1800

D-72597/25

IN THE SUPREME COURT OF INDIA
CIVIL APPELLATE JURISDICTION
(Under Article 136 of the Constitution of India)
[Supreme Court Rules, 2013 - Order XXII Rule 3 (1) (a)]
SPECIAL LEAVE PETITION (C) NO. OF 2025

FILED ON
15 DEC 2025
SUPREME COURT OF INDIA

[Against the Judgment and Final Order dated 21/08/2025 passed by the High Court of Judicature at Allahabad, Lucknow Bench in WRIT – C No. – 7723 of 2025]

IN THE MATTER OF:-

MUNICIPAL CORPORATION LUCKNOW ...PETITIONER

VERSUS

UTTAR PRADESH POLLUTION CONTROL BOARD& ORS. ...RESPONDENTS

I.A. NO. /2025:	36981	Application seeking permission to file additional documents.
I.A NO. /2025:	36982	Application seeking exemption from filing certified copy of the impugned judgment.
I.A NO. /2025:	36983	Application seeking exemption from filing official Translation of annexure.
I.A NO. /2025:	36985	Application Seeking Condonation of Delay in filing SLP
I.A NO. /2026:	36987	Application Seeking Condonation of Delay in refiling SLP

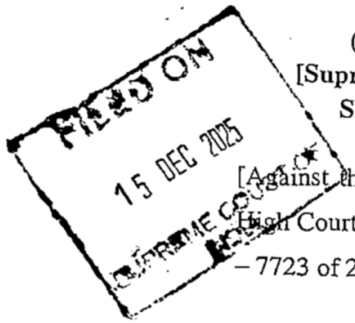
VOL-II: (PAGES : 451-696)

PAPER – BOOK
[For Index Kindly See Inside]
ADVOCATE FOR PETITIONER: MR. JAYDIPPATI

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PAPER – BOOK
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IN THE SUPREME COURT OF INDIA

CIVIL APPELLATE JURISDICTION

SPECIAL LEAVE PETITION (CIVIL) No. OF 2025

IN THE MATTER OF:-

MUNICIPAL CORPORATION LUCKNOW ...PETITIONER

VERSUS

UTTAR PRADESH POLLUTION CONTROL BOARD& ORS. ...RESPONDENTS

OFFICE REPORT ON LIMITATION

1. The Petition is/ are within time.
2. The Petition is barred by time and there is a delay of 26 days in filing the same against order dated 21/08/2025 petition for condonation of 26 days delay has been filed.
3. There is delay of 17 days in refilling the petition and petition for condonation of 17 days delay in refilling has been filed.

NEW DELHI

DATED: 15/12/2025

SECTION OFFICER

1808

A-1

PROFORMA FOR FIRST LISTING

SECTION

The case pertains to (Please tick/check the correct box):

- ☐ Central Act: **Constitution of India**
- ☐ Section: **Article 136**
- ☐ Central Rule: (Title) **N.A.**
- ☐ Rule No (s): **N.A.**
- ☐ State Act (Title): **N.A.**
- ☐ Section: **N.A.**
- ☐ State Rule: (Title) **N.A**
- ☐ Rule No (s): **N.A.**
- ☐ Impugned Interim Order: **N/A**
- ☐ Impugned final Order/Decree: **21.08.2025**
- ☐ High Court: **High Court of Judicature at Allahabad , Lucknow Bench**
- ☐ Names of Judges: **Hon'ble Mr. Manjive Shukla and Hon'ble Mr. Justice Rajan Roy**
- ☐ Tribunal/Authority: **N/A**

---

1. Nature of matter: Criminal

2. (a) Petitioner/appellant No.1: **Municipal Corporation Lucknow**
   (b) e-mail ID: **N.A.**
   (c) Mobile phone number: **N. A.**

3. (a) Respondent No.1: **UTTAR PRADESH POLLUTION CONTROL BOARD**
   (b) e-mail ID: **Not Known**
   (c) Mobile phone number: **Not Known**

4. (a) Main category classification: **14**
   (b) Sub classification: **1409**

5. Not to be listed before: **N. A.**

6. (a) Similar disposed off matter with citation, if any, & Case Details: **No similar disposed off matter.**
   (b) Similar pending matter with Case Details: **No similar matter is pending.**

7. **Criminal Matters: No**
   a) Whether accused/convict has surrendered: **NO**

1809

b) FIR No. No

c) Police Station: No

d) Sentence Awarded: **No**

e) Period of Sentence Undergone including Period of Detention/Custody Undergone: **No**

f) Whether any earlier case between the same parties is filed: **No**

g) Particulars of the FIR and Case: **No**

h) Whether any bail application was preferred earlier and decisionthereupon: **No**

8. **Land Acquisition Matters: N. A.**

a) Date of Section 4 notification: **N. A.**

b) Date of Section 6 notification: **N. A.**

c) Date of Section 17 notification: **N. A.**

9. **Tax Matters:** State the tax effect: **N. A.**

10. **Special Category** (first petitioner/appellant only)**:N/A**

☐ Senior citizen>65 years

☐ SC/ST

☐ Woman/child

☐ Disabled Legal Aid case

☐ In custody

11. Vehicle Number (in case of Motor Accident Claim matters): **N. A.**

12. Whether there was / is litigation on the same point of law, if yes, details thereof: No

Date: 15.12.2025

Jaydip Pati

(JAYDIP PATI)
Advocate-On-Record for Petitioner
Chamber No.- 80, A. K. Sen Block,
Supreme Court of India
E-mail I.D.: jaydippatiaoroffice@gmail.com
AOR Code: 3796

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B

SYNOPSIS

The present Special Leave Petition is directed against the Judgment and Final Order dated 21.08.2025 passed by the Hon'ble High Court of Judicature at Allahabad, Lucknow Bench, in Writ-C No. 7723 of 2025, whereby the High Court summarily dismissed the writ petition instituted by the petitioner, Lucknow Municipal Corporation, assailing the imposition of a massive, unprecedented and exorbitant Environmental Compensation of Rs. 59.99 crore levied by the Uttar Pradesh Pollution Control Board vide order dated 02.04.2025. The High Court declined to undertake any examination of the legality, jurisdictional competence or factual sustainability of the impugned Environmental Compensation order and dismissed the writ petition solely on the ground of availability of an alternate statutory remedy, thereby giving rise to grave and substantial questions of law warranting interference by this Hon'ble Court.

The petitioner, Lucknow Municipal Corporation, is a statutory urban local body constituted under the provisions of the Uttar Pradesh Municipal Corporation Act and is entrusted with the discharge of essential civic and municipal functions, including the collection, transportation, processing and management of municipal solid waste for the city of Lucknow. In furtherance of its statutory obligations, the petitioner entered into a tripartite

C

concession agreement dated 21.03.2017 with M/s Ecogreen Energy (Lucknow) Pvt. Ltd., whereby the responsibility for collection, transportation and processing of municipal solid waste was contractually entrusted to the concessionaire, subject to compliance with applicable environmental laws, rules and regulatory oversight by the competent authorities.

During inspections conducted by the Uttar Pradesh Pollution Control Board in the years 2019–2020, serious violations were found at the waste processing facility being operated by the concessionaire. The plant was found to be non-operational, untreated municipal waste had accumulated in large quantities, and statutory environmental norms and standards were found to have been breached. Recognising that the defaults and violations were attributable to the concessionaire, the UPPCB itself imposed Environmental Compensation of approximately Rs. 14.40 crore upon M/s Ecogreen Energy. Simultaneously, the petitioner repeatedly issued directions to the concessionaire to rectify the deficiencies, restore operations and clear the accumulated waste. Upon persistent and continued failure on the part of the concessionaire, the petitioner terminated the concession agreement and blacklisted M/s EcogreenEnergy on 06.07.2023, while also invoking

contractual remedies and raising claims for damages aggregating to approximately Rs. 275.34 crore.

Thereafter, the petitioner itself undertook extensive, sustained and comprehensive remedial and corrective measures to address the environmental situation inherited from the defaulting concessionaire. Fresh contracts for waste processing were awarded, in-house waste processing capacity was augmented and long-term, sustainable waste management solutions were implemented. The petitioner also complied with the directions issued by the Hon'ble National Green Tribunal in OA No. 654 of 2022, including ring-fencing of funds, adoption of scientific waste handling practices and systematic clearance of legacy waste. By early 2025, the petitioner had substantially eliminated the accumulated waste backlog and was operating the Shivri waste processing plant at the prescribed efficiency levels, a fact duly reflected in contemporaneous inspection records.

Notwithstanding the aforesaid remedial efforts and substantial compliance, the UPPCB issued a show-cause notice dated 09.12.2024 alleging non-compliance with the Solid Waste Management Rules, 2016 from 01.01.2024 onwards. The petitioner submitted a detailed and comprehensive reply on 26.03.2025, enclosing all relevant documents and specifically relying upon

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the UPPCB's own inspection report dated 20.03.2025, which categorically recorded that the petitioner was in compliance with the applicable environmental norms. The petitioner also expressly requested that it be granted an opportunity of personal hearing before any adverse or penal decision was taken.

In complete disregard of the petitioner's reply, the inspection report and the specific request for personal hearing, the UPPCB, without conducting any inquiry and without affording any opportunity of hearing, abruptly passed the impugned order dated 02.04.2025 imposing Environmental Compensation of Rs. 59.99 crore upon the petitioner. The computation of this amount was founded on an arbitrary, conjectural and unfounded assumption that the city of Lucknow generated 2,395 tonnes per day of municipal solid waste for 340 days. This assumption is demonstrably erroneous, as official weighbridge data maintained by the petitioner shows that the average waste generation in the year 2024 was approximately 1,986 tonnes per day. Even more strikingly, the UPPCB itself had represented before the Hon'ble National Green Tribunal in September 2024 that Lucknow generated only 99 tonnes per day, thereby exposing the complete absence of consistency, transparency and factual basis in the impugned computation.

F

Aggrieved by the arbitrary, disproportionate and jurisdictionally flawed order, the petitioner approached the High Court by filing Writ-C No. 7723 of 2025, specifically challenging the authority of the UPPCB to impose Environmental Compensation under the Environment (Protection) Act, 1986, the manifest arbitrariness and factual inaccuracies underlying the computation, and the flagrant violation of the principles of natural justice. However, by the impugned judgment dated 21.08.2025, the High Court dismissed the writ petition at the threshold solely on the ground that an alternate statutory remedy of appeal was available before the Hon'ble National Green Tribunal under the Water and Air Acts. The High Court placed reliance on Delhi Pollution Control Committee v. Lodhi Property Company, (2025) 5 SCC 1, as well as Indian Council for Enviro-Legal Action v. Union of India (1996), without examining the applicability of those decisions to the statutory framework governing the Environment (Protection) Act, 1986.

The Government of India formulated the Municipal Solid Waste Management Manual, 2016, wherein and whereby the role of the State Pollution Control Board / Pollution Control Committee has been clearly delineated as regulatory, supervisory and recommendatory in nature. The Manual specifically enumerates the duties of the State Pollution Control

G

Board, which are confined to monitoring the implementation of the Solid Waste Management Rules, granting, suspending or cancelling authorisation, issuing directions for compliance, and submitting reports to the Central Pollution Control Board and the State Government (pp. 28–30, Clause 16; pp. 334–335). The Manual does not confer any adjudicatory power upon the State Pollution Control Board to impose or levy any monetary penalty or environmental compensation, nor does it prescribe any upper cap, rate, or mechanism for calculation of such penalty (pp. 28–30; p. 34). On the contrary, the Manual makes it explicit that in cases of non-compliance, the role of the State Pollution Control Board is limited to reporting and recommending action to the competent authority and not to unilaterally determine or recover any monetary liability (p. 34). A holistic reading of the Manual clearly establishes that there is no provision authorising the State Pollution Control Board to quantify, assess or recover any penalty, and no formula or methodology for computation of penalty or compensation is provided anywhere therein, rendering the impugned action wholly dehors the framework of the Municipal Solid Waste Management Manual, 2016.

The High Court failed to examine whether the UPPCB had any delegated authority under Section 5 of the Environment (Protection) Act, 1986 to impose Environmental Compensation, whether the impugned order was

factually or legally sustainable, and whether the imposition of an enormous financial liability without affording a hearing violated settled principles of natural justice. The impugned judgment, therefore, raises substantial questions of law of general public importance concerning the scope and ambit of Section 5 of the Environment (Protection) Act, the jurisdictional competence of State Pollution Control Boards, the application of the Polluter Pays principle and the indispensability of procedural fairness.

The impugned Environmental Compensation order is ex facie arbitrary, punitive and disproportionate. The petitioner, a statutory municipal body discharging public duties, had already remedied the environmental harm and ensured compliance, whereas the original default lay with a private concessionaire against whom proceedings and contractual claims were initiated. Imposition of a liability of nearly Rs. 60 crore upon the petitioner on the basis of conjectural and inconsistent data completely distorts the Polluter Pays principle, which mandates that liability must attach to the actual polluter responsible for the environmental damage. The impugned order further violates the principles of transparency, proportionality and non-arbitrariness emphasised by this Hon'ble Court in DPCC v. Lodhi Property Company.

The impugned order is further vitiated by a patent and egregious violation of the principles of natural justice. Despite submission of a detailed reply supported by the UPPCB's own inspection report and despite a specific request for a personal hearing, the petitioner was never afforded any opportunity of being heard. No inquiry was conducted, no reasons were recorded for rejecting the petitioner's explanation and the order was passed mechanically. The denial of hearing assumes added gravity in view of the magnitude of the liability imposed, the disputed factual assumptions underlying the computation and the public character of the petitioner, whose financial resources are meant for civic governance and public welfare.

It is respectfully submitted that the UPPCB does not derive any independent statutory power under the Environment (Protection) Act, 1986 to levy or impose Environmental Compensation. Section 5 of the Act vests the power to issue directions exclusively in the Central Government, and any exercise of such power by a State Pollution Control Board can only be pursuant to a specific and express delegation. Even assuming such delegation, Section 5 contemplates only regulatory or preventive directions and does not create any adjudicatory mechanism for determination of liability or imposition of monetary compensation, nor does it prescribe any method, ceiling or formula for computation thereof. The Act does not confer upon the Pollution

Control Board the role of an adjudicating authority empowered to quantify environmental damage or levy punitive amounts. In the absence of a clear legislative mandate or prescribed procedure, the unilateral levy of Environmental Compensation by the UPPCB is wholly without authority and beyond the statutory scheme.

It is further submitted that the Municipal Solid Waste Management Manual, which operationalises the Solid Waste Management Rules, does not vest the State Pollution Control Board with any power to levy penalty or impose Environmental Compensation. The Manual delineates the role of the Board as one of monitoring, technical supervision, grant of authorisation and reporting, and emphasises compliance facilitation and mitigation. It does not prescribe any mechanism, formula or ceiling for monetary penalties, nor does it contemplate the Board assuming an adjudicatory role. Financial references therein pertain only to project planning and mitigation costs and not to punitive recovery. Any attempt to derive penal powers from the Manual is therefore wholly misconceived and legally untenable. During the relevant period, substantial and measurable improvements were achieved in waste-processing efficiency, dry-waste segregation and scientific windrow composting through the services of newly engaged contractors, resulting in tangible environmental restoration and stabilisation of the solid-waste

management system in the city of Lucknow. It is further submitted that Lucknow demonstrated exceptional performance under the Swachh Survekshan 2024–25 conducted pursuant to the Swachh Bharat Mission, securing a position among the top three cities in the country with an overall score of 96%. This performance was driven by strengthened door-to-door collection, strict wet-and-dry waste segregation, enhanced citizen participation and adoption of digital initiatives such as the "Lucknow One App", leading to sustained improvements in urban cleanliness and waste management.

In these circumstances, the impugned judgment and the underlying Environmental Compensation order raise serious and far-reaching questions relating to statutory authority, jurisdictional competence, procedural fairness and foundational principles of environmental law, and therefore call for authoritative determination by this Hon'ble Court.

