 per cent	3	10–20 per cent	2
		Average	2	40–59 per cent	2	5–10 per cent	1
		Poor	1	< 40 per cent	1		
				Reduction in expenses in drain unclogging	**Points**	**Reduction in waste burning*****	**Points**
				50 per cent	5	Completely eliminated	5
				25–49 per cent	3	Significantly reduced	4
				10–24 per cent	1	Average reduction	3
						No change	0

+ Time in which break even is achieved; *Compost price will vary from city to city; **Collector is incentivized by selling collected dry waste to recyclers;
***Scores will be calculated on the basis of response gathered by survey of residents using weightage method
Source: CSE, 2017

3. Cost-benefit analysis

This cost–benefit analysis is based on CSE's ground-level experience in supporting the implementation of zero landfill solid waste management system in Muzaffarpur, Bihar.

The cost-benefit analysis is given for a mid-sized city of five lakh population (which roughly translates to one lakh households) and a timeframe of three years for setting up and fully operationalizing the 'segregation model' of waste management.

(A) Capital cost

(i) Provision of bins for households, bags for commercial establishments, and litter bins at appropriate commercial and public places.

To begin with, and in order to encourage segregation, three bins (green, blue and black/red) should be distributed to households and one bag should be given to every shop to begin with. It is assumed that for every 10 households, there is one commercial establishment (mostly shops). So, a city with one lakh household will have about 10,000 commercial entities. Bags shall be provided to each shop. However, other commercial entities like hotels, hospitals, petrol pumps, banks, public and private offices, institutions etc., will have to organize bins on their own.

Two kinds of litter bins need to be placed at appropriate places in all commercial and public areas:

1. Larger metal containers with partitions to collect dry and wet wastes from commercial areas. These should be placed every 250 m in dense commercial areas like vegetable and fish markets with roadside shops. For a city like Muzaffarpur, about 100 metal containers will be required.
2. Two litter bins (one for dry and other for wet waste) at every 100 m on the roads in commercial areas and at public places like parks, playgrounds etc. For a city like Muzaffarpur, 500 pairs of litter bins are required.

Unit cost

- Approximate cost of a pair of bins (green, blue and red/black) for each household: ₹675
- Approximate cost of a bag to store dry waste in shops: ₹50
- Approximate cost of metal containers: ₹25,000
- Approximate cost of a pair of littler bins: ₹5,000

Total cost

- Household bins: ₹6.75 crore
- Bags for shops: ₹5.00 lakh

- Metal containers: ₹25 lakh
- Litter bins: ₹25 lakh

Total: Approximately ₹7.25 crore

(ii) Vehicles for segregated collection and transportation

For a city with one lakh households, approximately 50 tippers and 250 tricycles are required for efficient collection. The city will also need 10 customized trucks or tractors to collect segregated wastes from litter bins and containers, and road dust.

Unit cost

- Tipper: ₹7.0 lakh
- Tricycle: ₹35,000
- Tractor: ₹10 lakh
- Truck: ₹40 lakh

Total cost

- Tippers: ₹3.5 crore
- Tricycles: ₹1 crore
- Trucks and tractors: ₹2.5 crore

Total cost of vehicles: ₹7.0 crore

(iii) Composting pits (excluding land cost)

For one ward (with approximately 2,000 households), 15 composting pits are required for processing wet waste; hence, for one lakh households, 750 pits will be required.

- Cost of setting up one pit: ₹5,000

Total cost of construction of a thousand pits for one lakh households: Approximately ₹40 lakh

This includes cost of constructing sheds over the pits, platform for storing waste, storage of compost, and wall around the composting facility.

(iv) Construction of a small landfill site for disposal of road dust and other non-compostable, non-co-processing wastes

Approximate cost: ₹25 lakh

Total approximate fixed capital cost = (i) + (ii) + (iii) + (iv)= ₹15 crore

(B) Propagation and management support cost

For setting-up the system and infrastructure for door-to-door propagation and to handhold the municipality in implementation, a management and support team is required. This propagation and management support team will work with the city government for three years.

(i) Management support staff

- Five full-time implementation staffers are required on the field to manage the work, each at a monthly salary of about ₹30,000–50,000. For five employees, this comes to about ₹2 lakh per month.
- Two full-time management and technical staffers are needed to design, coordinate and implement the system, each at a monthly salary of ₹75,000. For two employees, the salary cost is about ₹1.5 lakh per month.
- Monthly travel and office expenses: ₹1 lakh

Annual management support cost: Approximately ₹55 lakh
Management support cost for three years: ₹1.65 crore

(ii) Propagation cost

1. Volunteers for propagation
During the first 12 months, 100 volunteers are required for door-to-door propagation. For the next 24 months, 25 volunteers are required for supervision and monitoring.

- Allowance for volunteers: ₹8,000 per month
- Cost of volunteers for the first 12 months: ₹1 crore
- Cost of volunteers for the next 24 months: ₹0.5 crore

Total cost of volunteers: ₹1.5 crore

2. Awareness programmes

- First year: ₹25 lakh
- Second year: ₹10 lakh
- Third year: ₹5 lakh

Total cost of awareness programmes: ₹40 lakh

3. IEC material for propagation
For propagation, information, education and communication (IEC) material like pamphlets, stickers, hoardings, banners, record-keeping notebooks etc. are required. The approximate cost of these is about ₹10 lakh.

Total propagation cost: ₹2 crore

Total propagation and management support cost: ₹3.65 crore

Total cost of implementation (including capital cost) of the project for three years is ₹18.65 crore

This is equivalent to about ₹1,900 per household

(C) Operation and maintenance cost

(i) Salary of waste collectors, processors and managers

- As a thumb rule, one waste collector is required for effective waste collection from 200 households and the corresponding number of commercial establishments, road sweeping, waste processing etc. This number includes drivers, waste processors and staff for marketing of compost. For every 5,000 households, one waste manager is required.
- Waste collectors required for a city of one lakh households: 500
- Waste managers required: 20
- Average monthly salary of waste collectors: ₹13,000*
- Average monthly salary of waste managers: ₹25,000

Annual salary bill: ₹8.4 crore

(ii) Operation and maintenance of equipment and infrastructure

Annual maintenance cost of vehicles and public bins: ₹0.8 crore
Annual running cost, including the fuel cost: ₹0.7 crore
Total: ₹1.5 crore

Total annual operation and maintenance cost: Approximately ₹10 crore
This is equivalent to about ₹80 per household per month

D. Revenue

(i) User fee

Local authorities will collect user fees from every household and commercial entity. The user charges will be different for different types of commercial establishments. However, the following user fee has been assumed (this is a very conservative thumb figure as cities are already charging much more):

- From households: ₹50 per household per month
- From commercial establishments and shops: Average ₹200 per commercial establishment per month

Annual revenue from collection of user fee from one lakh households and 10,000 commercial establishments: ₹8.4 crore

(ii) Compost

- Monthly wet waste generated per household: 15 kg
- Assuming that compost is about 30 per cent of the wet waste, the amount of compost generated per household per month: 4.5 kg
- Compost generated for one lakh households: 450 tonne per month

Assuming the city compost sells at ₹4,500 per tonne, annual revenue from compost generated from one lakh households: ₹2.4 crore

Total annual revenue: ₹10.8 crore
Once capital, propagation and management support costs are paid, the model is financially self-sufficient.