L

LIST OF DATES AND EVENTS

Date	Event
2016	The Government of India formulated the *Municipal Solid Waste Management Manual, 2016*, wherein and whereby the role of the State Pollution Control Board / Pollution Control Committee has been clearly delineated as regulatory, supervisory and recommendatory in nature. The Manual specifically enumerates the duties of the State Pollution Control Board, which are confined to monitoring the implementation of the Solid Waste Management Rules, granting, suspending or cancelling authorisation, issuing directions for compliance, and submitting reports to the Central Pollution Control Board and the State Government (pp. 28–30, Clause 16; pp. 334–335). The said Manual does not confer any adjudicatory power upon the State Pollution Control Board to impose or levy any monetary penalty or environmental compensation, nor does it prescribe any upper cap, rate, or mechanism for calculation of such penalty (pp. 28–30; p. 34). On the contrary, the Manual makes it evident that in cases of non-compliance, the role of the State Pollution Control Board is limited to reporting and recommending action to the competent authority,

Date	Event
	and not to unilaterally determine or recover monetary liability (p. 34). A comprehensive reading of the Manual demonstrates that there is no provision authorising the State Pollution Control Board to quantify, assess, or recover any penalty, and no formula or methodology for computation of penalty or compensation is provided anywhere in the Manual, thereby clearly establishing that the impugned action of imposing penalty is dehors the framework of the Municipal Solid Waste Management Manual, 2016. **True copy of the *Municipal Solid Waste Management Manual, 2016* is attached herewith and marked as Annexure–P/1.** **Page No.** 19-622
21.03.2017	The Petitioner, Lucknow Municipal Corporation (LMC), being the statutory urban local body entrusted with the constitutional and statutory obligation of managing municipal solid waste within the territorial limits of Lucknow, executed a tripartite concession agreement with M/s Ecogreen Energy (Lucknow) Pvt. Ltd. for the integrated functions of collection, transportation, processing, and scientific disposal of municipal waste generated in the city. The said agreement constituted the foundational contractual framework under which Ecogreen was expected to operate modern waste-

Date	Event
	processing systems in compliance with the Solid Waste Management Rules, 2016.
03.09.2019 – 18.12.2019	During this period, the Uttar Pradesh Pollution Control Board (UPPCB) conducted multiple inspections of the waste-processing facilities operated by Ecogreen. The inspections revealed persistent and grave non-compliances, including complete non-operation of the processing plant, accumulation of massive quantities of unprocessed municipal waste, and violations of the mandatory standards prescribed under the SWM Rules, 2016. Owing to the seriousness of these defaults, UPPCB imposed Environmental Compensation amounting to Rs. 1440.71 lakh upon Ecogreen.
August 2020	In view of the deteriorating sanitation conditions and the failure of Ecogreen to undertake corrective measures, the Petitioner issued a series of formal written notices and communications to the concessionaire, directing urgent clearance of accumulated waste, rectification of the backlog, compliance with contractual obligations, and payment of outstanding dues. Despite repeated reminders, no meaningful compliance was undertaken by Ecogreen. **True trnslated copy of the written notices issued in August 2020**

Date	Event
	is attached herewith and marked as Annexure–P/2. **Page No.** 623-651
06.07.2023	Owing to sustained, serious, and deliberate contractual defaults by Ecogreen, including its failure to process municipal waste and its violation of statutory standards, the Petitioner lawfully terminated the concession agreement and formally blacklisted the company from participating in future municipal projects. A quantified damages claim of approximately Rs. 275.34 crore was simultaneously raised against Ecogreen, representing environmental, financial, and administrative losses caused to the city. **True copy of the termination and blacklisting order dated 06.07.2023 is attached herewith and marked as Annexure–P/3.** **Page No.** 652-678
22.07.2023	Pursuant to the directions of the Hon'ble National Green Tribunal (NGT) issued on 13.02.2023 and 31.03.2023 in OA 654/2022 and RP 15/2023, the Petitioner ensured full compliance by depositing Rs. 63.95 crore into a ring-fenced account and by closing down the non-compliant transfer station at Priyadarshini Colony. These

Date	Event
	actions were duly recorded on 22.07.2023 and formed part of the compliance reported to statutory authorities. **True trnslated copy of compliance report dated 22.07.2023is attached herewith and marked as Annexure–P/4.** **Page No.** 679-683
07.02.2024	The Hon'ble NGT, while monitoring compliance in OA 654/2022, issued directions mandating 100% processing of municipal waste generated in Lucknow and time-bound clearance of all legacy waste. These directions significantly guided subsequent administrative steps taken by the Petitioner for augmenting municipal waste-processing infrastructure. **True copy of the NGT order dated 07.02.2024 is attached herewith and marked as Annexure–P/5. Page No.** 684-693
11.09.2024	During proceedings in OA 607/2024 relating to plastic-waste management, the UPPCB incorrectly represented before the Hon'ble NGT that the city of Lucknow generates merely 99 tonnes per day (TPD) of municipal waste. At that stage, the Petitioner had not been impleaded as a party and was unaware of the proceedings, and therefore could not correct this erroneous factual submission.

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Date	Event
	The Hon'ble Tribunal, however, imposed no penalty and merely directed a fresh status report, while simultaneously impleading the Petitioner as a party. **True copy of the proceedings/order dated 11.09.2024 is attached herewith and marked as Annexure–P/6.Page No.** 694-696
15.11.2024	The Petitioner formally engaged the new contractors, namely M/s Horizon Solutions and M/s Bhumi Green Energy, for legacy and fresh-waste processing respectively. The combined processing capacity at the Shivri facility thereby increased to 4000 TPD (legacy waste) and 2100 TPD (fresh waste), restoring operational stability after the collapse of Ecogreen's operations. **True copies of the documents evidencing award of fresh contracts dated 15.11.2024 are attached herewith and marked as Annexure–P/7.Page No.** 697-741
09.12.2024	The UPPCB issued a Show-Cause Notice to the Municipal Commissioner of Lucknow alleging non-compliance with SWM Rules for the period commencing 01.01.2024, and proposing imposition of Environmental Compensation. The notice did not afford an opportunity for personal hearing nor did it contemplate

Date	Event
	any inquiry under the amended statutory scheme governing Adjudicating Officers. **True translated copy of the Show-Cause Notice dated 09.12.2024 is attached herewith and marked as Annexure–P/8. Page No.** 742-748
26.03.2025	The Petitioner conducted a comprehensive inspection on 20.03.2025, confirming full-scale functioning of the Shivri plant with upgraded facilities. A detailed reply dated 26.03.2025 was submitted to the UPPCB enclosing operational data, weighbridge records, and capacity-utilisation statistics. Despite this, no hearing or inquiry was granted. **True copy of the inspection report and reply dated 26.03.2025 are attached herewith and marked as Annexure–P/9. Page No.** 749-755
02.04.2025	That ignoring the Petitioner's detailed reply, the UPPCB passed the order imposing Environmental Compensation of Rs. 59,99,20,000, relying on an assumed waste-generation figure of 2395 TPD, which was contrary to actual weighbridge data and inconsistent with UPPCB's earlier (albeit incorrect) submission of 99 TPD before the Hon'ble NGT. **True translated copy of the order dated 02.04.2025 is attached herewith and marked as Annexure–P/10.**

Date	Event
	Page No. 756-763
08/07/2025	That vide letter no. D/25/MC/EE/25 dated 08.07.2025, the Municipal Commissioner, Lucknow Municipal Corporation, submitted to the UP Pollution Control Board that the environmental penalty of Rs.5999.20 lakh imposed vide letter dated 02.04.2025 is liable to review and recall, as the Hon'ble NGT's order dated 11.09.2024 in OA No. 607/2024 did not direct any penalty but only sought a fresh report from UPPCB. The penalty was based on incorrect waste generation figures (99 TPD) instead of the actual ~2000 TPD, consistently communicated through reports and inspections. LMC's detailed reply to the show cause notice dated 26.03.2025 was not considered, nor was any personal hearing granted, violating principles of natural justice. The reply highlighted operational difficulties at the Shivri facility due to failure of the previous concessionaire, phased commissioning of new units achieving 2100 TPD, legacy waste remediation, compliance with NGT directions, and initiatives in C&D and plastic waste management. LMC emphasized severe financial constraints and irreparable hardship from the penalty, requesting UPPCB to

Date	Event
	review and recall the penalty and show cause notice in the interest of justice.**True copy of letter no. D/25/MC/EE/25 dated 08.07.2025is attached herewith and marked as annexure P/11.** **Page No.** 764-768
17.07.2025	That vide judgment dated 17.07.2025 in WRIT - C No. - 4816 of 2024 **(Suez India vs. Uttar Pradesh Pollution Control Board)**the Hon'ble High Court of Judicature at Allahabad, Lucknow Bench held that the Uttar Pradesh Pollution Control Board has no statutory authority to impose or recover environmental compensation from any industry, as the power to adjudicate liability for such compensation is exclusively vested in the National Green Tribunal under Sections 15 and 18 of the NGT Act. The Court clarified that the Board's powers under Section 33-A of the Water Act and Section 31-A of the Air Act are purely administrative and preventive, limited to issuing directions such as closure, regulation of operations, or stoppage of utilities, and do not extend to determining or imposing compensation. It further rejected the contention that NGT directions authorized the Board to levy

Date	Event
	compensation, holding that no tribunal can confer adjudicatory jurisdiction not granted by statute. Consequently, all compensation orders passed by UPPCB were quashed, with liberty reserved for the Board to approach the NGT for any claim of environmental compensation. **True copy of the judgement dated 17.07.2025in WRIT - C No. - 4816 of 2024(Suez India vs. Uttar Pradesh Pollution Control Board) is attached herewith and marked as Annexure–P/12. Page No.** 769-842
29.07.2025	That vide letter no. D/1175/A.N.A./P.A./24 dated 26.03.2025, the Municipal Commissioner of Lucknow informed the UP Pollution Control Board regarding environmental compensation imposed under the order dated 03.04.2025 in OA No. 607/2024 (*Hindustan Times*, 22.04.2024). The letter highlighted that Rs. 1440.70 lakh imposed on M/s Ecogreen Energy Pvt. Ltd. should be recovered directly from the contractor, and that Rs. 5999.20 lakh imposed on the Municipal Corporation was excessive, based on inflated waste estimates and without considering operational constraints. It detailed steps taken by the Corporation, including engagement of M/s Horizon Solutions and M/s Bhoomi Green Pvt. Ltd. for

Date	Event
	scientific waste disposal, installation of 3x700 TPD plants, and reclamation of land, as well as creation of a ring-fenced account of Rs. 63.95 crore for environmental works. The Commissioner requested exemption of the Corporation from recovery of compensation and indicated consideration of an appeal to the Hon'ble NGT for cancellation of the Rs. 5999.20 lakh imposed.**True translated copy of letter no. Letter No.:- D/306/A.N.A./P.A./25 dated 29.07.202is attached herewith and marked as Annexure–P/13. Page No.** 843-850
1/08/2025	The petitioner herein filed Writ Petition before the High Court of Judicature at Allahabad, Lucknow Bench with prayer to set-aside environmental compensation imposed by UPPCB in the light of Suez India vs. Uttar Pradesh Pollution Control Board. **True copy of writ petition filed before the Hon'ble High Court of Judicature at Allahabad, Lucknow Bench is attached herewith and marked as Annexure P/14. Page No.** 851-873
04.08.2025	ThisHon'ble Court, in DPCC v. Lodhi Properties, Civil Appeal No(s). 757-760/2013held that the environmental regulatory framework under the Water Act, Air Act, and Environment

Date	Event
	Protection Act suffers from statutory asymmetry and lacks clarity, especially after the 2024 and Jan Vishwas amendments which replaced imprisonment with monetary penalties and introduced a formal civil adjudication mechanism. The Court emphasized that after these amendments, penalties for contraventions must be imposed only through the statutory adjudicatory process by designated Adjudicating Officers appointed by the Central or State Governments, and **not by Pollution Control Boards**, whose powers under Sections 33A of the Water Act and 31A of the Air Act remain purely administrative. The Court noted that inconsistent appellate structures and regulatory gaps could lead to uncertainty and excessive litigation, and therefore directed that MoEF&CC be impleaded so the Court may examine and clarify the legal position comprehensively.**True copy of the judgment dated 04.08.2025 in DPCC v. Lodhi Properties, Civil Appeal No(s). 757-760/2013is attached herewith and marked as Annexure–P/15.** **Page No.** 874-910
21.08.2025	ThePetitioner's writ petition was dismissed by the Hon'ble High Court of Judicature at Allahabad, Lucknow Bench in the light of

Date	Event
	DPCC v. Lodhi Properties, Civil Appeal No(s). 757-760/2013 whereby helding that under Section 5 of the Environment Protection Act, the Central Government and its delegated authority **do possess jurisdiction to impose environmental compensation**, and therefore, the petitioner's only ground—that the Board lacked jurisdiction—**cannot be sustained.** Consequently, the petition was dismissed; however, the Court granted liberty to the petitioner to avail any other statutory remedy available in law, such as filing an appeal.**(Impugned Order)**
17.09.2025	M/s Ecogreen Energy initiated arbitration proceedings regarding disputes arising out of the terminated contract and vide order dated 17.09.2025 in Civil Misc. Arbitration Application No. 88 of 2025, the Hon'ble High Court appointed an Arbitrator to adjudicate all contractual issues, including performance failures and liabilities of Ecogreen.
October 2025	That during the said period, substantial and measurable improvements were achieved in waste-processing efficiency, dry-waste segregation, and scientific windrow composting through the

Date	Event
	services of newly engaged contractors, resulting in tangible environmental restoration and stabilisation of the solid-waste management system in the city of Lucknow. It is further submitted that Lucknow demonstrated exceptional performance under the SwachhSurvekshan 2024–25 conducted pursuant to the Swachh Bharat Mission, securing a position among the top three cities in the country with an overall score of 96%. The city's performance was driven by strengthened door-to-door garbage collection, strict wet-and-dry waste segregation, enhanced citizen participation, and the adoption of digital initiatives such as the "Lucknow One App", all of which collectively led to significant and sustained improvements in urban cleanliness and waste management.
15.12.2025	Hence, the Special Leave Petition.

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IMPUGNED ORDER

HIGH COURT OF JUDICATURE AT ALLAHABAD

LUCKNOW BENCH

Neutral Citation No. – 2025:AHC-LKO:49065-DB
Court No. – 11

Case: – WRIT – C No. – 7723 of 2025
Petitioner: – Municipal Corporation Lucknow through Municipal Commissioner
Respondent: – U.P. Pollution Control Board through Chief Environmental Officer, Circle 5, Lucknow and Others

Counsel for Petitioner: – Namit Sharma
Counsel for Respondent: – Ashok Kumar Verma, C.S.C.

Hon'ble Rajan Roy, J.
Hon'ble Manjive Shukla, J.

1. Heard learned counsel for the petitioner, Sri Ashok Verma, learned counsel for the U.P. Pollution Control Board, and Sri Nishant Shukla, learned Additional Chief Standing Counsel for the State.
2. In this case, an order has been passed by the U.P. Pollution Control Board under Section 5 of the Environment Protection Act in exercise of the power delegated to it by the Central Government. This issue is also covered by our judgment passed today in one of the connected writ petitions bearing WRIT – C No. – 7305 of 2025 wherein we have

considered the decision of Hon'ble the Supreme Court in *D.P.C.C. vs. Lodhi Property Co. Ltd.* (Civil Appeal Nos. 757–760 of 2013). As it is not in doubt that under Section 5 of the Environment Protection Act, the Central Government or its delegates possess the power to impose environmental compensation, as earlier held in *Indian Council for Enviro Legal Action vs. Union of India*, 1996 (3) SCC 500 and reiterated in *D.P.C.C. vs. Lodhi Property Co. Ltd.* (supra), therefore the only ground raised herein, which is of lack of jurisdiction, cannot succeed.

3. The writ petition is accordingly dismissed, however, with liberty as far as permissible in law to pursue other statutory remedies such as appeal.