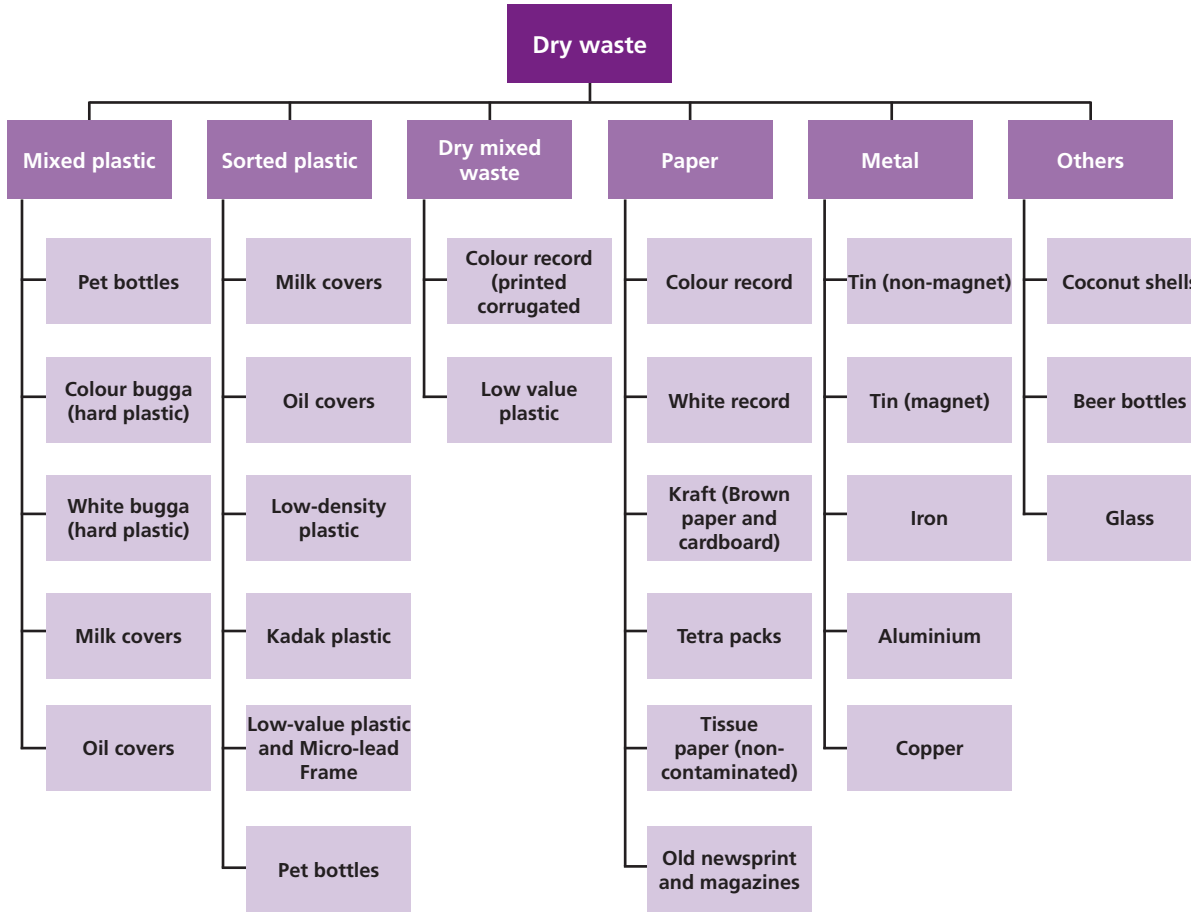
* Waste collectors will also get monthly allowances from the sale of dry waste. In Muzaffarpur, this comes to about ₹2,000 per waste collector per month.

4. Dry waste management

The fundamental challenge of dry waste management is to get as much out of the waste as possible. In a developing economy like India, the importance of resource recovery from dry waste is underlined by the fact that it provides livelihood to large numbers in the informal sector. Recycling should also be given preference because it not only ensures resource recovery and re-utilization, conserving precious natural resources, but also saves energy and water. Producing recycled goods consumes considerably less energy and resources compared to what is required for producing the same goods from virgin material. For example, producing recycling aluminum requires 75 per cent less energy than producing aluminum from bauxite.

Different categories of recyclable dry waste need to be handed over to the appropriate authorized recycler or local franchise (see *Figure 3: Informal categorization of dry waste*). Alternative treatment processes must only be utilized when recycling is not feasible.

Figure 3: Informal categorization of dry waste



Source: CSE, 2018

Table 3: Categories of plastic

Type	Category	Examples	Recyclable?
Thermoplastics	PS (Polystyrene)	Foam hot drink cups, plastic cutlery, containers, and yogurt	Partially
	PP (Polypropylene)	Lunch boxes, take-out food containers, ice cream containers	Partially
	LDPE (Low-density polyethylene)	Garbage bins and bags	Partially
	PVC (Plasticized polyvinyl chloride or polyvinyl chloride)	Juice or squeeze bottles	Yes
	HDPE (High-density polyethylene)	Shampoo containers or milk bottles	Yes
	PET (Polyethylene terephthalate)	Fruit juice and soft drink bottles	Yes
Thermoset and others	Multi-layer and laminated plastics, polyurethane foam, Bakelite, polycarbonate, melamine, nylon etc.	Car parts, mattresses, circuit boards and electrical insulators	No

Source: CSE, 2018

While glass and metal are readily recycled, plastic waste poses a significant challenge in recycling because of its low density and value. There are many types of plastic (see *Table 3: Categories of plastic*). Sorting of the different types is a crucial but labour-intensive exercise, which increases the difficulties of recycling the material.

Currently, only polyethylene terephthalate (PET), high-density polyethylene (HDPE) and polyvinyl chloride (PVC) are being recycled with some efficiency in India. Polystyrene (PS), polypropylene (PP), and low-density polyethylene (LDPE) are hardly being recycled because these plastic materials get stuck in the sorting equipment in recycling facilities causing them to break or stop working. Lids and bottle tops cannot be recycled as well. This problem with recycling become even more prominent in case of multi-layered packaging and low-value plastics (LVPs).

4.1 Low-value plastics and multi-layered packaging

Some of the most common household packaging materials—including potato chip packets, biscuit and chocolate wrappers, and toothpaste tubes often comprise of multi-layered packaging that aren't typically recycled and generally find their way to landfills or illegal dumpsites. LVPs comprise of mostly thin-layered plastic such as carry bags for vegetables. It is very difficult to recycle both these types of plastics for various reasons.

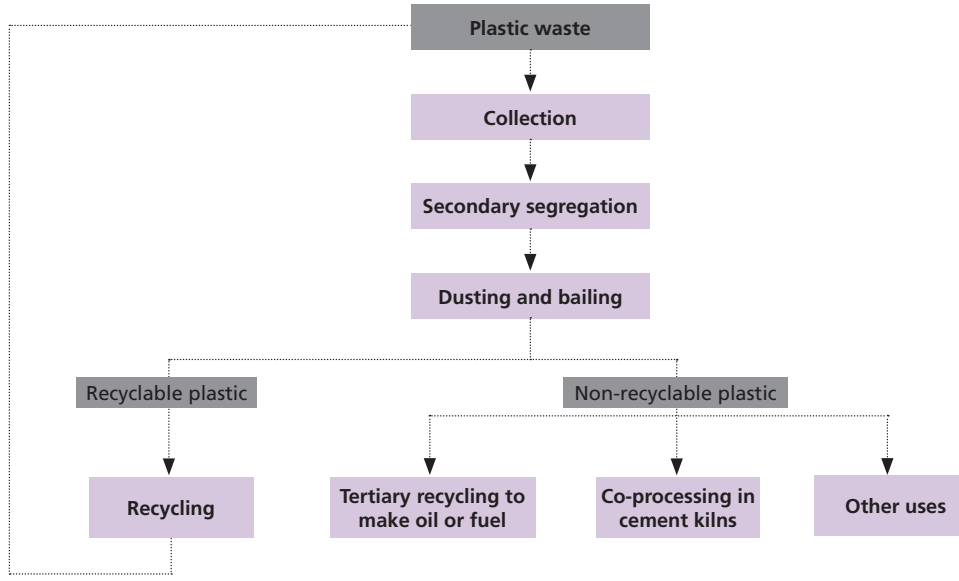
- LVPs are plastics with thickness of less than 50 microns, so the density of LVP waste is very low. Hence, it is not economically feasible to transport LVP waste and recycle it.
- For multi-layered packaging, it is extremely difficult to separate the different layers. For instance, the typical snack chip bag is made up of seven layers of foil and plastic, making it impossible or extremely costly to separate the layers.
- Since a lot of multi-layered packaging is used for food products, another hurdle for recycling is food contamination.

Several alternative methods have been developed for recycling these types of plastic wastes. *Figure 4: Plastic waste collection and treatment* shows various methods of plastic waste treatment.

4.1.1 Tertiary recycling into a chemical or fuel

It is the most preferred method for recycling of LVPs and multi-layered packaging. Pyrolysis and gasification are two key technologies currently used for tertiary recycling of multi-layered packaging waste.

Figure 4: Plastic waste collection and treatment



Source: CSE, 2018

Table 4: Tertiary recycling technologies

Process	Method	End product	Advantage
Pyrolysis	• Processing of plastic waste by thermal or catalytic depolymerization at moderate temperatures and in the absence of oxygen	Usable oil	Pyrolysis is quite different from incineration (an aerobic process). It has low emissions and greenhouse gas footprint and yields useful downstream chemical products. No dioxins are produced during pyrolysis.
Gasification	• Partial combustion at elevated temperatures • Has also proven successful for treating mixed plastic waste	Gaseous fuel (syngas) appropriate for electricity generation or conversion to a liquid fuel	Using syngas (synthesis gas of H_2 and CO) is potentially more efficient than direct combustion of the original fuel because its energy density is higher.

Source: Adapted from Recycling of Laminated Packaging, Waste Resources and Management Programme, UK

4.1.2 Co-processing of plastic in cement kilns

Many countries practice this method of combustion as an environmentally-sound option for managing plastic wastes. In cement kiln, different kinds of hazardous and non-hazardous wastes, including plastic waste, get utilized as alternative fuel and raw materials (AFRs). During the usage of plastic wastes in cement kiln as AFRs, the material and energy value present in them gets fully utilized, saving fossil fuels as well.

4.1.3 Other uses

LVPs and multi-layered plastic can be re-utilized and recycled to even make furniture such as chairs and table, or handicraft items such as bags and home décor items. Some countries in Africa are also using plastic to make bricks to construct houses, reaping the twin benefits of re-utilization of plastic waste as well as affordable housing.

4.2 The case of plastics in India and extended producer responsibilty (EPR)

According to the Plastic Infrastructure report, 2017, India consumes close to 12.8 million tonne of plastic per annum. Production of plastic is growing at an estimated average annual rate of 10 per cent, which is 2.5 times the growth rate of GDP of the country. The annual per capita consumption of plastic is 11 kg. Approximately, five million tonne plastic waste is generated in the country every year—this is a small fraction (about 7 per cent) of the total MSW generated in the country, but its recycling and disposal is a huge problem.

In March 2016, the Ministry of Environment, Forest and Climate Change (MoEF&CC) notified the Plastic Waste Management (PWM) Rules. The Rules introduced extended producer responsibility (EPR) for producers, importers and brand owners to ensure environmentally sound management of plastic products until the end of their life.

Under Section 9(1) of the Plastic Waste Management (PWM) Rules, 2016, the producers, within six months of the notification of the Rules, shall work out modalities (either individually or collectively) for a waste collection system based on extended producer responsibility (EPR) through their own distribution channel or through the local body concerned and by involving the state urban development departments. Under Section 9(2), the primary responsibility for collection of used multi-layered plastic sachets or pouches or packaging is of producers, importers and brand owners who introduce the products in the market. They need to establish a system for collecting back the plastic waste generated by their products. This plan of collection has to be submitted to the state pollution control boards (SPCBs) while applying for consent to establish, operate or renew.

4.2.1 Implementation of PWM Rules, 2016

Over the past one year, the research and ground-level work by CSE shows the following:

1. Under the EPR provisions, companies have to set up collection centres wherever their products are sold across the length and breadth of the country. Else, they have to pay some other agency to do the collection on their behalf. None of the companies have put in place modalities to ensure sound implementation of EPR.
2. At the city level, all wastes, including plastic waste, are collected together by waste collectors. Valuable plastic waste is collected and sold by the informal waste collectors and multi-layered plastic sachets or pouches or packaging becomes part of the mixed waste. In the 'segregation model' of waste management, multi-layered plastic sachets or pouches or packaging will be separately collected and sold for recycling or co-processing. In such a scenario, having another system for plastic waste management in terms of collection centres doesn't seem to be a viable proposition. If companies try to set-up a separate plastic waste system, it will impact a thriving informal plastic waste collection and recycling industry.
3. For a company, meeting the EPR targets in each state is impractical. EPR targets have to be accounted for at the national-level, irrespective of which state the products are sold or consumed in.

Currently, certain business models are being promoted by some regulators under which producers, importers and brand owners are being asked to pay a certain amount of money for every kilogram of plastic they are putting into the market to a third party. This third-party will supposedly collect plastic wastes on behalf of companies and send them for recycling and proper disposal. But considering the integrated nature of waste management, this model is not likely to work.

It is clear that plastic waste management has to be integrated with the existing municipal waste management systems. In fact, plastic waste management gives us an opportunity to significantly improve municipal waste management systems by using the resources and management skills of the private sector. This can be done as follows:

a. A credit or offset mechanism under which companies can take credit for plastic waste management if they support municipalities in implementing MSW management. Under this mechanism, plastics collected and recycled everyday will count as offsetting the EPR target of the company.
b. All accounting of EPR targets to be met at the national-level, irrespective of which state the products are sold or consumed in.

By integrating with the implementation of EPR, plastic waste management and improvement of solid waste management systems can be achieved together at the city level.

4.2.2 Offset mechanism to implement EPR

The responsibility of the producer or brand owner under this mechanism would be the following:

(i) Producers or brand owner will work with urban local bodies to implement the 'segregation model' of waste management. They will provide management support in propagation. They will also contribute to development of infrastructure for implementation.

(ii) Producers or brand owners would be responsible for developing and implementing the EPR plan. They will also be responsible for creating appropriate waste exchanges to ensure ready market and value realization by waste collectors, segregators or recyclers of different categories of wastes collected.

(iii) Producers or brand owners shall set up a permanent team to monitor and support the implementation of the 'segregation model' and keep proper account of plastic waste.