(Manjive Shukla, J.) **(Rajan Roy, J.)**

Order Date: – 21.08.2025

Anuj Singh

IN THE SUPREME COURT OF INDIA

CIVIL APPELLATE JURISDICTION

(Under Article 136 of the Constitution of India)

[Supreme Court Rules, 2013 - Order XXII Rule 3 (1) (a)]

SPECIAL LEAVE PETITION (C) NO. OF 2025

(WITH PRAYER FOR INTERIM RELIEF)

IN THE MATTER OF: -

BETWEEN

	POSITION OF PARTIES		
	BEFORE THE TRIAL COURT	**IN THE HON'BLE HIGH COURT**	**IN THIS HON'BLE COURT**
MUNICIPAL CORPORATION, LUCKNOW Through The Municipal Commissioner, Lucknow **Triloknath Marg, Lalbagh, Lucknow, Up 226001**	N.A	Petitioner	Petitioner
VERSUS			
1. UTTAR PRADESH POLLUTION CONTROL BOARD, Through Chief Environment Officer, Circle–5 Tc-12v Vibhuti Khand, Gomti Nagar, Lucknow –	N.A	Respondent No.1	Respondent No.1

	226010			
2.	**STATE OF UTTAR PRADESH** Through Principal Secretary, Department of Environment, Government of U.P.	N.A	Respondent No. 2	Respondent No.2
3.	**DISTRICT MAGISTRATE,** Lucknow Collectorate, Lucknow	N.A	Respondent No.3	Respondent No.3
4.	**ADDITIONAL DISTRICT MAGISTRATE,** Environment, Collectorate, Lucknow	N.A	Respondent No.4	Respondent No.4

TO,
HON'BLE THE CHIEF JUSTICE OF INDIA AND HIS
COMPANION JUDGES OF THE SUPREME COURT OF INDIA.

THE HUMBLE PETITION ON BEHALF
OF THE PETITIONER ABOVE NAMED

MOST RESPECTFULLY SHOWETH: -

1. The petitioner is constrained to prefer the present Special Leave Petition is constrained to prefer this appeal against the impugned Judgment and Final order dated 21.08.2025 passed by the Hon'ble High Court of Judicature at Allahabad, Lucknow Bench, in Writ – C No. – 7723 of 2025wherein and whereby the Hon'ble High Court has erroneously and in a mechanical manner dismissed the writ petition.

2. QUESTIONS OF LAW

The following questions of law arise for consideration by this Hon'ble Court

a) Whether the decision in *Delhi Pollution Control Committee v. Lodhi Property Co. Ltd.* (2025), which concerns the powers of Pollution Control Boards under the Water and Air Acts, is applicable to Environmental Compensation orders issued under the Environment (Protection) Act, 1986, in the absence of statutory procedure, delegated power, or rule-making authority?

b) Whether the UP Pollution Control Board has jurisdiction under Section 5 of the Environment (Protection) Act, 1986 to impose Environmental Compensation on a municipal corporation without specific delegation or prescribed procedure?

c) Whether the High Court erred in dismissing a writ petition challenging an order passed without jurisdiction or hearing, solely on the ground of availability of an alternate remedy?

d) Whether imposing massive Environmental Compensation on Lucknow Municipal Corporation — despite its remedial actions and the primary fault lying with a private

concessionaire — violates the Polluter Pays principle and Article 14?

e) Whether an Environmental Compensation order passed without hearing, factual determination, or transparency violates Articles 14 and 21 and established environmental jurisprudence?

f) Whether a State Pollution Control Board can assume adjudicatory or penal powers under the Environment (Protection) Act or the MSW Management Manual, 2016, when its role is only regulatory, supervisory, and recommendatory?

3. DECLARATION IN TERMS OF RULE 2(2):

The petitioner states that no other petition seeking leave to appeal has been filed by the petitioner against the impugned judgment and final order dated 21.08.2025passed by the Hon'ble High Court of Judicature at Allahabad, Lucknow Bench, in Writ – C No. – 7723 of 2025.

4. DECLARATION IN TERMS OF RULE 4:

The Annexures P-1 to P-17 produced along with the special leave petition are true copies of the pleading / documents , which formed part of the records of the case in the courts below against whose order the leave to appeal is sought for in this petition.

5. **GROUNDS:**

Aggrieved by the impugned Judgment and Final Order dated 21/08/2025 passed by the High Court of Judicature at Allahabad, Lucknow Bench in WRIT – C No. – 7723 of 2025 the present special leave petition is being files on the following grounds of appeal amongst other without prejudice to one and another:

A. Because the Uttar Pradesh Pollution Control Board (UPPCB) has no statutory authority under Section 5 of the Environment (Protection) Act, 1986 to impose Environmental Compensation on a Municipal Corporation without a valid, specific delegation by the Central Government, rendering the impugned EC order ultra vires and void ab initio

B. Because the exclusive statutory jurisdiction to adjudicate and award environmental compensation is vested in the National Green Tribunal under Sections 15 and 18 of the NGT Act, 2010, and therefore the UPPCB could not have imposed Environmental Compensation directly upon the petitioner.

C. Because even if powers under Section 5 of the EPA are assumed to have been delegated, such powers cannot be

exercised arbitrarily, capriciously or without a statutory procedure, methodology, formula, or rules — the EC calculation in the present case being based on assumptions and conjectural data rather than verifiable scientific records

D. Because the High Court erred in dismissing the writ petition solely on the ground of availability of an alternate remedy, despite the settled principle that writ jurisdiction is maintainable where the impugned action is without jurisdiction, arbitrary, or in blatant violation of natural justice.

E. Because the impugned EC order was passed in total disregard of the principles of audi alteram partem, as no meaningful opportunity of personal hearing or inquiry was afforded to the petitioner despite specific requests and submission of documentary evidence.

F. Because the UPPCB proceeded on factually incorrect and inconsistent assumptions, including treating 2,395 TPD as municipal waste generation, whereas actual weighbridge records reflect 1,986 TPD, resulting in a grossly inflated, unreasonable, and arbitrary compensation figure

G. Because the impugned action contravenes the Polluter Pays principle, as the original concessionaire — M/s Ecogreen

Energy — was the actual polluter, and has been separately penalized, making it impermissible to saddle the petitioner with liability it neither caused nor contributed to.

H. Because the Environmental Compensation is punitive in nature, and in the absence of any statutory adjudication procedure, rules, or prescribed norms for determining the quantum of such compensation, the order is arbitrary, discriminatory, and violates Articles 14 and 21 of the Constitution.

I. Because the High Court failed to appreciate that the petitioner had already remediated the environmental situation by clearing the legacy waste backlog, upgrading processing facilities, implementing scientific waste management practices, and complying with NGT directives, rendering the imposition of EC wholly unjust, unreasonable, and purposeless.

J. Because the impugned EC order is a non-speaking, mechanistic order, devoid of reasoning, scientific basis, environmental impact assessment, or justification connecting the alleged harm to the petitioner, thereby violating the principles of reasoned and accountable decision-making.

K. Because the High Court's reliance on *DPCC v. Lodhi Property Co. Ltd.* (2025) is misplaced, as that judgment involved powers of Pollution Control Boards under the Water and Air Acts, whereas the present case arises under the Environment (Protection) Act, 1986, which has a distinct statutory framework and does not confer similar adjudicatory powers.

L. Because the absence of any adjudicating authority, statutory mechanism, or structured methodology for determining Environmental Compensation grants the UPPCB unfettered, unguided, and excessive discretion, contrary to the constitutional mandate of governance under law and principles of administrative fairness.

M. Because imposing a crippling financial liability of Rs. 59.99 crore without statutory jurisdiction would severely affect essential civic functions and public interest, burdening taxpayers for a default that was neither committed nor caused by the petitioner.

N. Because the impugned EC order and the High Court judgment collectively raise substantial questions of law relating to environmental governance, statutory authority, jurisdictional competence, procedural fairness, adherence to

principles of natural justice, and constitutional protections, warranting interference by this Hon'ble Court under Article 136.

O. Because the UPPCB failed to apply the principles of transparency, proportionality, and non-arbitrariness emphasized by this Hon'ble Court in environmental jurisprudence, resulting in a manifestly unreasonable and punitive order.

P. Because the impugned order disregards contemporaneous evidence of compliance, scientific waste management measures, and improvements in civic operations, thereby violating settled principles that liability must attach to actual environmental harm and responsible parties.

Q. Because the lack of any methodology, cap, or formula for calculating the EC renders the order speculative, arbitrary, and inconsistent with legislative intent, administrative law principles, and environmental norms.

R. Because allowing the impugned EC order to stand would set a dangerous precedent, permitting State Boards to impose massive financial liabilities on statutory municipal authorities without legal authority, adjudicatory process, or

procedural safeguards, undermining public trust and environmental governance frameworks.

6. GROUNDS FOR INTERIM RELIEF:

a) Because the UP Pollution Control Board (UPPCB) has no statutory authority under Section 5 of the Environment (Protection) Act, 1986 to impose Environmental Compensation on a Municipal Corporation without a valid and specific delegation issued by the Central Government, rendering the impugned EC order ultra vires and void ab initio.

b) Because the exclusive statutory jurisdiction to adjudicate and award environmental compensation is vested in the National Green Tribunal under Sections 15 & 18 of the NGT Act, 2010, and therefore UPPCB could not have imposed EC directly upon the petitioner.

c) Because the High Court's reliance on *DPCC v. Lodhi Properties* is misplaced, as that judgment involved PCB powers under Water/Air Acts, whereas the present case arises under EPA, and therefore the legal framework is not pari materia.

7. MAIN PRAYER:

a) Grant Special Leave to Appeal against the judgment and final order dated 21.08.2025 passed by the High Court of Judicature at Allahabad, Lucknow Bench, in Writ-C No. 7723 of 2025; and/or

b) Pass such other and further order(s) as this Hon'ble Court may deem fit and proper in the facts and circumstances of the case.

8. PRAYER OF INTERIM RELIEF:

It is, therefore, most respectfully prayed that your Lordships may graciously be pleased to: -

a) Stay the operation, implementation, and enforcement of the impugned order Number-126524/C-5/M.S.W-1/25 dated 02.04.2025 by Uttar Pradesh Pollution Control Board, imposing Environmental Compensation on the petitioner.

b) Stay the effect and operation of the impugned judgment dated 21.08.2025 passed by the Hon'ble High Court of Judicature at Allahabad, Lucknow Bench in Writ-C No. 7723 of 2025

c) Restrain the respondents from taking any coercive steps for recovery of the impugned Environmental Compensation amount of Rs. 59.99 crores, including initiation or continuation of any proceedings for attachment, bank guarantee invocation, or distraint of municipal assets.

AND FOR THIS ACT OF KINDNESS THE PETITIONER AS IN DUTY BOUND SHALL EVER PRAY.

AND FOR THIS ACT OF KINDNESS AS IN DUTY BOUND THE PETITIONER SHALL EVER PRAY.

FILED BY

Draw on:. **07.12.2025**
Filed on: **15.12.2025**
New Delhi

Jaydip Patti

[JAYDIPPATI]
ADVOCATE FOR THE PETITIONER

IN THE SUPREME COURT OF INDIA
CIVIL APPELLATE JURISDICTION
SPECIAL LEAVE PETITION (C) NO. OF 2024

IN THE MATTER OF:

MUNICIPAL CORPORATION LUCKNOW ---Petitioner

Versus

UTTAR PRADESH
POLLUTION CONTROL BOARD & ORS. ---Respondents

CERTIFICATE

Certificate that the Special Leave Petition is confined only to the pleadings before the Court/Tribunal whose order is challenged and the other documents relied upon in those proceedings. No additional facts, documents or grounds have been taken therein or relied upon in the Special Leave Petition. It is further certified that the copies of the documents/Annexures and Additional Documents attached to the Petition are necessary to answer the question of law raised in the petition or to make out grounds urged in the Special Leave Petition for consideration of this Hon'ble Court. This Certificate is given on the basis of the instruction given by the Petitioner/person authorized by the Petitioner whose Affidavit is filed in support of the Special Leave Petition.

Drawn on: 07.12.2025
Filed on: 15.12.2025
New Delhi

Drawn & Filed by:
Jaydip Pati
[JAYDIP PATI]
Advocate for the Petitioner

Rakesh Kumar
Advocate & Notary
Tehsil Sadar, Lucknow
R. No. 31(66) 1990
GOVT. OF U.P. INDIA

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IN THE SUPREME COURT OF INDIA
CIVIL APPELLATE JURISDICTION
SPECIAL LEAVE PETITION (CIVIL) NO. /2025

IN THE MATTER OF:

MUNICIPAL CORPORATION, LUCKNOW **PETITIONER**

VERSUS

UTTAR PRADESH POLLUTION CONTROL BOARD & ORS **RESPONDENTS**

AFFIDAVIT

I, Gaurav Kumar, Aged About 32 Years S/o Ompal Singh presently working as Municipal Commissioner, Lucknow Municipal Corporation, Lucknow, Uttar Pradesh presently at Lucknow do hereby state and declare on solemn affirmation as under:

1. That I am the Municipal Commissioner, Lucknow Municipal Corporation, Lucknow the Petitioner named above in the above captioned Special Leave Petition and hence well conversant with the facts and circumstances of the case and as such authorized and competent to swear this affidavit, on behalf of the petitioner, in the above-mentioned Special Leave Petition.

2. That I state that the contents of the accompanying SLP comprising of the List of Dates and events from pages B to Y, and the Special Leave Petition Para 1 to 8, pages 3 to 15, Questions of Law A

Rakesh Kumar
Advocate & Notary
Tehsil Sadar, Lucknow
R. No. 31(66) 1990
GOVT. OF U.P. INDIA

Sworn & Verified before me
AKESH KUMAR
Adv. & Notary
09/12/25

नगर आयुक्त
नगर निगम लखनऊ

to F, Grounds A to R, and the accompanying I.A.s., have been drafted under my instructions and are true and correct to the best of my knowledge and belief and rest are submissions made on the basis of legal advice rendered to me by the conducting counsel, which I believe to be correct.

3. I state that the accompanying SLP is confined only to the pleadings before the Courts below and documents relied upon in those proceedings. No additional facts, documents or grounds have been urged in the accompanying SLP.

4. I also state that the Annexures annexed to the accompanying SLP are true / translated / typed copies of their respective originals and form part of the record of the Courts below.

Deponent
नगर आयुक्त
नगर निगम लखनऊ

VERIFICATION:

Verified at on this the day of December, 2025 that the averments made in the aforementioned paragraphs are based on the true statements of facts based on the personal belief and knowledge of the Deponent derived from the records of the matter and nothing material has been concealed therefrom.

Deponent
नगर आयुक्त
नगर निगम लखनऊ

TAR
Rakesh Kumar
Advocate & Notary
Tehsil Sadar, Lucknow
R. No. 31(96) 1996
GOVT. OF U.P. INDIA

Sworn & Verified
before me
RAKESH KUMAR
Adv. & Notary
09/12/25

I know and identify the deponent
who has signed/put T.I. Before me

ik
wh

APPENDIX

THE ENVIRONMENT (PROTECTION) ACT, 1986

5. Power to give directions.—Notwithstanding anything contained in any other law but subject to the provisions of this Act, the Central Government may, in the exercise of its powers and performance of its functions under this Act, issue directions in writing to any person, officer or any authority and such person, officer or authority shall be bound to comply with such directions.