4.2.3 Changes required in the PWM Rules, 2016

To give effect to the above mechanism, a provision for offset mechanism has to be introduced under Section 9 of the Plastic Waste Management Rules, 2016. It should achieve the following:

1. Develop phase-wise implementation of the EPR programme with yearly targets and a system of nation-wide offsets and credit.
2. Develop an offset mechanism for effective implementation of EPR. Under this, the amount of equivalent plastic and packaging that the producers and brand owners are able to recover and recycle will be used as an offset. Such mechanisms will be product and brand neutral and the collection will not be confined to packaging of the producer or brand owners' products only and can be carried out in any location(s) of their choosing.
3. Build a national framework on EPR credits which can be earned by

Form 1: Format for annual reporting by producer or brand owner of plastic packaging introduced nationally into the market

Quantity (tonne)	Film	Rigid
Monolayer		
Multilayer		

Source: CSE, 2017

Form 2: Format for annual reporting by producer or brand owner of plastic waste for which recovery or recycling as per ISO 15270 has been achieved through partnership with urban local bodies

Site	Concerned SPCB where EPR site is located	Multilayered packaging or thin film plastic (tonne)	Film (tonne)	Rigid (tonne)
ULB 1				
ULB 2				
ULB 3				
National total				

Source: CSE, 2017

producers through a variety of activities including those done for or with urban local bodies, and targets can be indexed against the total plastic packaging put out into the market.

4. Provide independent third party audited reports of the offset mechanism, yearly data for which shall be submitted by the producers or brand owners involved in the EPR programme (see *Form 1: Format for annual reporting by producer or brand owner of plastic packaging introduced nationally into the market* and *Form 2: Format for annual reporting by producer or brand owner of plastic waste for which recovery or recycling as per ISO 15270 has been achieved through partnership with urban local bodies*).
5. Develop a national registry of plastic packaging introduced into the market by all producers or brand owners. An online reporting mechanism for the same to be developed where producers and brand owners can furnish details. This must be made available to the CPCB based on annual third party assured submissions.
6. Details of all financial flows and material flow of plastic waste as well as credits earned to be available in the public domain.

5. Case study Muzaffarpur

Background

Known as 'the land of litchi', Muzaffarpur is a sub-metropolitan city in Bihar north of and across the Ganga from Patna. In 2016, like several other North Indian cities, it had major solid waste pollution issues. The city had litter spots every 500 meters. Waste burning was a common practice. Even the drains were clogged with plastics due to which it was becoming increasingly difficult for the city to deal with flood situations.

The Muzaffarpur Municipal Corporation (MMC) is responsible for solid waste management in the town. However, in the past, it had only invested in collection and transportation of waste to a dumping yard, situated 12 km away from the city in a village called Rautaniya. No treatment or processing of waste was being undertaken. In August 2016, CSE did a detailed reconniassance on the status of solid waste management in the city, and suggested the need for a decentralized waste management system.

Swachhta Swasthya Samridhi programme

On 15 December 2016, the Swachhta Swasthya Samridhi programme was launched in Muzaffarpur under which an MoU was signed between CSE, MMC and ITC Ltd for facilitating better solid waste management in the city. The programme is helping transform Muzaffarpur into a zero landfill city by adopting segregation and processing at source.

Muzaffarpur waste statistics

The 49 wards of Muzaffarpur city are divided into ten circles. Each ward consists of 1,500–3,000 houses. As per information provided by MMC, Muzaffarpur generates about 170 metric tonne of waste daily, with the daily per capita waste generation being close to 300 g.

Awareness and propagation for waste segregation

Under ITC's 'well-being out of waste' initiative, 70 volunteers chosen from the city are responsible for door-to-door propagation to educate residents on why and how they must segregate their household waste. The volunteers accompany waste collector and check the levels of segregation. Their role is to ensure that over a period of time, segregation becomes a habit of the citizenry.

Volunteer selection

Volunteer training

So far, households in 28 wards and commercial establishments in all 49 wards have adopted a decentralized mechanism for waste management.

Ward inauguration and distribution of bins to households

MMC has provided all households in these wards with two superior quality plastic bins (green for wet and blue for dry waste) costing ₹195 each. Commercial establishments such as shops only generate dry waste and store it in cartons. Any biomedical, sanitary or hazardous waste is handed separately from the wet and dry waste.

The details of the residents of the houses that have received the bins are noted and houses are marked with stickers to keep a track of the progress of segregation. The citizens also receive pamphlets explaining the process of segregation.

Marking a household with a sticker

Propagation work (distribution of pamphlets)

Waste collection and transportation

Waste collection in a tricycle

Tipper with compartments to collect segregated wet and dry from households

Tippers, tractors and tricycles provided by MMC are used for collection of waste. Currently, one tipper, one tractor and three tricyles are available for each ward. Four waste collectors gather waste from each ward. The tipper has two partitions for collection of segregated dry and wet waste streams. In addition, the tricycles have been partitioned to ensure transportation of segregated waste to all relevant facilities (dry waste franchise and to the Town Hall composting sites).

Waste processing

About three–four tonne of wet waste is collected every day from the 14 wards and sent to a model aerobic composting facility near the Town Hall. The facility near the Town Hall has 40 pits, each with a capacity of 1,000 kg. MMC is planning to set up seven such decentralized composting centresin the near future.

Model composting facility at the Town Hall

Collectors are incentivized as they earn about ₹2,000 per month by selling dry recyclable waste. They sell dry waste to the local scrap dealers (dry waste franchise) at their collection center where it is further segregated into different kinds of waste for recycling purposes.

Secondary segregation at a dry waste collection center

Results

The project has witnessed tremendous participation from the residents with over 80 per cent segregation achieved on a daily basis. This is a remarkable result, as in a majority of other cities where segregation at source is happening the segregation percentage is about 50.

Muzaffarpur has seen incredible improvement in cleanliness with streets and public areas looking very clean. Litter spots have declined, and so has waste burning. The citizens are very happy with the progress as the incidence of vector diseases has also lessened.

Drastic change in 28 wards, littering has reduced

A completely transformed slum area in Ward 11

The city also improved its rank in the Swachh Survekhsan 2017 and has been included in the list of smart cities. The city has become the first in Bihar to have its own solid waste management bye-laws, which have been duly reviewed by the elected board and shall be passed soon by the state government.

Annexures

Annexure 1: Volunteer recruitment form

Volunteer Profile

Name:

Father's name:

Address:

Contact No:

Email ID:

Educational Qualification:

Experience:

Bank A/c no:

IFSC code:

Signature

Source: CSE, 2017

Annexure 2: IEC material for propagation

WASTE SEGREGATION GUIDELINES

Organic/Wet waste

Vegetable/fruit peels , Cooked food/leftovers, Egg shells /chicken/fish bones

Rotten fruits/vegetables, Tea bags/coffee grinds, Leaf plates

Fallen Leaves/twigs, Flowers/garlands, Grass

Dry waste

Plastic - Carrybags, Chips/toffee wrappers, Plastic cups, Milk/curd packets, Packaging waste

Paper and cardboard

Metal & Glass

Other dry waste -Rubber/thermocol , Ceramics/ wooden Chips

Domestic Hazardous waste

Sanitary waste - Diapers/sanitary napkins/ condoms *

Medical Waste such as needles, expired medicines, bandages

Bulbs/tube lights/CFLs

Discarded paint drums/ pesticide cans

*Wrap it in newspaper and give to the collector separately

Please separate the waste as shown above and give it to the collector. Collector will not collect mix waste any more.
Do not throw waste on the roads and litter in public places.

For more details contact:

Helpline:

Reduce **Reuse** **Recycle**

Source: CSE, 2017

Annexure 3: Form to keep record of households that have received bins during propagation

<MUNICIPALITY NAME>, <CITY NAME>
<ADDRESS OF MUNICIPALITY>

No. …… Profile of household Date: ……..

Name of householder ……..…… No. of members ……

Phone no. ……..... Email ID ……..……

Full address ……..……

Dust bin issued Yes …… No …… Landmark……

Signature of householder Emp ID…… Name of the PE

Source: CSE, 2017

Annexure 4: Sample tenders for procuring vehicles

Technical specifications of a garbage mini-tipper

General specifications

The four-wheeler tipper with a closed garbage box body is useful for door-to-door collection and transportation of municipal and other waste from the collection to the disposal point. The body capacity should be 2.5 cubic metre. The container should have two compartments of equal capacity, divided along the length of the tipper for segregation of waste at source. Discharge gates should also partitioned so that the garbage from each compartment can be discharged independently. The unit should have the following characteristics:

- Fully-enclosed tipper with three openable lids at the top for collection of waste
- There must be a hydraulic arrangement for tipping
- There must be an under-body hydraulic system
- The hydraulic system should be operated by an engine- or gearbox-driven power take-off mechanism
- The complete tipping system should be designed to suit chassis units, consisting of a body with a suitable frame.

Chassis make

Ashok Leyland, Mahindra, TATA or an equivalent make.

Engine

Type:	Direct injection common rail BS4 diesel engine
Capacity:	1,375 cc and above
Maximum output:	70 hp @ 4,000 rpm
Maximum torque:	140 Nm @ 1,800–3,000 rpm

Clutch type

Single-plate dry friction diaphragm type

Gearbox type

Synchromesh (five forward gears)
Sliding mesh (reverse gear)

Steering

Power-assisted hydraulic rack and pinion, with a diameter of 38 cm.

Brakes

Front brakes:	Disc brakes
Rear brakes:	Drum brakes

Suspension

Type:	Front—independent, strut type
	Rear—semi-elliptic leaf spring
Shock absorber:	Hydraulic double-acting telescopic type

Wheels and tyres
Tyres 165 R14 LT 8PR radial tube tyre

Dimensions (length)
434 cm

Weight
Maximum gross vehicle weight: 2,250 kg
Payload: 1,000 kg

Seating capacity
Driver + 1

Fuel tank capacity
38 litres

Minimum turning circle radius
5.1 m

Performance
Maximum speed: 125 kmph
Maximum gradeability: 38 per cent

Source of power for the hydraulic system
Engine- or gear-box driven power take-off mechanism.

Unloading arrangement
Hydraulic cylinder—hypratek or Wipro single-stage double-acting or equivalent with a minimum 50 degree fitting angle.

Frame
The sub-frame should be an all-welded construction of rectangular hollow section, reinforced adequately on the load members and mounted on chassis with nuts and bolts.

Tipper body (container)
The tipper body should be an all-welded construction of sheet metal adequately reinforced by stiffeners having ribs on the floor of the container

Floor panel: 2 mm hot rolled sheet and body panel with a thickness of 1.6 mm

Dimensions: Containers shall comprise of a rectangular or trapexoidal portion of suitable dimensions to suit the chassis. The bidder shall design and submit drawings for approval.

Driver's cabin
The machine should be provided with a company-fitted, all-weather steel driver's cabin with excellent all-round visibility.

Body prop
A body prop should be provided to support the body for servicing and safety purposes.

Hydraulic cylinders
All cylinders must be tested at 1.5 times the rated working pressures. Rods of all cylinders should be made of high-strength hardened steel rods and should be hard chrome-plated. Where necessary, pin mounting connections of cylinders should incorporate hardened spherical bushings on hardened pins. The cylinders should be of a reputed make and should adhere to dimension given in the technical schedule.

Hydraulic tank and filters
The hydraulic oil tank (with a minimum capacity of 15 litres) should be fitted with a suction strainer to ensure the supply of clean hydraulic oil, air breather, oil filter and oil-level indicator.

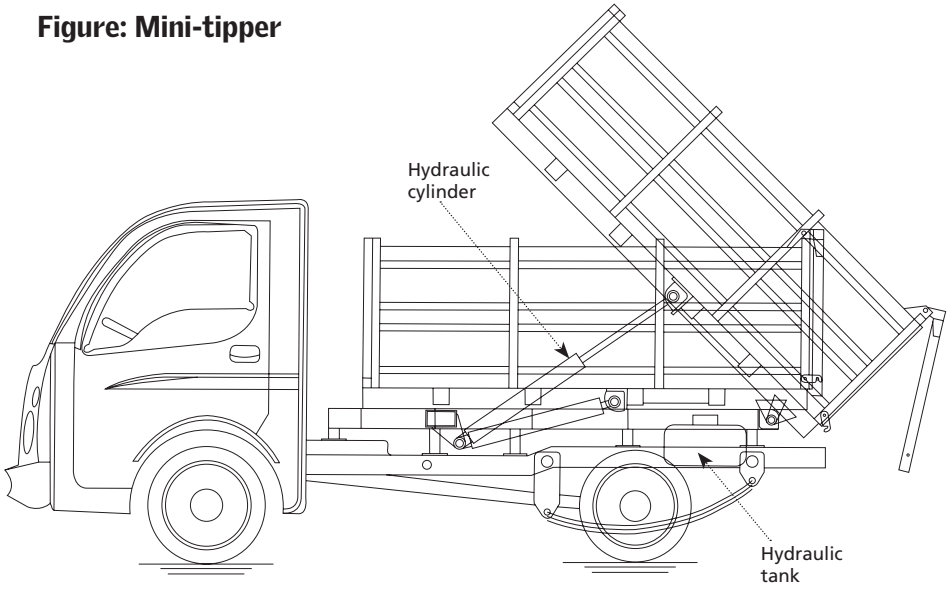
Accessories
Mud-guard:	Four in number
Mud-flap:	Four in number

Items to be provided by the manufacturer or supplier
- Two copies of the operator's manual
- Two copies of the workshop and service manual
- Two copies of the spare parts catalogue operation manual
- Warranty card for one year
- Battery warranty card for one year
- Manufacturer's standard tools for maintenance with lockable security box.

Warning system and essential accessories
- Speedometer
- Engine oil pressure gauge or warning light
- Fuel level gauge
- Water temperature gauge
- Ammeter or warning light
- Horn
- External rear view mirrors
- Radiator protection grill
- Head, tail and cabin lights
- Reversing alarm or beeper system
- Spare wheel with tyre and inner tube with wheel carrier
- Jack and wheel wrench

Painting and writing
Two coats of acrylic enamel on the external surface and two coats of corrosion-resistant or water-resistant rubber paint on the internal surface. The body should be colour-coded, green for dry waste and green for other waste. The name and slogan of the bidder should be painted in legible writing as well.

Figure: Mini-tipper



Drawings

The bidder should provide drawings of the goods or equipment proposed with the bid and the selected bidder would be required to submit the working drawing for approval by the purchaser at the time of execution of the contract.