Explanation.—For the avoidance of doubts, it is hereby declared that the power to issue directions under this section includes the power to direct—

(a) the closure, prohibition or regulation of any industry, operation or process; or

(b) stoppage or regulation of the supply of electricity or water or any other service

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ANNEXURE P/1

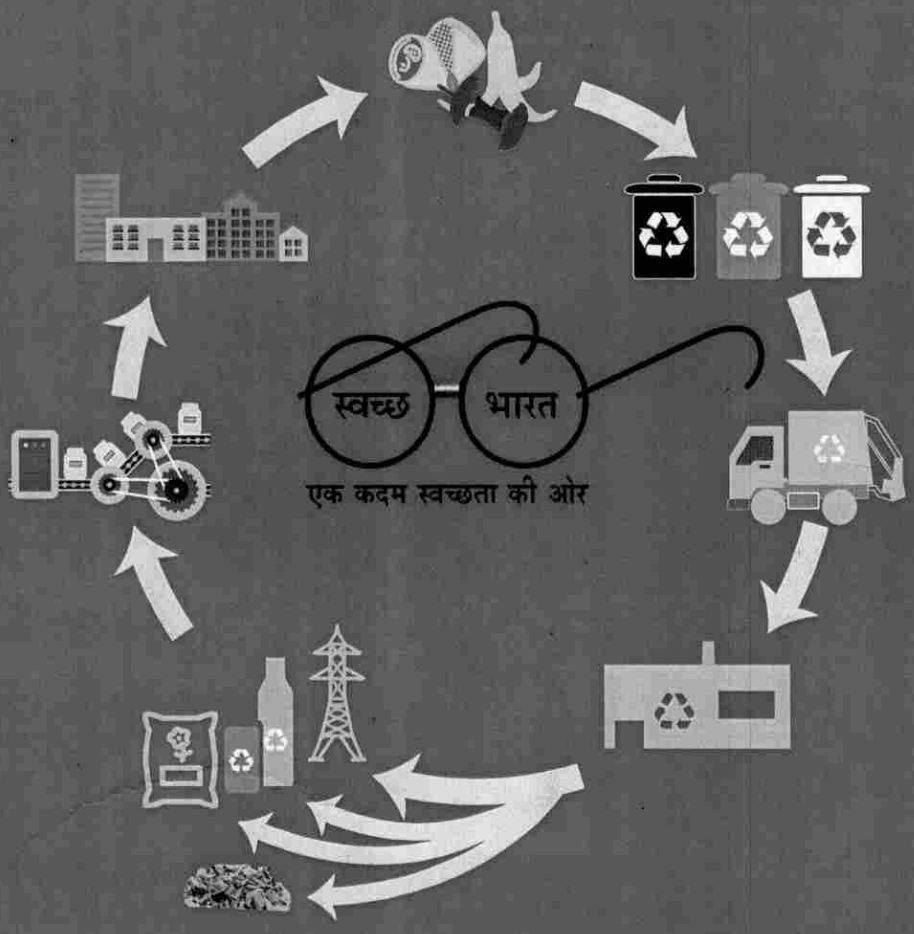
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GOVERNMENT OF INDIA

SWACHH BHARAT MISSION

MUNICIPAL SOLID WASTE MANAGEMENT MANUAL

PART II: THE MANUAL



Central Public Health and Environmental Engineering Organisation (CPHEEO)

MINISTRY OF URBAN DEVELOPMENT

www.moud.gov.in

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2016

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GOVERNMENT OF INDIA
MINISTRY OF URBAN DEVELOPMENT
http://moud.gov.in

MUNICIPAL SOLID WASTE MANAGEMENT MANUAL

Central Public Health and Environmental Engineering Organisation (CPHEEO)

IN COLLABORATION WITH

german cooperation
DEUTSCHE ZUSAMMENARBEIT

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

German International Cooperation

2016

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PART II:
Manual on Municipal Solid Waste Management

AN INTRODUCTION TO THE MANUAL

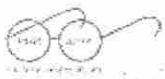
The management of municipal solid waste in India has surfaced or continued to be a severe problem not only because of environmental and aesthetic concerns but also because of the enormous quantities generated every day. Even though only 31% of Indian population resides in urban areas, this population of 377 million (Census of India, 2011) generates a gigantic 1,43,449 metric tonnes per day of municipal solid waste, as per the Central Pollution Control Board (CPCB), 2014-15 and these figures increase every day with an increase in population. To further add to the problem, the total number of towns (statutory and census) in the country have also increased from 5,161 in 2001 to 7,936 in 2011, thus increasing the number of municipal waste generation by 2,775 within a decade.

The management of municipal solid waste is one of the main functions of all Urban Local Bodies (ULBs) in the country. All ULBs are required to meticulously plan, implement and monitor all systems of urban service delivery especially that of municipal solid waste. With limited financial resources, technical capacities and land availability, urban local bodies are constantly striving to meet this challenge.

With the launch of the flagship programme by the Government of India, Swachh Bharat Mission in 2014 that aims to provide basic infrastructural and service delivery with respect to sanitation facilities to every family, including toilets and adopting the scientific methods to collect, process and disposal of municipal solid waste. The mission focuses on quality and sustainability of the service provision as well as emphasising on the commitment on every stakeholder to bring about a visible change in society.

This manual on Municipal Solid Waste Management provides guidance to urban local bodies on the planning, design, implementation and monitoring of municipal solid waste management systems. Issues of environmental and financial sustainability of these systems are a critical consideration.

The manual clearly defines the planning process to be adopted by urban local bodies for preparing, revising and implementing Municipal Solid Waste Management Plans (MSWM Plans). The long term planning horizon of 25 years is further divided into short term plans to be prepared once every five years, with a mid-term review once every 2-3 years within this 5 year period, as per requirement. 'A seven step approach for MSWM Planning' is defined (Chapter 1), with special emphasis on community or stakeholder contribution and inter-departmental coordination at the local authority level to ensure implementation success. The Planning process suggests the adoption of the integrated solid waste management hierarchy for deciding on processing or technology solutions for municipal solid waste. Procedure for establishing the baseline of municipal solid waste management in urban local bodies is detailed



out. Ensuring financial viability of municipal solid waste management systems through revenue generation and encouraging Private Sector Participation (PSP) and Public Private Partnerships (PPPs) is suggested in this manual.

The MSWM Planning has to be supplemented with 'Technical Aspects of MSW Segregation, Collection and Transportation' that are addressed in detail (Chapter 2) in this manual. Processes for ensuring segregation at the household level in wet, dry and domestic hazardous waste, as suggested in the Solid Waste Management (SWM) Rules, 2016, are defined. Guidance mentioned under the SWM Rules, 2016 on waste collection and transportation systems is highlighted where relevant. Requirements for segregated secondary storage and transportation of segregated waste to appropriate processing and disposal facilities, sizing of systems for different scales of operation, norms for transfer stations, typical configurations of transfer stations, norms for street sweeping and corresponding resource allocation are provided in detail. Potential for involvement of the informal sector is explored, with a strong message that ULBs should consider the involvement of the informal sector after appropriately recognizing their services and with due focus on their livelihood and health.

MSWM Planning has to be strengthened by the 'Technical Aspects of Processing and Treatment of MSW (Chapter 3)': Urban Local Bodies, in the planning process, should make appropriate technology choices for waste management within the jurisdiction of the ULB, either independently or through the involvement of the private sector, with an aim to maximise resource conservation and efficiency and minimize health and environmental impacts. Waste minimization should be the primary focus of all community awareness programmes. Material recovery and recycling potential of municipal solid waste should be the first consideration in the management of generated waste. Where ever possible waste should be segregated into fractions promising viable recycling potential. Subsequently other forms of treatment and processing should be considered in accordance to the guidance given by the ISWM waste treatment and processing hierarchy. Guidance under the Solid Waste Management, Rules 2016 on waste processing and treatment technologies is highlighted where relevant. Technical specifications and design considerations for composting: windrow composting, aerated static pile, in-vessel composting decentralised composting, vermicomposting and yard waste composting, are given in detail. Waste to Energy technologies: incineration, biomethanation and RDF production and use are also covered in this manual. Specific issues to be considered while planning for and implementing these systems are defined and the scale at which these technologies are viable is clearly mentioned. Technologies under development: pyrolysis, gasification are discussed for guidance of urban local bodies. C&D waste management and guidance for urban local bodies is also included as part of this chapter.

The ISWM hierarchy clearly indicates that landfilling of municipal solid waste is the least preferred option for MSW management. However, given that the

municipal solid waste management system in the country has not yet reached a stage where landfilling can be avoided, sanitary landfill design guidelines and operational guidance is detailed out (Chapter 4). Rehabilitation of old dump sites is also addressed.

MSWM plan preparation considers operational and technological choices for an appropriate implementation route. This could be done either independently by the ULB or through private sector involvement or informal sector and with defined contracting and financing arrangements. Plan implementation should commence after the plan is approved by the Municipal Council and the buy- in from the community is ascertained.

Management aspects of municipal solid waste include statutory clearances like environmental clearances that are required for establishing municipal solid waste treatment, processing and disposal facilities. Pre-feasibility and feasibility studies may be required for ascertaining appropriate modes of treatment and processing at selected locations. Detailed Project Reports will need to be prepared to ensure detailed planning and financial viablity of projects. Guidance on these aspects and on tendering, contracting and contract monitoring are also detailed out in Chapter 5.

Managing municipal solid waste is not easy, it requires regular monitoring of MSWM service provision by the ULB through basic or advanced Management Information Systems. All services provided by the ULB either through its own sources or through those outsourced to private entities, should be appropriately documented and monitored in order to ensure effective implementation and to identify issues that are to be addressed in the mid-term review of the MSWM plan and in subsequent short term plans (Chapter 6). Aspects of environmental monitoring, record keeping, training requirements for MSWM service provision are also addressed in this chapter.

Several waste types find their way into the municipal solid waste stream, which require special handling and disposal because of their quantity, concentration, physical and chemical characteristics or biological properties (special wastes). Many of these waste streams are also governed by specific Rules, viz. Plastic Waste Management Rules, 2016. Guidance on the ULBs' responsibilities for managing specific special waste streams namely, plastic waste, bio-medical waste, slaughter house waste, E-waste, waste tyres and lead battery waste are included in this manual (Chapter 7).

A compendium of good practises both national and international are included as Part III of the manual. All Rules and guidelines that are of relevance in the management of municipal solid waste for an ULB and are referred to in the different sections of Part II of the manual are included in the Part III of the Manual.

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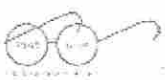
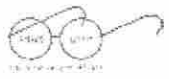


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ABBREVIATIONS

ABC	Asphalt, Brick and Concrete
ABS	Area Based System
AD	Anaerobic Digestion
ADB	Asian Development Bank
ADDA	Asansol Durgapur Development Authority
ADS	Air Density Separator / De-stoner
AFR	Alternative Fuels and Raw material
ALM	Advanced Locality Management
AMC	Asansol Municipal Corporation
APITCO	Andhra Pradesh Industrial & Technical Consultancy Organization
APPCB	Andhra Pradesh Pollution Control Board
ASR	Auto Shredder Residue
ASTM	American Society for Testing and Materials
BARC	Bhabha Atomic Research Centre
BBMP	Bruhat Bangalore Mahanagara Palika
BFB	Bubbling Fluidized Bed
BIS	Bureau of Indian Standards
BOD	Biochemical Oxygen Demand
BOO	Build Own Operate
BOOT	Build Own Operate and Transfer
BOT	Build Operate Transfer
C&D	Construction & Demolition
CA	Concession Agreement
CAA	Constitutional Amendment Act
CBG	Compressed Biogas
CBOs	Community Based Organizations
CCF	Clean City Foundation
CE	Combustion Efficiency
CEO	Chief Executive Officer
CFB	Circulating Fluidized Bed
CFL	Compact Fluorescent Lamps
CIPET	Central Institute of Plastics Engineering and Technology
CMA	Commissionerate of Municipal Administration
CMWMF	Common Municipal Waste Management Facilities
CNG	Compressed Natural Gas
CoC	Cochin Municipal Corporation

COD	Chemical Oxygen Demand
CoP	Corporation of Panaji
CPCB	Central Pollution Control Board
CPHEEO	Central Public Health and Environmental Engineering Organization
CPU	Carcass Processing Unit
CPWD	Central Public Works Department
CREDAI	Confederation of Real Estate Developers' Associations of India
CRRI	Central Road Research Institute
CSI	City Sanitary Inspector
CSP	City Sanitation Plan
CSTR	Continuously Stirred Tank Reactor
D2D	Door-to-door
DBFOT	Design, Build, Finance, Operate and Transfer
DBO	Design-Build-Operate
DBOOT	Design-Build-Own-Operate and Transfer
DC	Drain Cleaning
DEA	Department of Economic Affairs
DMA	Directorate of Municipal Administration
DMC	Durgapur Municipal Corporation
DPR	Detailed Project Report
DRANCO	Dry Anaerobic Composting
DRE	Destruction Removal Efficiency
DWCC	Dry Waste Collection Centres
EAC	Expert Appraisal Committee
EDMC	East Delhi Municipal Corporation
EIA	Environment Impact Assessment
EM	Effective Micro Organisms
EMP	Environmental Management Plan
EoI	Expression of Interest
EPF	Employment Provident Fund
EPR	Extended Producer Responsibility
EPS	Expanded Polystyrene
EPTRI	Environment Protection Training and Research Institute
ESI	Employees' State Insurance
ESP	Electrostatic Precipitator
ETP	Effluent Treatment Plant
EU	European Union
FAQ	Frequently Asked Question
FCA	Full Cost Accounting
FCO	Fertilizer Control Order
FGT	Flue Gas Treatment

FRP	Fiber Reinforced Plastic
GCL	Geo Synthetic Clay Liner
GDP	Gross Domestic Product
GHG	Green House Gas
GIS	Geographic Information System
GNCTD	Government of National Capital Territory of Delhi
GoI	Government of India
GPRA	General Pool Residential Accommodation
GPRS	General Packet Radio Identification
GPS	Global Positioning System
GSB	Granular Sub Base
GSI	Geologic Survey of India
HAPs	Hazardous Air Pollutants
HDPE	High-Density Polyethylene
HH	Households
HRT	Hydraulic Retention Time
HUDCO	Housing and Urban Development Corporation
IARI	Indian Agricultural Research Institute
IC	Internal Combustion
ICICI	Industrial Credit and Investment Corporation of India
ICT	Information and Communication Technology
IDBI	Industrial Development Bank of India
IDFC	Infrastructure Development Finance Company
IEC	Information, Education and Communication
IEISL	IL&FS Environmental Infrastructure and Services Limited
IFCI	Industrial Finance Corporation of India
IGCC	Integrated Gasification Combined Cycle
IL&FS	Infrastructure Leasing and Financial Services
ILO	International Labour Organization
IMD	Indian Meteorological Department
IPNM	Integrated Plant Nutrient Management
IREDA	Indian Renewable Energy Development Agency
IS	Indian Standards
ISWM	Integrated Solid Waste Management
ITB	Instruction to Bidders
JBIC	Japan Bank for International Cooperation
JMC	Jabalpur Municipal Corporation
JnNURM	Jawaharlal Nehru National Urban Renewal Mission
KfW	Kreditanstalt für Wiederaufbau
KKPKP	Kagad Kach Patra Kashtakari Panchayat
KKPNSPS	Kagad Kach Patra Sahkari Patra Sansthan

KMC	Kolkata Municipal Corporation
KPI	Key Performance Indicators
LCD	Liquid Crystal Display
LCS	Leachate Collection System
LCV	Light Commercial Vehicle
LDO	Light Diesel Oil
LDPE	Low-density polyethylene
LED	Light Emitting Diode
LEL	Lower Explosive Limit
LIC	Life Insurance Corporation of India
LoI	Letter of Intent
LPG	Liquid Petroleum Gas
M&E	Monitoring & Evaluation
MCD	Municipal Corporation of Delhi
MCGM	Municipal Corporation of Greater Mumbai
MIS	Management Information System
MMRDA	Maharashtra Metropolitan Regional Development Authority
MNRE	Ministry of New and Renewable Energy
MoA	Ministry of Agriculture
MoEFCC	Ministry of Environment and Forests & Climate Change
MoUD	Ministry of Urban Development
MPPCB	Madhya Pradesh Pollution Control Board
MRF	Material Recovery Facility
MSW (M&H)	Municipal Solid Waste (Management and Handling)
MSWMP	Municipal Solid Waste Management Plan
NABARD	National Bank for Agriculture and Rural Development
NABL	National Accreditation Board for Testing and Calibration Laboratories
NAC	Notified Area Committee
NAPCC	National Action Plan on Climate Change
NBCC	National Buildings Construction Company
NCC	National Cadet Corps
NCRPB	National Capital Region Planning Board
NCV	Net Calorific Value
NEERI	National Environmental Engineering Research Institute
NGO	Non- Government Organization
NGRI	National Geophysical Research Institute
NIMBY	Not in My Backyard
NMC	Nashik Municipal Corporation
NMMC	Navi Mumbai Municipal Corporation
NMSH	National Mission on Sustainable Habitat
NTPC	National Thermal Power Corporation

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NUSP	National Urban Sanitation Policy
O&M	Operation and Maintenance
OEM	Original Equipment Manufacturer
OHSAS	Occupational Health and Safety Assessment System
OMC	Optimum Oxygen Content
OWC	Organic Waste Converters
PBG	Performance Bank Guarantee
PBVS	Parisar Bhagini Vikas Sangha
PCC	Pollution Control Committee
PCMC	Pimpri Chinchwad Municipal Corporation
PFDF	Pooled Finance Development Fund
PIL	Public Interest Litigation
PIM	Project Information Memorandum
PNG	Piped Natural Gas
PPE	Personal Protection Equipment
PPP	Public Private Partnership
PROM	Phosphate Rich Organic Manure
PS	Polystyrene
PSA	Pressure Swing Adsorption
PSP	Private Sector Participation
PTO	Power Take-Off
PUF	Polyurethane Foam
PVC	Polyvinyl Chloride
PVP	Parisar Vikas Programme
RA	Recycled Aggregates
RCA	Recycled Concrete Aggregates
RCC	Reinforced Cement Concrete
RDF	Refuse Derived Fuel
RFID	Radio Frequency Identification
RFP	Request for Proposal
RFQ	Request for Qualification
RMC	Ready Mix Concrete
RPM	Respirable Particulate Matter
RSPM	Respirable Suspended Particulate Matter
RWA	Resident Welfare Association
S.I.	Sanitary Inspector
S.O	Sanitary Officer
S.S.	Sanitary Supervisor
S.S.I	Sanitary Sub-Inspector
SC&T	Street Collection & Transportation
SCR	Selective Catalytic Reduction



SEAC	State Expert Appraisal Committee
SEHB	Shimla Environment Heritage Conservation and Beautification Society
SEIAA	State Environment Impact Assessment Authority
SHGs	Self Help Groups
SLB	Service Level Benchmark
SLF	Sanitary Landfill Facility
SMC	Saharanpur Municipal Corporation
SMS	Stree Mukti Sanghathana
SNCR	Selective Non-catalytic Reduction
SOP	Standard Operating Procedure
SPCB	State Pollution Control Board
SPFE	State Pooled Finance Entities
SPI	Society of the Plastics Industry
SS	Street Sweeping
SSD	Saturated Surface Dry
SSS	State Sanitation Strategy
STP	Sewage Treatment Plant
SWaCH	Solid Waste Collection & Handling
TCLP	Toxicity Characteristic Leaching Procedure
TEAM	TERI Enhanced Acidification and Methanation
TERI	The Energy & Resources Institute
TOR	Terms of Reference
TPD	Tonnes per Day
TSDF	Treatment, Storage & Disposal Facility
UAFP	Up-flow Anaerobic Filter Process
UASB	Up-flow Anaerobic Sludge Blanket
UDD	Urban Development Department
UIDSSMT	Urban Infrastructure Development Scheme for Small & Medium Towns
UIG	Urban Infrastructure and Governance
ULB	Urban Local Body
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
UV	Ultra Violet
VAT	Value Added Tax
WEEE	Waste of Electrical and Electronic Equipment
WMC	Warangal Municipal Corporation
WOW	Waste Out of Wealth
WPLF	Waste Processing & Landfill
WTE	Waste to Energy

CHEMICALS AND COMPOUNDS

As	Arsenic
C	Carbon
C_6H_5OH	Phenol / Carbolic Acid
Cd	Cadmium
CH_4	Methane
Cl	Chloride
CN	Cyanide
CO	Carbon monoxide
Co	Cobalt
CO_2	Carbon dioxide
Cr	Chromium
Cu	Copper
F	Fluoride
H2S	Hydrogen sulphide
HCl	Hydrochloric acid
HF	Hydrogen fluoride
Hg	Mercury
K	Potassium
K_2O	Potassium Oxide
KF	Potassium fluoride
Li-ion	Lithium-ion
LSHS	Low Sulphur Heavy Stock
Mn	Manganese
MS	Multi station
N	Nitrogen
Ni	Nickel
NO	Nitrogen monoxide
NOx	Nitrogen oxides
P	Potassium
P_2O_5	Phosphorus pentoxide
PAHs	Polychlorinated Aromatic Hydrocarbons
Pb	Lead
PCBs	Polychlorinated biphenyl
PCDD	Polychlorinated di-benzodioxins
PCDF	Polychlorinated di-benzofurans
PET	Polyethylene terephthalate

pH	Acidity or alkalinity of a solution
PM	Particulate Matter
POP	Persistent Organic Pollutants
PP	Polypropylene
Sb	Antimony
Sn	Tin
SO_2	Sulphur oxide
SO_4	Sulphate
Th	Thorium
Tl	Thallium
TOC	Total organic carbon
TPH	Tonnes per Hour
V	Vanadium
VOC	Volatile Organic Compound
Zn	Zinc

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METRIC CONVERSION TABLE

AREA

ha	Hectares	1 hectare = 2.47 acres or 1,07,639 square feet (sq ft)
sq.km	Square kilometre	1 sq. km = 0.386102 square mile (sq mi)

LENGTH

km	Kilometre	1 km = 1000 m
m	Meter	1 m = 1000 cm
cm	Centimetre	1 cm = 1000 mm
mm	Millimetre	1 mm = 1000 µm
µm	Micrometre	

VOLUME

l	Litre	1 l = 0.001 m m^3
m^3 or cu.m	Cubic metre	1 m^3 or cu.m = 10,00,000 cm^3
cm^3	Cubic centimetre	1 cm^3 = 1e+21 Nm^3
Nm^3	Normal cubic metres	
TEQ / Nm^3	Dioxin toxic equivalent per normal cubic metres	
KLD	Kilolitre per day	

MASS

MT or T	Metric tonne or tonne	1 MT or T = 1000 kg
kg	Kilogram	1 kg = 1000 g
g	Gram	1 g = 10,00,000 µg
µg	Microgram	
gsm	Grams per square metre	

ENERGY

MW	Megawatt	1 MW = 1000 KW
kW	Kilowatt	1 KW = 1000 W
kcal	Kilocalories	1 kcal = 1000 cal

TEMPERATURE

°C	Celsius	1°C = 33.800 Fahrenheit (°F)

CURRENCY CONVERSION CHART

INDIAN NUMBERING SYSTEM	INTERNATIONAL NUMBERING SYSTEM
One lakh 1,00,000	One hundred thousand 100,000
Ten lakhs 10,00,000	One million 1,000,000
One crore 1,00,00,000	Ten millions 10,000,000
Ten crores 10,00,00,000	Hundred millions 100,000,000
Hundred crores 100,00,00,000	One billion 1,000,000,000

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Municipal Solid Waste Plan: Step-Wise Guidance

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IN THIS SECTION

1.1 Requirements and stipulations by the Rules 3

1.2 Guiding Principles for Municipal Solid Waste Management 4

1.3 Overview of Developing a Municipal Solid Waste Management Plan in an Urban Local Body 8

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1. MUNICIPAL SOLID WASTE MANAGEMENT PLAN: STEP-WISE GUIDANCE

As many of the municipal authorities are still to develop in-house capabilities to independently govern their solid waste, the central and state governments continue to play a crucial role by formulating policies, programmes, and regulations and by providing technical and financial assistance for infrastructure development including management of municipal solid waste (MSW) in urban areas. Although municipal solid waste management (MSWM) is an essential service and a mandatory function of municipal authorities across the country, it is still being managed in an unplanned manner, giving rise to environmental degradation and serious health problems especially for women and children. This clearly underlines the need for preparing a strategic and detailed MSWM plan by the urban local bodies (ULBs). Every ULB should undertake the preparation of a MSWM plan, addressing short term and long term actions.

MSWM is an integral component of municipal services delivered by ULBs, who are responsible for the safe and healthy environment of a city Therefore, preparation and implementation of a strategic and detailed MSWM plan is essential

1.1 REQUIREMENTS AND STIPULATIONS BY THE RULES

Clause 15(a) of Solid Waste Management (SWM) Rules, 2016 stipulate that the local authorities shall " prepare a solid waste management plan as per state policy and strategy on solid waste management within six months from the date of notification of state policy and strategy and submit a copy to respective departments of State Government or Union territory Administration or agency authorised by the State Government or Union territory Administration"

SWM Rules, 2016 stipulate that every ULB shall prepare a MSWM plan and every state a SWM strategy or policy

This chapter provides stepwise guidance to local authorities in the preparation of MSWM plans. MSWM is essentially a municipal function; it is mandatory for all municipal authorities to provide this service efficiently to keep the cities and towns clean and to dispose the MSW in an environmentally acceptable manner, complying with the SWM Rules, 2016.

It is also pertinent that MSWM systems adopt measures (as per the Supreme Court Directives, 1998) which not only reduce environmental degradation but also look at how high levels of toxins are affecting the health of men, women, and children. The state level municipal acts clearly mention the mandatory functions and additional discretionary functions that the ULBs must perform. ULBs, therefore, have to prioritise their mandatory functions by duly considering their current status and deficiencies.

It is imperative to take stock of the existing situation and develop an MSWM plan, which addresses all aspects of MSWM in compliance with the SWM Rules, 2016 and in alignment with the respective

A long term MSWM Plan: once every 20-25 years

A short term MSWM Plan – once every 5 years

Review of short term plan: once every 2-3 years

State Sanitation Strategy under the National Urban Sanitation Policy (NUSP), and which follows the principles of the Integrated Solid Waste Management (ISWM) hierarchy.

The MSWM plan encompasses:

(i) institutional strengthening;

(ii) human resources development;

(iii) technical capacity building;

(iv) financial capacity and arrangements (public private partnership [PPP] framework);

(v) community participation;

(vi) legal framework and mechanism for enforcement; and

(vii) public grievance or complaint redressal.

The MSWM plan should consider a long term planning horizon of 20–25 years. Short term implementation plans covering 5 years each should be slotted within the long term plan for ease of implementation. The short term plan should be reviewed and updated once every 2–3 years for any midcourse correction as required. Local authorities should ensure that the short term plan is aligned with long term planning and implementation.

1.2 GUIDING PRINCIPLES FOR MUNICIPAL SOLID WASTE MANAGEMENT

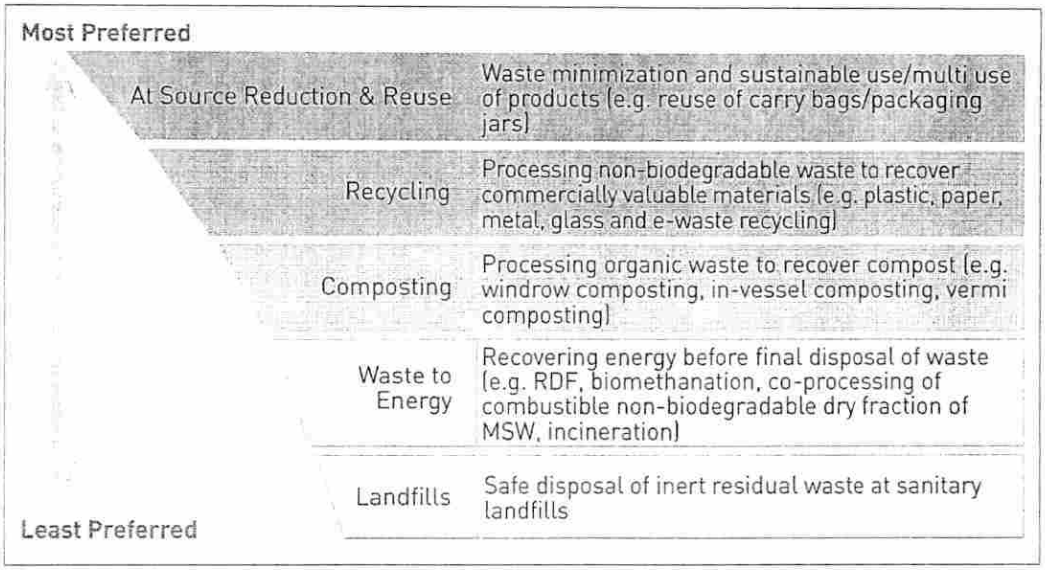
ISWM is a strategic approach to MSWM in a sustainable manner by considering the generation, segregation, transfer, sorting, treatment, recovery, and disposal of waste in an integrated manner, with an emphasis on maximising efficiency of resource use

1.2.1 THE INTEGRATED SOLID WASTE MANAGEMENT SYSTEM

MSWM and adoption of processing technologies are dependent on the quantity and characteristics of the total waste generated in a local authority, the financial resources available, and in-house capability of local authorities to oversee project implementation.

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 ISWM hierarchy ranks waste management operations according to their environmental, economic, and energy impacts. Source reduction or waste prevention, which includes reuse, is considered the best approach (tier 1); followed by recycling (tier 2); and composting of organic matter of waste, resulting in recovery of material (tier 3). The components of waste that cannot be prevented or recycled can be processed for energy recovery (tier 4). Tier 5 is disposal of waste in sanitary landfill, which is the least preferred option. Based on this waste management hierarchy and local conditions, an appropriate system and technology should be selected in the MSWM plan. For example, if the land for composting organic material is close to habitation, biomethanation may be a preferred choice despite the lower ranking and higher cost as compared to the composting in the ISWM hierarchy.

Figure 1.1: Integrated Solid Waste Management System Hierarchy



The ISWM hierarchy ranks waste management strategies according to their environmental benefits.

- **At source reduction and reuse:** 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.

- **Waste recycling:** The next preferred option for waste management in the ISWM hierarchy is recycling of waste to recover material resources through segregation, collection, and re-processing to create new products. In the waste management hierarchy, composting is considered as an organic material recovery process and is often considered at the same hierarchical level as inorganic waste recycling.

- **Waste to energy:** Where material recovery from waste is not possible, energy recovery from waste through production of heat, electricity, or fuel is preferred. Biomethanation, waste incineration, production of refuse derived fuel (RDF), co-processing of combustible non-biodegradable dry fraction from MSW in cement kilns and pyrolysis or gasification are some waste-to-energy technologies.

- **Waste disposal:** Residual inert wastes at the end of the hierarchy are to be disposed in sanitary lined landfills, which are constructed in accordance with stipulations prescribed in SWM Rules, 2016. All over the world, landfills which integrate the capture and use of methane are preferred over landfills which do not capture the landfill gas. As per the hierarchy, the least preferred option is the disposal of waste in open dumpsites. However, Indian laws and rules do not permit disposal of organic matter into sanitary landfills and mandate

Preferential order of waste management options as per the ISWM hierarchy:
At Source Reduction and Reuse
Waste Recycling
Composting
Waste to Energy
Waste Disposal

that only inert rejects (residual waste) from the processing facilities, inert street sweepings, etc. can be landfilled. In cases where old dumps are to be closed, there is a possibility of capturing methane gas for further use. However, repeated burning of waste significantly decreases the potential of capturing methane.

The hierarchy indicates that all options of source waste minimisation should be utilised before appropriate treatment technologies are selected and implemented.

ISWM is closely linked to the 3R approach (reduce, reuse, and recycle), which also preliminarily emphasises the importance of waste reduction, reuse, and recycling over other forms of waste processing or management. The adoption of these principles helps in minimising the amount of waste to be disposed, thus also minimising the public health and environmental risks associated with it. Maximisation of resource recovery at all stages of solid waste management is advocated by both approaches.

1.2.2 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., for batteries). EPR programs are commonly made mandatory through legislation, but can also be adopted voluntarily (i.e., retail take-back programs). 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 (refer to Section 2.1.2 of Part II for further guidance.)

1.2.3 DECENTRALISED WASTE MANAGEMENT SYSTEMS

Decentralised community level waste management systems are preferred to centralised waste management solutions under certain circumstances. Decentralised waste management systems or community level waste management systems reduce the burden of handling large volumes of MSW at a centralised location, with corresponding reduction in costs of transportation and intermediate storage.