Financial bid specifications template

Municipal Corporation, Muzaffarpur URBAN DEVELOPMENT AND HOUSING DEPARTMENT, BIHAR				
NIT No.		:-	03/2017–18	
Sl. No.		:-	GR-04	
Name of work/bill of quantity for		:-	Supply of garbage tipper	
Quantity		:-	50	
Earnest money (in ₹)		:-	50,000.00	
Time of completion (in months)		:-	Two	
Cost of bill of quantities (in ₹)		:-	5,000	
Bid processing fee (in ₹)		:-	1,150	
FINANCIAL BID FORM				
TO BE FILLED IN BY BIDDER				
1	Estimated cost	:-	₹	Nil
2	Cost of government material	:-	₹	Nil
3	Name of the supplier	:-		
4	Address of the supplier	:-		
5	Quoted rate	:-		

Technical specifications of a tricycle bin with two compartments

General specifications

Door-to-door collection equipment fulfils the objective of transportation of segregated garbage from source and unloading at the secondary collection point. The equipment consists of a pedal-driven cycle rickshaw, and a one-piece moulded segregation trough of not less than 425 litres capacity with a built-in moulded partition of not less than 25 mm width at the centre, and two fully openable rear doors for off-loading garbage.

Basic qualities

Door-to-door collection equipment is made from premium quality chassis integrated with plastic containers for storage of garbage, is capable of carrying a minimum weight of 250 kg of garbage.

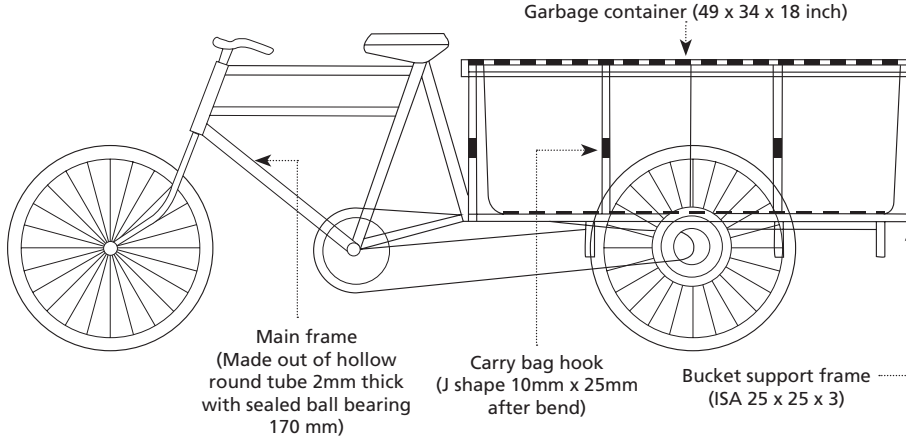
Material

Tricycles are mounted and integrated with chassis designed to house one segregation trough of not less than 425 litres capacity as per the specifications. A tricycle is provided with a sturdy bar frame with the rider at the front. It has big hubs with sealed bearings and two standard hand-brakes. It has an axle capacity of about 300 kg. All wheels are provided with mudguards. A tricycle is painted first with a coat of red oxide primer and then two coats of anti-corrosive synthetic enamel paint to ensure durability under corrosive conditions. Standard shade is black.

Design

One-piece moulded partition without any welding or joint. Each compartment not to be less than 360 mm wide for segregation of garbage. Partition not to be less than 40 mm thick. High impact strength, and rough and tough. Fully openable two rear doors. User-friendly design without sharp corners or welds. Moulded in-built rib of not less than 40 mm width x 40 mm height on all sides of the container for extra strength.

Figure: Tricycle



Overall dimensions

Top: Not less than 1,150 x 750 mm
Bottom: Not less than 1,050 x 700 mm
Height: Not less than 400 mm

Financial bid specifications template

Municipal Corporation, Muzaffarpur URBAN DEVELOPMENT AND HOUSING DEPARTMENT, BIHAR				
NIT No.		:-	03/2017–18	
Sl. No.		:-	GR-03	
Name of work/ bill of quantity for		:-	Supply of tricycle with bin	
Quantity		:-	150	
Earnest money (in ₹)		:-	50,000	
Time of completion (in months)		:-	Two	
Cost of bill of quantities (in ₹)		:-	5,000	
Bid processing fee (in ₹)		:-	1150	
FINANCIAL BID FORM				
TO BE FILLED IN BY BIDDER				
1	Estimated cost	:-	₹	Nil
2	Cost of government material	:-	₹	Nil
3	Name of the supplier	:-		
4	Address of the supplier	:-		
5	Quoted rate	:-		

Source: Muzaffarpur Municipal Corporation

Annexure 5: Details of the composting process

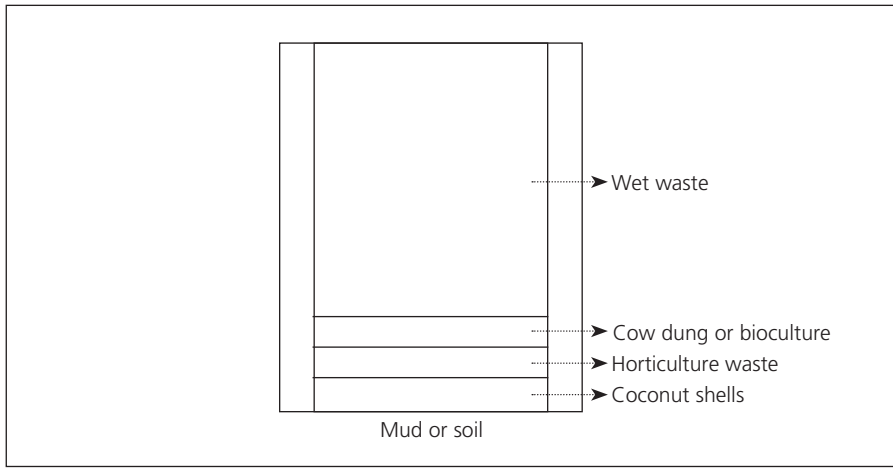
i. Construction of composting pits

The box composting model should have three equal-sized cubical pits of size 7 feet × 4.5 feet × 4.5 feet. The sides of the pits are made using basic construction material such as bricks and cement. They are designed leaving gaps in between so that the decomposing waste receives sufficient oxygen from all sides—this is very important in order to speed up the rate of decomposition. Preferably, pits should not have a concrete or brick-lined base, to allow microbes and worms to enter the wet waste directly and facilitate faster composting. This will also help in easy absorption of leachate, making the soil adjacent to the pit healthy and fertile. Pits are provided with wide opening in the front for the convenience of workers hauling the compost out.

ii. Process of wet waste composting

Segregated wet waste can be composted aerobically. To set up the composting pits, a layer of discarded green coconut shells is arranged upside down at the bottom of the pit, to let the leachate flow out of the heap efficiently and to improve the ventilation of the heap. Over this, a layer of husk or horticultural waste such as dry leaves or grass is placed and on top of that a layer of cow dung is spread. This is done in order to facilitate the growth of micro-organisms which in turn increases the rate of decomposition of waste. Above this, wet waste is placed. After dumping the waste in the cubical pits, it is mixed manually after every two–five days using a shovel or a diamond fork.

Figure: Composting pit layers



Source: CSE, 2017

Wet waste is taken to the composting setup, and the pits are filled with it one by one. Once a pit is full, it is left undisturbed for decomposition. Depending on the weather, it takes around 45–60 days for the compost to get ready. Once ready, the mixture is sieved to obtain homogeneous and fine compost. The decomposition process can be enhanced by utilizing cow dung or cow urine. Cow dung helps to maintain the nitrogen balance of the mixture. Similarly, dry leaves can be mixed in to maintain the carbon level. Maintaining both carbon and nitrogen level is important for achieving optimum decomposition

and obtaining good quality compost. To speed up the decomposition process, bioculture can be added to the mixture. This product also helps in reducing the smell from the decomposing waste.

Schedule –IV

[See clause 2(h) and (q)]

Part – A
Specifications of organic fertilizers

SPECIFICATION OF ORGANIC FERTILISER		
1. City compost:		
(i)	Moisture, per cent by weight	15-25
(ii)	Colour	Dark brown to black
(iii)	Odour	Absence of foul odour
(iv)	Particle size	Minimum 90 per cent material should pass through 4 mm IS sieve
(v)	Bulk density (g/cm^3)	<1
(vi)	Total organic carbon, per cent by weight, minimum	12
(vii)	Total Nitrogen (as N), per cent by weight, minimum	0.8
(viii)	Total Phosphates (as P_2O_5), per cent by weight, minimum	0.4
(ix)	Total Potash (as K_2O), per cent by weight, minimum	0.4
(x)	C:N ratio	<20
(xi)	pH	6.5 - 7.5
(xii)	Conductivity (as dsm^{-1}), not more than	4
(xiii)	Pathogens	Nil
(xiv)	Heavy metal content, (as mg/kg), maximum	
	Arsenic as (As_2O_3)	10
	Cadmium (as Cd)	5
	Chromium (as Cr)	50
	Copper (as Cu)	300
	Mercury (as Hg)	0.15
	Nickel (as Ni)	50
	Lead (as Pb)	100
	Zinc (as Zn)	1,000

Source: Biofertilizers and Organic Fertilizers in Fertilizer (Control) Order, 1985

Annexure 6: Bye-laws for solid waste management

Draft solid waste management bye-laws for the city of (name of the city)

In exercise of the powers conferred by Section (__) of the Municipal Act, (year), and in order to implement the provisions made in the Integrated Waste Management Rules, 2017, the (City) Municipal Corporation, hereby makes the following bye-laws for management of solid waste, namely:

1. Short title and commencement
   i. These bye-laws may be called the (city) Solid Waste Management Bye-laws, (year).
   ii. They shall come into force upon approval by the elected board or empowered standing committee of (the city) and with effect from the date of its publication in the official gazette.

2. Every owner and occupier of premises within the municipal area will have to abide by and maintain the system of collection, segregation and storage of solid waste apart from having the duty to have the premises clean. Further, the owners and occupiers of premises within the municipal area shall segregate waste under three categories:
   (a) Organic or biodegradable wastes (called wet waste)
   (b) Recyclable or non-biodegradable wastes (called dry waste)
   (c) Domestic hazardous wastes

3. The (city) municipal corporation shall provide one bin for wet waste and two bins or bags for dry and hazardous waste storage to every owner and occupier of premises within the municipal area.

4. It is provided herein that each and every owner and occupier of a commercial or residential area, apartment owner or societies, co-operatives, institutions, industry etc. shall maintain three types of 'dustbins', i.e. 'green' for storing wet wastes, 'blue' for storing dry waste, and 'red' for storing domestic hazardous waste.

5. Domestic hazardous waste like discarded paint drums, pesticide cans, CFL bulbs, tube lights, expired medicines, broken mercury thermometers, used batteries, used needles and syringes and contaminated gauge etc. generated at the household level shall be stored separately in a 'red' bag and be given to the waste collector. Date expired medicines or chemicals thus collected shall be given to the concerned medicine distributor for safe disposal under the EPR programme.

6. The (city) municipal corporation shall bear the responsibility for the collection and disposal of sanitary and domestic biomedical waste like expired medicines, broken mercury thermometers, used needles and syringes etc. to the nearest common biomedical waste treatment facility.

7. It will be the responsibility of the (city) municipal corporation to provide adequate number of litter bins at commercial areas and all important public

places such as places of worship, parks, bus-stands, and railway stations. At each location, two types of litter bins shall be provided; 'green' for disposing of wet wastes and 'blue' for disposing of dry waste.

8. In commercial areas and important public places, litter bins shall be placed every 200 meters by the (city) municipal corporation. In other areas, they shall be placed every 500 meters.

9. Every street vendor and hawker will buy their own two dustbins for wet and dry waste disposal.

10. It shall be the responsibility of street vendors and hawkers to segregate waste into wet and dry and transfer the waste every day in a collection vehicle designated by the corporation.

11. Slaughter waste from meat, poultry and fish shops shall be stored separately in a bin and collected in a separate collection vehicle designated by the corporation and disposed of appropriately.

12. In every designated commercial area, it shall be the responsibility of the market associations or group of shop owners to ensure that there is no littering and throwing of garbage on the roads, drains and public spaces.

13. Horticultural waste (agricultural waste, garden waste) generated in residential and commercial areas should be segregated and stored separately within the premises. It should be composted within the premises or sent to the nearest compost facility of the corporation.

14. The (city) municipal corporation shall be responsible for collection and composting of horticulture waste from public parks and gardens. Tree leaves on the roads and other public spaces shall also be collected and composted by the corporation.

15. It shall be the responsibility of the owner or occupier of premises to store the construction material and construction and demolition (C&D) waste within the premises.

16. In case the construction material or C&D waste has to be stored on the road and other public spaces due to unavoidable reasons like lack of space or requirements of construction or demolition works, the owner or occupier of the premises shall take permission from the municipal corporation to do so. The municipal corporation shall charge a fee to allow storage of construction material and construction and demolition (C&D) waste on the road and other public spaces.

17. It shall be the responsibility of the owner or occupier of premises to dispose C&D waste at a place designated by the municipal corporation. The C&D waste can be used for filling low-lying areas, provided it is done in an environmentally-safe manner and with the permission and consent of the owner of the land.

18. The (city) municipal corporation shall bear the responsibility of collection and disposal of C&D waste generated from its own activities and activities of other government departments working in the municipal area.

19. The (city) municipal corporation shall earmark a specific area for the disposal of C&D waste and other inert wastes like road sweepings at a notified dumpsite.

20. The (city) municipal corporation shall also ensure that inert waste collected from road sweepings, de-silting of drains, digging of roads and public spaces for various activities etc. is collected and disposed of in a time-bound matter at a specific site as notified. It can also use these wastes, if it deems appropriate, for filling low-lying areas.

21. The (city) municipal corporation shall explore all opportunities for the gainful utilization of the C&D waste.

22. Sales or distribution of plastic carry bags is prohibited in the municipal area, except for use of waste collection bags in bins.

23. Persons or establishments found selling or distributing plastic carry bags below 50 microns thickness shall be fined under these Rules, except the provision under Rule 22.

24. No person shall throw waste or litter at any public place. They shall use dustbins and litter bins so provided for disposing of the waste.

25. The (city) municipal corporation shall develop an effective collection system to collect and transfer segregated waste for processing.

26. The segregated wet waste from each house, shop, commercial area, hotel, restaurant, street bin, educational institute and all other generators of solid waste in the city shall be collected by the corporation on a regular basis.

27. The (city) municipal corporation shall develop and execute a plan by 1 January 2018 to collect segregated wet waste every day; segregated dry waste every alternate day and segregated sanitary waste and domestic hazardous waste once a week.

28. Marriage or event halls shall take permission from the (city) municipal corporation at least seven working days prior to the date of the event or function and shall themselves make the arrangement for segregation and storage of waste at the place of event or function. The segregated waste shall be handed over to waste collectors of the (city) municipal corporation. The (city) municipal corporation can grant permission for days, for weeks, for months or for one year. It shall charge a fees for holding the function or event. In case of non-compliance, a fine as per Section 40 shall be levied.