Some of the advantages of decentralised waste management include the following:

- Decentralised systems allow for lower level of mechanisation than the centralised solutions, and provide job opportunities for informal workers and small entrepreneurs.
- Decentralised options can be tailor made for the local waste stream, climate, social, and economic conditions.
- Decentralised systems reduce the cost incurred for the collection, transportation, and disposal of waste by the ULBs.

However, ULBs should be aware of some of the limitations of decentralised waste management such as the following:

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

Collection of recyclables at the community level, preferably through involvement of the informal sector, and management of organic waste through home composting systems and community level composting systems are preferred (refer to Section 1.4.5.8 of Part II for further details).

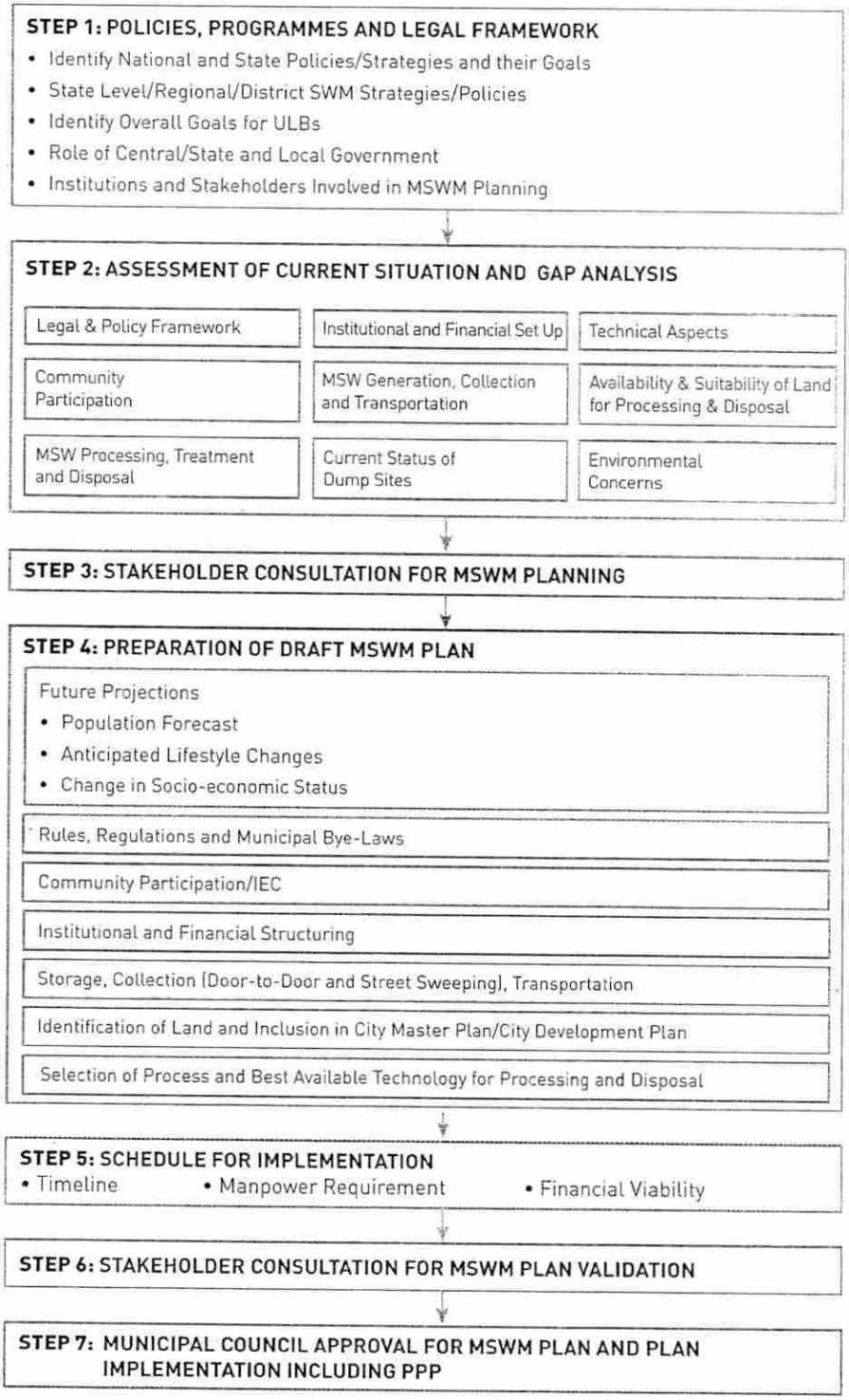
1.2.4 INTEGRATION OF THE INFORMAL SECTOR

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 (Section 1.4.5.9 of Part II further elaborates these aspects).

1.3 OVERVIEW OF DEVELOPING A MUNICIPAL SOLID WASTE MANAGEMENT PLAN IN AN URBAN LOCAL BODY

The preparation of an MSWM plan follows a seven step process, complying with SWM Rules, 2016 and other guidelines provided by the Government of India

Figure 1.2: Seven-Step Approach for Developing a Plan



Planning for the MSW management services follows a seven-step process (as illustrated in Figure 1.2), which should be undertaken by all ULBs to ensure compliance with SWM Rules, 2016 and other guidelines provided by the Government of India and respective state governments The MSWM plan is prepared for 20–25 years and embedded with several short term plans (5 years), which shall be reviewed once every 2–3 years. The following steps provide an overview of the planning process. Each step is further elaborated in Section 1.4.

Step 1: Policies, Programmes and Legal Framework

Step 1 entails a detailed review and analysis of national, state, and municipal level laws, rules, policies, programmes, and guidance related to MSWM. The ULB shall prepare a list of all mandatory and recommended actions required as per SWM Rules, 2016 and other policy guidance and shall ensure that the MSWM plan is developed within these framework conditions.

Step 1: Review and analysis of policies, programmes and legal framework

Step 2: Assessment of Current Situation and Gap Analysis

The municipal authority should then carry out a critical assessment of the current status of SWM in the city as per the SWM Rules, 2016; NUSP; service level benchmarks (SLBs) for SWM service delivery (prescribed by the Ministry of Urban Development [MoUD]), the directives of the State Government and the local Municipal Acts governing the ULBs. The assessment should clearly identify deficiencies or gaps that need to be bridged to meet legal obligations. Gaps with respect to human resources, institutional capacity, infrastructure, financial resources, inclusiveness in service provision, conducive regulatory framework, availability of essential data, land availability, stakeholder willingness, awareness levels, as well as information, education, and communication (IEC) needs of the community should also be identified.

Step 2: Critically assess current situation and identify gaps or deficiencies that need bridging

All aspects of the existing MSWM system need to be considered in detail before MSWM plan can be prepared

Assessment of Current Municipal Solid Waste Management Situation in the City – What to do?

Ward-wise and Consolidated Details

- Demographic data of population (which includes sex-disaggregated data), number of households, shops and establishments, population growth pattern, waste generation data
- Physical and chemical composition of waste
- Inventory of human resources at various levels
- Inventory of equipment, bins, vehicles, and available land for municipal solid waste management (MSWM) facilities
- Public private partnership (PPP) status in providing services, extent of private sector participation (PSP) in delivery of service, and cost benefits or quality of service derived
- Involvement of community participation in MSWM with an overview of the kind of community engagement, the outreach services, the number of men and women, and also the activities in engaging communities
- Note on the kind of information, education, and communication (IEC) material developed, whether they target a particular aspect of MSWM and whether the message is gender-sensitive and not merely reinforcing stereotyped roles of men and women

Storage at Source and Segregation

- Details of waste storage at source and source segregation (including the number of fractions in which waste is segregated)

Primary Collection System in Practice

- Door-to-door collection, collection from community bins or any other method, requirements of collectors, frequency of collection, percentage of coverage under each collection method including a proper gap analysis

Street Sweeping

- Frequency of street sweeping, coverage, inclusiveness of slums and informal settlements, and safety provisions

Secondary Storage

- Secondary storage in covered street bins, containers, masonry, concrete bins, enclosures, dhalaos, open waste storage sites, or any other method, bin-population ratio, or no secondary storage (direct transportation of waste)

Transportation

- Type and number of vehicles used, quantity and percentage of waste transported each day in covered vehicles and open vehicles, frequency of transportation from secondary storage sites, percentage of manual loading in relation to mechanical loading

Processing of Waste

- Quantity and percentage of waste processed, technology adopted, percentage of residual waste sent to disposal site, realisation of revenues from the processing facility, beneficiaries of the revenues

Disposal of Waste

- If the city has a sanitary landfill? If yes, area, designated site, and capacity of the landfill, volume of the current cell and expected life, quantity of waste deposited annually at the landfill (over the life of the landfill)
- Identifying location of existing dump sites and issues with these sites
- Land availability for MSWM as per city development plan or city master plan

Financial Assessment

- The budgetary allocations and actual annual expenditure on MSWM services in relation to total revenue budget of the municipal authority
- Cost per tonne of various components of MSWM service
- Assessment of tax or user fees levied for providing MSWM service and extent of cost recovery

Assessment of Social Impacts

- Estimate the impacts of the existing waste management system on the informal sector of kabadi system and waste pickers, either negatively (hygienic impacts) or positively (revenues for the informal sector)

Assessment of Environmental and Health Impacts

- Impacts on the environment and public health due to existing waste management practices, impact on groundwater, soil, etc.
- Assess existing MSWM facilities and related land use issues and old dumpsite closure issues
- Analyse gaps (including socioeconomic and gender-related disparities that may exist) focusing on deficiencies of the existing system by reflecting all issues mentioned above
- Compare the current situation with service level benchmarks (SLBs) prescribed by the Government of India

Step 3: Stakeholder Consultation for Planning

MSWM has a direct relation with the community and other waste generators. Due to the number of institutions and stakeholders involved in MSWM, it is important that the MSWM plan, which aims to bridge the gaps or improve the level of service, is developed through a consultative process. Stakeholders' views, including their willingness to participate and pay for the service, should be considered. ULBs shall ensure that women, as important providers of MSWM services as well as beneficiaries of these services, shall be adequately involved in the stakeholder consultations and decision making processes.

Step 4: Preparation of Draft Municipal Solid Waste Management Plan

Identified gaps, future population projections and waste generation rates, current and future quality and quantity of waste (based on changing lifestyles and economic status), inputs from stakeholders, financial situation, and technical capabilities of the local body should be assessed. The municipal authority should prepare its draft short term and long term MSWM plan, considering the provisions of the local Municipal Act, SWM Rules, NUSP, and SLBs. Requirements for equipment, vehicles, staffing, land revenues etc., for providing door-to-door collection, street sweeping, secondary storage, transportation, processing, and final disposal of waste should be considered.

Waste minimisation or reduction, waste reuse, and waste recycling practices (3Rs) have a significant impact on the waste composition and quantities of waste to be handled and disposed. ULBs should therefore plan for an effective IEC campaign to promote the concept of 3Rs to minimise waste generation. Decentralised approaches for treatment and disposal of waste will also reduce waste quantities to be transported and handled as compared to centralised plants, and should therefore be included in the MSWM plan, wherever appropriate.

The size of the city; projected waste generation rate; waste characterisation; geographical location; climatic conditions; hydro-geological conditions and environmental, social, and economic considerations have an impact on the selection of appropriate systems and technologies for processing and disposal of waste.

The choice of technologies should be guided by proven performance track records within or outside India, technical feasibility under local conditions, financial viability or potential for cost recovery and environmental regulations.

The institutional framework for providing MSWM services and its monitoring and supervision through municipal departments or PPP need to be planned. Depending on the size of the city, a dedicated



Adoption of novel technologies, whose performance has not been proved in the Indian context and whose performance is dependent on very specific input waste characteristics should be avoided.

MSWM department, an MSWM cell, or responsible staff should be made accountable for MSWM and implementation of the MSWM plan in the city. Duties of the responsible staff should be detailed out and disclosed to the general public. Capacity building needs of staff must be addressed.

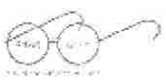
Identifying appropriate benchmarks for performance and delivery of MSWM services is an integral part of the planning process. As a minimum, the SLB indicators need to be regularly monitored. Performance of all contracted services shall also be appropriately monitored, reported, and analysed. A management information system (MIS) should be set up to record and monitor all information or data on MSWM.

Step 5: Schedule for Implementation

An implementation plan, indicating allocation of resources and specifying timelines should be prepared. The implementation plan should address institutional strengthening; raising financial resources through rationalising taxes and supported by user fees as per the relevant regulations; accessing loans from financial institutions; and obtaining government grants, specific project development, and rollout. The institutional and financial operating plan should be an integral part of the MSWM plan. PPP for infrastructure development and service delivery may be fully explored during this exercise. A macro-level time plan for implementation of key activities proposed under the short term and long term plans should be included in the MSWM plan.

Step 6: Stakeholder Consultation for Municipal Solid Waste Management Plan Validation

Provision of effective MSWM services is substantially dependent on community behaviour and practices. Segregation of waste at source, delivering waste to doorstep collectors, avoiding littering, participating in waste recycling, buyback programmes and, most importantly, exploring options for waste minimisation are all dependent on active and appropriate public involvement and support. Citizens should be made aware of the full scale of MSWM services provided by the ULBs and their potential involvement in implementing the plan. Including women in the plan validation and decision-making process is critical for ensuring successful plan implementation. The financial, health, and environmental benefits accruing under the MSWM plan should be determined and highlighted.



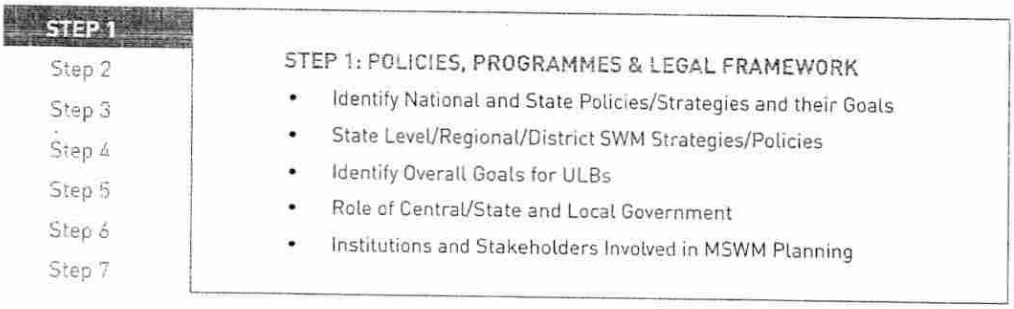
Step 7: Municipal Council Approval for Municipal Solid Waste Management Plan and Implementation Including Public Private Partnership

The final MSWM plan is to be presented to the elected body of the local authority to seek approval and to officially formalise the plan. Municipal council should be made aware of the short term and long term actions and should also approve the financial plan for implementation of these actions. PPP or private operators should also be made aware of the MSWM plan. Contracting models should be transparent and performance based. Both the ULB and PPP operator should be accountable for their roles to ensure successful and sustainable project implementation.

1.4 SEVEN STEP APPROACH FOR MUNICIPAL SOLID WASTE MANAGEMENT PLANNING

1.4.1 STEP 1: POLICIES, PROGRAMMES AND LEGAL FRAMEWORK

Figure 1.3: Step 1 in Municipal Solid Waste Management Plan



1.4.1.1 IDENTIFY NATIONAL AND STATE POLICIES OR STRATEGIES AND THEIR GOALS

Identify relevant policies, programmes and applicable legal framework

The Government of India has undertaken a number of initiatives to address MSWM issues since 2000.[1] The policy interventions by the Government of India in MSWM can be traced back to 1960s, when the Ministry of Food and Agriculture (MoA) announced loans for composting of solid waste. However, a focused policy approach towards managing solid waste gained momentum only after the plague outbreak in Surat in 1994. The J.S. Bajaj Committee constituted in 1995 by the Planning Commission immediately after the plague outbreak, made wide-ranging recommendations including waste segregation at source, primary collection, levy of user charges, use of appropriate equipment and vehicles, and focus on composting and landfilling. Parallel to this, the Ministry of Health and Family Welfare initiated a National Mission

1 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

on Environmental Health and Sanitation while the Central Public Health and Environmental Engineering Organisation (CPHEEO) under MoUD prepared a draft policy paper that detailed funding issues and requirements for MSWM.

In order to better manage MSW within their jurisdiction, ULBs should be aware of the other different categories of waste that should not be allowed to mix with MSW

The Ministry of Environment, Forests and Climate Change (MoEFCC) notified the Municipal Solid Waste (M&H) Rules in September 2000. The rules provide detailed guidelines on various aspects of MSWM and identify the Central Pollution Control Board (CPCB) and the State Pollution Control Boards (SPCBs) as nodal agencies to monitor its implementation directly in the union territories and the states respectively. The Ministry of Environment Forests and Climate Change has recently revised the rules and renamed it as Solid Waste Management Rules, 2016.

Other policy initiatives which inform and guide provision of MSWM services include the recommendations of the Technical Advisory Group on MSWM (2005) and the Inter-Ministerial Task Force on Integrated Plant Nutrient Management (2005); the Hazardous Waste (Management, Handling & Transboundary Movement) Rules (1989, 2008); Bio-Medical Waste Management Rules (2016); the Plastic Waste Rules (2016); and the E-Waste Rules (2016). All of these cover specific types of waste that are not regulated by the MSW (M&H) Rules, 2000. However, they provide guidance to the management of certain streams of waste which may otherwise inadvertently find their way into the municipal waste streams.

Launched in 2014 under the flagship programme namely Swachh Bharat Mission aims to provide the sanitation facilities with respect to scientific municipal solid waste management and liquid waste management to every citizens. SBM stipulates to build the capacities of urban local bodies strong in order to design, execute and operate all systems related to service provision. This requires close linkage between planning, operationalising and sensitizing of the sanitation and waste management services within the departments as well as the citizens for achieving the overall goal of SBM. The initiative has also encouraged the participation of private sector by providing the suitable environment for their active and reliable participation in the sector.

Introduced in 2008, the National Urban Sanitation Policy (NUSP) broadly covers aspects of urban sanitation. MSWM is an important focus area in the NUSP. The NUSP stipulates that MSWM should also be covered in the state sanitation strategy (SSS) and the city sanitation plan (CSP). This requires close linkages between the waste management and the sanitation planning in a particular ULB. The National Mission on Sustainable Habitat, which was approved in 2008 under the National Action Plan on Climate Change (NAPCC), highlights the importance of adopting recycling strategies to avoid greenhouse gas (GHG) emissions.

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There are the rules, regulations, policies, and reforms that guide the MSWM service delivery (Table 1.1). Provisions for floating tax-free bonds by ULBs, income tax relief to waste management agencies, introduction of double accounting system in ULBs, development of model municipal bye-laws are other major policy or regulatory directives which guide ULBs in certain aspects of planning for and operationalising MSW services. Overarching guidelines for private sector participation (PSP) and PPP arrangements have also been drawn by the Department of Economic Affairs. The "Toolkit for Public Private Partnership Frameworks in Municipal Solid Waste Management" was developed by the Ministry of Urban Development.

Table 1.1: Important Policy Landmarks and Initiatives by Government of India[2] on Solid Waste Management

YEAR	RULES, POLICIES, SCHEMES, FINANCIAL PLANS
1989	The Hazardous Waste (M&H) Rules
1994–1995	MSWM strategy paper by NEERI
	J.S. Bajaj Committee (The High Powered Committee on Urban Solid Waste Management)
1998	Bio-medical Waste (M&H) Rules
	Supreme Court appointed Barman Committee
2000	MSW (M&H) Rules
	CPHEEO Manual on MSW
2005	Report of the Technology Advisory Group on SWM
	JNNURM (2005–2012)—40 MSW projects costing Rs. 2,186 Cr sanctioned from a total of 65 cities covered
	UIDSSMT (2005–2012)—51 MSW projects costing Rs. 327 Cr sanctioned from a total of 632 cities covered
	12th Finance Commission (2005–2010)—Rs. 2,500 Cr for 423 Class I cities
2006	Strategy and Action Plan-Use of compost in cities
2007	11th Five-Year Plan (2007–2012)—Rs. 2,210 Cr for MSWM
2008	National Urban Sanitation Policy (NUSP)
	Service Level Benchmarks (SLBs) in MSWM
	Hazardous Waste (Management, Handling & Transboundary Movement)Rules
	National Mission on Sustainable Habitat (NAPCC)
2010	13th Finance Commission (2010–2015)—Establishing standards for delivery of essential services
2011	Plastic Waste (M&H) Rules
	E-Waste (M&H) Rules
	Draft Bio-medical Waste (M&H) Rules
2014	Swachh Bharat Mission, October 2014
2016	Waste Management Rules, 2016 comprising of Solid Waste Management Rules, Plastic Waste Management Rules, Bio-Medical Waste Management Rules, E-Waste Management Rules, Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016 and Construction and Demolition Waste Management Rules, 2016.

2 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

1.4.1.2 STATE LEVEL MUNICIPAL SOLID WASTE MANAGEMENT STRATEGIES OR POLICIES

MSWM plans should take cognisance of state level SWM strategies and policies. These policies provide further guidance to ULBs to implement the SWM Rules, 2016.

While various states are in the process of defining the state level MSWM strategy, some states like Karnataka and, most recently, Andhra Pradesh have notified state level MSWM strategies.

Karnataka State Policy on Integrated Waste Management

The State Government of Karnataka adopted a policy on integrated solid waste management (ISWM) in 2004 with the objective of developing and implementing scientific and sustainable methods for municipal solid waste management (MSWM). Funds were made available under 11th Finance and 12th Finance Commissions for purchase of land, development of landfill sites, procurement of tools, equipment & vehicles and IEC activities.

The primary objectives of the Karnataka State policy on ISWM are to:

- provide directions for MSWM activities in an environmentally, socially, and financially sustainable manner;
- establish an integrated and self-contained operating framework for MSWM; and enhance the ability of ULBs to provide effective waste management services to their citizens.

Some of the principles of the state policy on ISWM include:

- promoting public awareness regarding minimizing and avoiding multiple handling of waste;
- defining the roles and responsibilities of various stakeholders in an operating framework;
- developing systems for effective resource utilisation and deployment;
- promoting recovery of value from municipal solid waste (MSW); and
- developing treatment and final disposal facilities as per statutory requirements.

In order to enhance the stakeholders' involvement in MSWM, the state policy also proposes the following innovations:

- The responsibility of source segregation and primary collection shall be entrusted to the waste generator level (community-based organisations);
- Information, education, and communication (IEC) activities and awareness programs shall be developed and maintained;
- The role of non-government organisations (NGOs) as a communication bridge among the ULB, community, self-help groups (SHGs), and resident welfare associations (RWAs) shall be defined and utilized to help in promoting awareness programme and to engage with communities in understanding difficulties, gaps, and challenges in implementation. There shall be recommendations and consultations with NGOs or RWAs on how to ensure an effective MSWM system;
- ULBs shall allow RWAs or SHGs to contract with private operators for various waste management activities, under specified guidelines and structures.

The state policy on various activities of MSWM includes the following:

- **Primary collection:** The ULBs shall charge a user fee for door-to-door collection. The MSW from bulk generators shall be collected and transferred directly to the secondary transport system.
- **Street sweeping and drain cleaning:** ULBs shall enter into appropriate contractual agreement with private operators for street sweeping and should engage in fair wage practices.
- **Secondary collection and transportation:** The ULBs shall abide by the statutory guidelines of SWM Rules, 2016 and adopt the rule of thumb of usage of metal containers and reduced multiple handling by using dumper placers or tractors with tipping trailer mechanism.
- **Treatment and disposal:** 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.

Facilitating establishment of regional facilities and promoting decentralised waste management facilities, as appropriate, should be included in the key provisions of the state level strategy

1.4.1.3 IDENTIFY AND ANALYSE REGIONAL OR DISTRICT SOLID WASTE MANAGEMENT PLANS

Technical, financial, and managerial challenges of MSWM in cities can be addressed by considering regional arrangements for MSWM.[3]

Some of the benefits of regional MSWM facilities are the following:

- enable authorities to take advantage of economies of scale by collecting inert waste generated across their respective jurisdictions. These facilities reduce the financial and technical burden on each individual authority and help authorities address MSW management in a cost effective manner. They also enable access to technologies requiring a higher order of resources other than available with a single ULB.
- results in more efficient use of land and other scarce natural resources within the region.

Guidance for establishing regional facilities shall be provided by the state governments. A solid waste management cell may be constituted within the Urban Development Department at state level or within the Directorate or Commissionerate of Municipal Administration or its equivalent department. Policy decisions regarding criteria for clustering of ULBs, structure of partnerships and guidance on cost and revenue sharing, and ensuring protection of human rights of all workers or labourers shall be taken by this state level nodal agency.

3 Municipal Solid Waste Management on a Regional Basis; Ministry of Urban Development; available at: http://www.urbanindia.nic.in/programme/uwss/mswm/msw_guide_note.pdf

1.4.1.3.1 Objectives of Regional Solid Waste Management Plans

A regional MSWM facility serves multiple ULBs and facilitates regional level disposal of MSW. In cases where land is not available for processing and disposal, regional processing and disposal facilities may be proposed. To the extent possible, efforts should be made to treat waste locally. Only in cases where there is scarcity of land or expertise, regional processing facilities shall be proposed.

With a view to reduce expenditure of hauling small quantities of waste to regional facilities, transfer stations may be established. Regional systems benefit both large municipal bodies, which experience scarcity of land resources, and smaller municipalities, which are challenged by limited technical and financial resources for establishing their own facilities.

Regional approach facilitates establishment of MSW processing and disposal facilities for ULB clusters, and benefits both large and small ULBs

Availability of land in urban areas is one of the major constraints in management of waste. With an increase in urban population, the land requirements for management of waste also increase. It is however not economically viable for each small ULB to maintain and operate a treatment and sanitary landfill facility.

ULBs are therefore encouraged to develop organic waste processing facilities locally; inerts and process rejects may be hauled from a transfer facility to a centralised or regional processing facility. In cities with a population of over 1 lakh, where the dry and inert waste is being transferred to a regional facility, a transfer station should be constructed for the storage of waste; the capacity may be decided based on a viable size for transport up to the regional facility. Long haul container systems should be used to transport this waste to the regional waste processing or landfill facility.

The Suchitwa Mission of the State Government of Kerala initiated a study to compare the costs of providing sanitary landfills in all of its 5 city corporations and 49 municipalities. The State of Kerala is constrained by the lack of suitable land for landfill construction. Therefore, regional sanitary landfill facilities (SLFs) are suggested. A comparative study on the land and cost requirements for an SLF for a single ULB and the requirements for a regional SLF are given below.

NO	ITEM	INDIVIDUAL SLF FOR EACH ULB	REGIONAL SLF
1	Land requirement (hectare)	2316	957
2	Cost of land (Rs per ha)	0.40 crores	0.18 crores
3	Savings on land cost (Rs)	754 crores	
4	Operation and Maintenance (O&M) cost per tonne (Rs)		388
5	Savings per annum on O&M (Rs)	13 crores	

Source: Suchitwa Mission. http://www.sanitation.kerala.gov.in/

1.4.1.3.2 Institutional Aspects of Regional Approaches

A regional facility entails an institutional arrangement that enables the association of partnering municipalities to provide specific MSWM services. Some of the attributes of a regional approach are the following:[4]

- It is constituted specifically to provide a particular service (MSW processing or disposal).
- It is governed by a board of directors, a council, or an executive body which is unique to the organisation.
- It is usually not dependent on taxes for funding, but raises fund through service tipping fees paid by partnering local bodies.
- It may or may not involve the participation of a private sector service provider.
- It often requires special legislation and ordinances for its establishment.

1.4.1.3.3 Implementation of Regional Municipal Solid Waste Management Plans

Regional projects can be implemented through any of the following:[5]



Various implementation arrangements can be applied to establish a regional MSWM project

Inter-municipal agreements: These are contracts between two or more municipalities who combine their resources to perform a specific task together. The primary advantages of inter-municipal agreements are flexibility and customisation. Inter-municipal agreements are often better suited for limited regional projects. One of the challenges to these agreements is the difficulty in obtaining capital financing because each participating municipality might have to raise money for the project individually.

Authorities, trusts, and special districts: These can be created by governments dedicated to organise their regional programs. These entities have the power to impose regulations, contract with private companies, issue bonds, levy taxes or assessments, or use other means to raise funds for specific projects.

Regional councils: These are another approach used for inter-municipal cooperation to organise and manage all types of cooperative projects. The council provides flexibility and helps in bringing public and private partners together to make decisions.

Private sector participation: This can be used for different services like transporting MSW to the regional landfill system, financing,

4 'Moving Towards the Regional Approach, Water and Sanitation Program', Water and Sanitation Program (2007). Available at http://www.wsp.org/sites/wsp.org/files/ publications/519200880608_SWM_dec_07.pdf

5 'Improving Solid Waste Management in India', D. Zhu, et al., (2008). Available at: http://www.tn.gov.in/cma/swm_in_india.pdf



construction, and operation. Regional organisations can enter into binding agreements with businesses to provide specified and improved services at less cost. Contracts between local governments and businesses generally are governed by the public contracting laws of the state.

Some of the guiding principles that should be taken into consideration while planning, developing, implementing, and managing regional MSW projects are discussed briefly below.

1.4.1.3.4 Land Allocation for Regional Municipal Solid Waste Projects

Land for a regional MSW project can be provided through any of the following mechanisms:

- provided and owned by the state government or by one of the authorities participating in the regional MSW project;
- acquired by one of the participating authorities and allocated by passing appropriate resolutions, without any state government assistance;
- acquired by the state government and vested with a particular municipality or a group of municipalities; and
- provided by the private sector participant.

Land identified for a regional facility cannot be assigned to other uses to ensure and protect the viability of proposed MSWM facilities

Before the selection of any site for the development of a regional MSW facility, it should be ensured that the land use cannot be changed by the competent authority for the duration of the project to ensure bankability and viability of the project. Moreover, the following should be noted:

- The area of land being provided should be sufficient to enable the type of regional MSW facility intended to be developed using specified technology.
- The location should enable optimum number of authorities to have viable access to the facility.
- Land that is already within the possession of either the state government or any authority may be preferred over lands that require acquisition from private or other entities.
- Acquisition of privately owned land may be undertaken in cases where no government land is available.
- Land that has been identified for development or implementation of regional MSW projects shall be notified as having been allocated for the purpose of regional MSW projects only.

- The state government should control land use in and around the regional MSW facility in accordance with development controls to prevent encroachment or development of habitations, structures, etc.

1.4.1.3.5 Solid Waste Quantity and Tipping Fee



Appropriate arrangements for collection of user charges and tipping fees will ensure financial viability of MSWM projects.

- Depending on the type of waste processing facility to be established, each authority shall have to assure a certain quality and quantity of MSW it supplies to the project.
- The tipping fee should be structured so as to enable viable implementation of the project depending on the circumstances and the location of the project.
- In order to guarantee their ability to pay the tipping fee, each participating authority shall make appropriate arrangements such as imposing and collecting fees from within its jurisdiction for the provision of MSW services. An escrow account and charge structure with respect to the identified revenue streams may be created to provide for security of payment of the tipping fee.
- State governments may also resort to an intercept mechanism whereby, the State Government may provide the required payments directly, for and on behalf of the Authority. Under the proposed structure, the participating authorities will contractually agree to the State intercept mechanism.

1.4.1.3.6 Collection and Transportation of Municipal Solid Waste

The authorities participating in a regional MSW project should undertake to improve the efficiency of their MSW collection and transportation systems in a phased and time-bound manner to ensure that the minimum quantity of waste reaches the processing facility or disposal site on a regular basis.