29. The (city) municipal corporation shall levy the following user fees for waste management:

S. no.	User category	Monthly user charge
A.	Residential	
1	Residential house (per family, flat or house)	
2	Slums and below-poverty-line residences	
B.	Non-residential	
1.	Street vendors	
	c) Without structure (roadside)	
	d) With structure	
2.	Eating joints, restaurants, cafes, sweet shop, coffee house etc.	
3.	Meat, fish and poultry shops	
4.	Other shops	
5.	Restaurants (Non-AC)	
6.	Restaurants (AC)	
7.	Guest houses	
8.	Malls	
9.	Hostels	
10.	Dharmshalas	
11.	Star or equivalent hotels	
12.	Commercial and government offices and educational institutions per unit	
13.	Banks and insurance offices	
14.	Coaching classes	
C.	Health service institutes (except biomedical waste)	
1.	Clinics per unit	
	Dispensaries and laboratories	
2.	Hospitals (up to 50 beds)	
3.	Hospitals (more than 50 beds)	
D.	Others	
1.	Religious places	Religious centres can willingly contribute to cleanliness in and around their premises
2.	Small-scale industries, cottage units, workshops, petrol pumps (only non-hazardous waste)	
3.	Cold storage, godowns and storage areas where large amount of waste is generated	
5.	Marriage and event halls, exhibitions, and fairs	
6.	Others	
E.	User charges for bulk collection	
1.	C&D waste	---------/ tractor truck
2.	C&D waste	---------/ tipper truck

30. The user fees as listed in Section 29 shall be revised after every two years.

31. The user fee shall start to be collected one month after the passing of the bye-laws in the official gazette.
32. The user fee shall be collected on a monthly basis by the corporation and a printed slip will be issued by the corporation for payment of the fee by the user listed in Section 29.

33. The (city) municipal corporation shall make every effort to increase the awareness of people on waste management and the user fees. Proper announcement through advertisement in media, hoardings, public announcements, distribution of leaflets etc. shall be undertaken.

34. The (city) municipal corporation shall constitute a 'city waste management task force' for overseeing the successful implementation of the Municipal Corporation Solid Waste Management Bye-laws, (Year). The Task Force shall be constituted of the following:
    (a) Mayor
    (b) Deputy mayor
    (c) Municipal commissioner or an official nominated by the commissioner not below the rank of city manager
    (d) Two elected councillors nominated by the mayor

35. The city waste management task force shall meet every two weeks to take stock of the implementation of the bye-laws and resolve issues.

36. The (city) municipal corporation shall constitute a 'ward waste management task force' in all wards of the corporation. This task force shall supervise collection, transfer and proper processing of segregated wastes. The task force shall constitute of the following:
    a) Elected members from the ward
    b) Ward supervisor
    c) Two respected local residents (doctors or academics) of the ward nominated by the mayor

37. The 'ward waste management task force' shall have the responsibility to spread awareness for segregation at source in every ward and sensitize people through IEC.

38. The ward waste management task force shall undertake sensitization programmes to inform people about the bye-laws and fines or penalty for non-compliance and littering.

39. The ward waste management task force shall monitor the implementation of the (City) Municipal Corporation Solid Waste Management Bye-laws, (Year) and recommend to the city waste management task force the actions that need to be taken for successful implementation of the bye-laws.

40. The (city) municipal corporation shall be empowered to levy fine from households, owners or occupiers of the premises for not abiding with the bye-laws and for littering in public areas. The amount of fine shall be as follows:

S. no.	Category	Amount of fine or penalty
(i)	Guest houses, hostel, star or equivalent hotel, commercial offices, government offices, banks, insurance offices, educational institutions, malls, clinics, dispensaries, laboratories, hospitals, cold storage, godowns, marriage and event halls, exhibition and fairs, and storage areas where large amount of waste is generated.	1st offence: Warning 2nd offence – ------- Every subsequent offence – --------
(ii)	Eating joints, restaurants, cafes, sweet shops, coffee houses, meat, fish and poultry shops, coaching classes, petrol pumps, small-scale industries, cottage units, workshops (only non-hazardous waste) etc.	1st offence: Warning 2nd offence – ------- Every subsequent offence – -------
(iii)	Street vendors, with or without a structure	1st offence: Warning 2nd offence – ------ Every subsequent offence – -------
(iv)	Any other commercial establishments other than those mentioned in serial no. (i), (ii) and (iii)	1st offence: Warning 2nd offence – ------- Every subsequent offence – ---------
(v)	Households and individuals	1st offence: Warning 2nd offence – ------- Every subsequent offence – ------
(vi)	Open burning of the waste	1st offence: Warning 2nd offence – ------ Every subsequent offence ----------
(vi)	Penalty for dumping C&D waste	
A	Penalty for dumping of C&D waste on road or on public spaces by individual without prior permission	------/day + amount for sending municipal vehicle to lift and dispose the C&D waste
B	Penalty for dumping of C&D waste by commercial premises, industry or any other bulk generator	------/ tonne/ day + amount for sending municipal vehicle to lift and dispose the C&D waste
(vii)	Mixing of biomedical waste with municipal waste by hospitals, nursing homes, clinic, pathology lab etc.	1st offence: Warning 2nd offence ------ Every subsequent offence -------
(viii)	Non-compliance in approval from corporation for event by marriage halls, event halls, exhibition, and fairs etc.	--------/day

41. Every violation shall be recorded and the corporation shall provide a slip to the violators to deposit the fine within seven days of the violation at an office(s) designated by the (city) municipal corporation for the purpose.

42. If a violator, who is the owner or occupier of a premise, fails to deposit the fine within the stipulated timeframe, then the fine plus 12 per cent annual interest rate shall be added to the property tax and recovered.

43. If the violation continues, the defaulter can be taken to a civil court as per the Environment Management Act.

44. If an individual or street vendor is found littering on the road or other public places, a spot fine can be imposed and recovered.

45. The ward waste management taskforce shall submit a fortnightly report to the city waste management task force about the violation so found and action taken.

46. The (city) municipal corporation shall publish a status report on the number of violations and violators, the amount of fines imposed and recovered etc. on its website every month.

47. The (city) municipal corporation shall carry out information, education and communication (IEC) and awareness raising in residential and commercial areas of the city for spreading the message of segregation at source.

48. The (city) municipal corporation shall circulate information on the bye-laws through use of newspapers, radio, hoardings and local TV channels for one month after the date of publication of the bye-laws in the Official Gazette. After that, a summary of the bye-laws shall be displayed at prominent public places in the form of hoardings.

With a staggering population of 1.3 billion and waste generation amounting to 62 million tonne every year, there is no denying that India is drowning in waste. As the economy continues to grow at a fast pace, the increase in waste generation is outpacing the increase in population growth by a factor of five. Currently, the focus of solid waste management in India is merely on collection and transportation to landfills, with hardly 23 per cent waste getting treated or processed. Land for disposal is fast exhausting. In any case, landfills are an environmental and health hazard.

In this scenario, decentralized waste management presents itself as the best option. It not only cuts costs considerably, as less money is spent on transportation and obtaining land for landfills, but it also helps generates additional resources from waste via composting and recycling, which means more income for a large set of people (such as waste collectors, informal workers and recyclers) in the chain. The environmental costs incurred due to pollution of land, water and air from unsanitary landfills are also reduced drastically.

As India immerses into a paradigm of decentralized management for its teeming rivers of waste, we hope that these guidelines will help streamline the process.

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