Examples of Regional or Inter-Municipal Arrangements currently under Development[6]

Gujarat: Regional landfill sites have been identified in Gujarat: 45 sites have been proposed for 161 municipalities; with a maximum transport distance of 25 km. Proposals envisage private sector involvement and the Gujarat State Waste Management Company will be the sole contracting agent. Memorandum of understanding will be signed between the cooperating municipalities and the state nodal agency. Nine sites are at an advanced stage of construction of sanitary landfill facilities.

Kerala: A study conducted by Suchitwa Mission recommended that the 14 districts in the state be divided into 6 zones, each with its own landfill site for receiving waste from all towns in that particular zone. The feasibility study for construction of one regional landfill has commenced.

West Bengal: In the Kolkata Metropolitan Development Authority area, six municipalities propose to use one common landfill site. Regional landfills are also being planned in other parts of the state such as the Asansol Municipal Corporation and Durgapur Municipal Corporation. The municipalities of Ranigunj, Jamuria, and Kulti, under the nodal Asansol Durgapur Development Authority, have developed a regional engineered landfill facility. A public private partnership was formed for project implementation.

Maharashtra: The Mumbai Metropolitan Regional Development Authority has decided to develop a regional landfill facility to cater to 2,500 tons of waste with a design period of 25 years. Urban local bodies (ULBs) in the metropolitan region from six municipal corporations or councils are envisaged to use this facility such as Kalyan-Dombivali, Bhiwandi-Nizampur, Ulhasnagar, Ambarnath, and Kulgaon-Badlapur.

Orissa: The cities of Bhubaneswar and Cuttack have associated to commission a common municipal solid waste management facility for treating approximately 600 tonnes of waste from both ULBs. The Orissa Industrial Infrastructure Development Corporation is acting as transaction advisory to facilitate this project. The selected concessionaire will be responsible for designing and constructing the requisite transfer station; transporting waste from the transfer station to the waste management facility; and identifying, designing, constructing, and operating waste management facilities based on appropriate technologies selected by the concessionaire.

Andhra Pradesh: The state government has developed a strategy and issued comprehensive guidelines for setting up regional facilities. 124 ULBs have been clubbed into 19 clusters. Five facilities were established and operated through private sector concession agreements.

6 Adopted from "Moving Towards the Regional Approach, Water and Sanitation Program", Water and Sanitation Program (2007); and further updated by the Expert Committee for revision of MSWM manual (2013-15).

1.4.1.4 ROLE OF CENTRAL, STATE AND LOCAL GOVERNMENTS

While the onus of providing MSWM services in urban areas lies with the ULBs, central and state governments have a significant role to play in defining the framework within which service provision can be planned and executed by ULBs. The following are prescribed authorities and their roles and responsibilities in relation to ensuring the implementation of the provisions of the SWM Rules, 2016.

Table 1.2: Role of Central, State and Local Governments in Municipal Solid Waste Management

LEVEL OF GOVERNMENT	ROLE
Central Government	• Legal & Policy Framework: The SWM Rules, 2016 by the Ministry of Environment, Forest & Climate Change (MoEFCC) mandate provision of MSWM services by municipal authorities in urban areas in the country. Clause 5: Duties of Ministry of Environment, Forest and Climate Change.- (1) The Ministry of Environment, Forest and Climate Change shall be responsible for over all monitoring the implementation of these rules in the country. It shall constitute a Central Monitoring Committee under the Chairmanship of Secretary, Ministry of Environment, Forest and Climate Change comprising officer not below the rank of Joint Secretary or Advisor from the following namely,- Ministry of Urban Development, Ministry of Rural Development, Ministry of Chemicals and Fertilizers, Ministry of Agriculture, Central Pollution Control Board, Three State Pollution Control Boards or Pollution Control Committees by rotation, Urban Development Departments of three State Governments by rotation, Rural Development Departments from two State Governments by rotation, Three Urban Local bodies by rotation, Two census towns by rotation, FICCI, CII, Two subject experts (2) This Central Monitoring Committee shall meet at least once in a year to monitor and review the implementation of these rules. The Ministry of Environment, Forest and Climate Change may co-opt other experts, if needed. The Committee shall be renewed every three years. Clause 6: Duties of Ministry of Urban Development.- (1) The Ministry of Urban Development shall coordinate with State Governments and Union territory Administrations to,- (a) take periodic review of the measures taken by the states and local bodies for improving solid waste management practices and execution of solid waste management projects funded by the Ministry and external agencies at least once in a year and give advice on taking corrective measures; (b) formulate national policy and strategy on solid waste management including policy on waste to energy in consultation with stakeholders within six months from the date of notification of these rules; (c) facilitate States and Union Territories in formulation of state policy and strategy on solid management based on national solid waste management policy and national urban sanitation policy;



Table 1.2: Role of Central, State and Local Governments in Municipal Solid Waste Management [contd.]

LEVEL OF GOVERNMENT	ROLE
	(d) promote research and development in solid waste management sector and disseminate information to States and local bodies; (e) undertake training and capacity building of local bodies and other stakeholders;and (f) provide technical guidelines and project finance to states, Union territories and local bodies on solid waste management to facilitate meeting timelines and standards. Clause 7: Duties of Department of Fertilisers, Ministry of Chemicals and Fertilisers.- (1) The Department of Fertilisers through appropriate mechanisms shall,- (a) provide market development assistance on city compost; and (b) ensure promotion of co-marketing of compost with chemical fertilisers in the ratio of 3 to 4 bags: 6 to 7 bags by the fertiliser companies to the extent compost is made available for marketing to the companies. Clause 8. Duties of Ministry of Agriculture, Government of India.- The Ministry of Agriculture through appropriate mechanisms shall,- (a) provide flexibility in Fertiliser Control Order for manufacturing and sale of compost; (b) propagate utlisation of compost on farm land; (c) set up laboratories to test quality of compost produced by local authorities or their authorised agencies; and (d) issue suitable guidelines for maintaining the quality of compost and ratio of use of compost visa-a-vis chemical fertilizers while applying compost to farmland. Clause 9. Duties of the Ministry of Power.-The Ministry of Power through appropriate mechanisms shall,- (a) decide tariff or charges for the power generated from the waste to energy plants based on solid waste. (b) compulsory purchase power generated from such waste to energy plants by distribution company. Clause 10. Duties of Ministry of New and Renewable Energy Sources- The Ministry of New and Renewable Energy Sources through appropriate mechanisms shall,- (a) facilitate infrastructure creation for waste to energy plants; and (b) provide appropriate subsidy or incentives for such waste to energy plants.

Table 1.2: Role of Central, State and Local Governments in Municipal Solid Waste Management [contd.]

LEVEL OF GOVERNMENT	ROLE
	Clause 14: Duties of Central Pollution Control Board.-The Central Pollution Control Board shall, - (a) co-ordinate with the State Pollution Control Boards and the Pollution Control Committees for implementation of these rules and adherence to the prescribed standards by local authorities; (b) formulate the standards for ground water, ambient air, noise pollution, leachate in respect of all solid waste processing and disposal facilities; (c) review environmental standards and norms prescribed for solid waste processing facilities or treatment technologies and update them as and when required; (d) review through State Pollution Control Boards or Pollution Control Committees, at least once in a year, the implementation of prescribed environmental standards for solid waste processing facilities or treatment technologies and compile the data monitored by them; (e) review the proposals of State Pollution Control Boards or Pollution Control Committees on use of any new technologies for processing, recycling and treatment of solid waste and prescribe performance standards, emission norms for the same within 6 months; (f) monitor through State Pollution Control Boards or Pollution Control Committees the implementation of these rules by local bodies; (g) prepare an annual report on implementation of these rules on the basis of reports received from State Pollution Control Boards and Committees and submit to the Ministry of Environment, Forest and Climate Change and the report shall also be put in public domain; (h) publish guidelines for maintaining buffer zone restricting any residential, commercial or any other construction activity from the outer boundary of the waste processing and disposal facilities for different sizes of facilities handling more than five tons per day of solid waste; (i) publish guidelines, from time to time, on environmental aspects of processing and disposal of solid waste to enable local bodies to comply with the provisions of these rules; and (j) provide guidance to States or Union territories on inter-state movement of waste.
State Government	– The SWM Rules, 2016 indicate that the Secretary-in charge of the Department of Urban Development or Local Self Government department of the concerned State or the Union territory, as the case may be, shall have the overall responsibility for the enforcement of the provisions of these rules in the metropolitan cities. – The Urban Development Department in charge of municipal authorities in the State or Union Territory shall: Clasue 11: Duties of the Secretary-in-charge, Urban Development in the States and Union territories.- (1) The Secretary, Urban Development Department in the State or Union territory through the Commissioner or Director of Municipal Administration or Director of local bodies shall:-

Table 1.2: Role of Central, State and Local Governments in Municipal Solid Waste Management [contd.]

LEVEL OF GOVERNMENT	ROLE
	(a) prepare a state policy and solid waste management strategy for the state or the union territory in consultation with stakeholders including representative of waste pickers, self help group and similar groups working in the field of waste management consistent with these rules, national policy on solid waste management and national urban sanitation policy of the ministry of urban development, in a period not later than one year from the date of notification of these rules; (b) while preparing State policy and strategy on solid waste management, lay emphasis on waste reduction, reuse, recycling, recovery and optimum utilisation of various components of solid waste to ensure minimisation of waste going to the landfill and minimise impact of solid waste on human health and environment; (c) state policies and strategies should acknowledge the primary role played by the informal sector of waste pickers, waste collectors and recycling industry in reducing waste and provide broad guidelines regarding integration of waste picker or informal waste collectors in the waste management system. (d) ensure implementation of provisions of these rules by all local authorities; (e) direct the town planning department of the State to ensure that master plan of every city in the State or Union territory provisions for setting up of solid waste processing and disposal facilities except for the cities who are members of common waste processing facility or regional sanitary landfill for a group of cities; and (f) ensure identification and allocation of suitable land to the local bodies within one year for setting up of processing and disposal facilities for solid wastes and incorporate them in the master plans (land use plan) of the State or as the case may be, cities through metropolitan and district planning committees or town and country planning department; (h) direct the town planning department of the State and local bodies to ensure that a separate space for segregation, storage, decentralised processing of solid waste is demarcated in the development plan for group housing or commercial, institutional or any other non-residential complex exceeding 200 dwelling or having a plot area exceeding 5,000 square meters; (i) direct the developers of Special Economic Zone, Industrial Estate, Industrial Park to earmark at least five percent of the total area of the plot or minimum five plots or sheds for recovery and recycling facility. (j) facilitate establishment of common regional sanitary land fill for a group of cities and towns falling within a distance of 50 km (or more) from the regional facility on a cost sharing basis and ensure professional management of such sanitary landfills; (k) arrange for capacity building of local bodies in managing solid waste, segregation and transportation or processing of such waste at source; (l) notify buffer zone for the solid waste processing and disposal facilities of more than five tons per day in consultation with the State Pollution Control Board; and (m) start a scheme on registration of waste pickers and waste dealers.

Table 1.2: Role of Central, State and Local Governments in Municipal Solid Waste Management [contd.]

LEVEL OF GOVERNMENT	ROLE
	Clause:16: Duties of State Pollution Control Board or Pollution Control Committee.- (1) The State Pollution Control Board or Pollution Control Committee shall,- (a) enforce these rules in their State through local bodies in their respective jurisdiction and review implementation of these rules at least twice a year in close coordination with concerned Directorate of Municipal Administration or Secretary-in-charge of State Urban Development Department; (b) monitor environmental standards and adherence to conditions as specified under the Schedule I and Schedule II for waste processing and disposal sites; (c) examine the proposal for authorisation and make such inquiries as deemed fit, after the receipt of the application for the same in Form I from the local body or any other agency authorised by the local body; (d) while examining the proposal for authorisation, the requirement of consents under respective enactments and views of other agencies like the State Urban Development Department, the Town and Country Planning Department, District Planning Committee or Metropolitan Area Planning Committee, as may be applicable, Airport or Airbase Authority, the Ground Water Board, Railways, power distribution companies, highway department and other relevant agencies shall be taken into consideration and they shall be given four weeks time to give their views, if any; (e) issue authorisation within a period of sixty days in Form II to the local body or an operator of a facility or any other agency authorised by local body stipulating compliance criteria and environmental standards as specified in Schedules I and II including other conditions, as may be necessary; (f) synchronise the validity of said authorisation with the validity of the consents; (g) suspend or cancel the authorization issued under clause (a) any time, if the local body or operator of the facility fails to operate the facility as per the conditions stipulated: provided that no such authorization shall be suspended or cancelled without giving notice to the local body or operator, as the case may be; and (h) on receipt of application for renewal, renew the authorisation for next five years, after examining every application on merit and subject to the condition that the operator of the facility has fulfilled all the provisions of the rules, standards or conditions specified in the authorisation, consents or environment clearance. (2) The State Pollution Control Board or Pollution Control Committee shall, after giving reasonable opportunity of being heard to the applicant and for reasons thereof to be recorded in writing, refuse to grant or renew an authorisation. (3) In case of new technologies, where no standards have been prescribed by the Central Pollution Control Board, State Pollution Control Board or Pollution Control Committee, as the case may be, shall approach Central Pollution Control Board for getting standards specified.

Table 1.2: Role of Central, State and Local Governments in Municipal Solid Waste Management [contd.]

LEVEL OF GOVERNMENT	ROLE
	(4) The State Pollution Control Board or the Pollution Control Committee, as the case may be, shall monitor the compliance of the standards as prescribed or laid down and treatment technology as approved and the conditions stipulated in the authorisation and the standards specified in Schedules I and II under these rules as and when deemed appropriate but not less than once in a year. (5) The State Pollution Control Board or the Pollution Control Committee may give directions to local bodies for safe handling and disposal of domestic hazardous waste deposited by the waste generators at hazardous waste deposition facilities. (6) The State Pollution Control Board or the Pollution Control Committee shall regulate Inter-State movement of waste.
District/ Region	Clause 12: Duties of District Magistrate or District Collector or Deputy Commissioner.- The District Magistrate or District Collector or as the case may be, the Deputy Commissioner shall, - (a) facilitate identification and allocation of suitable land as per clause (f) of rules 11 for setting up solid waste processing and disposal facilities to local authorities in his district in close coordination with the Secretary-in-charge of State Urban Development Department within one year from the date of notification of these rules; (b) review the performance of local bodies, at least once in a quarter on waste segregation, processing, treatment and disposal and take corrective measures in consultation with the Commissioner or Director of Municipal Administration or Director of local bodies and secretary-in-charge of the State Urban Development.
Municipal Authorities	As per the 74th CAA, the SWM Rules, 2016 and the State Municipal Laws, ULBs are primarily responsible for the provision of municipal solid waste management services. Clause 15: Duties and responsibilities of local authorities and village Panchayats of census towns and urban agglomerations.- The local authorities and Panchayats shall,- (a) prepare a solid waste management plan as per state policy and strategy on solid waste management within six months from the date of notification of state policy and strategy and submit a copy to respective departments of State Government or Union territory Administration or agency authorised by the State Government or Union territory Administration; (b) arrange for door to door collection of segregated solid waste from all households including slums and informal settlements, commercial, institutional and other non residential premises. From multi-storage buildings, large commercial complexes, malls, housing complexes, etc., this may be collected from the entry gate or any other designated location; (c) 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 of waste;

Table 1.2: Role of Central, State and Local Governments in Municipal Solid Waste Management [contd.]

LEVEL OF GOVERNMENT	ROLE
	(d) facilitate formation of Self Help Groups, provide identity cards and thereafter encourage integration in solid waste management including door to door collection of waste; (e) frame bye-laws incorporating the provisions of these rules within one year from the date of notification of these rules and ensure timely implementation; (f) prescribe from time to time user fee as deemed appropriate and collect the fee from the waste generators on its own or through authorised agency; (g) direct waste generators not to litter i.e throw or dispose of any waste such as paper, water bottles, liquor bottles, soft drink canes, tetra packs, fruit peel, wrappers, etc., or burn or burry waste on streets, open public spaces, drains, waste bodies and to segregate the waste at source as prescribed under these rules and hand over the segregated waste to authorised the waste pickers or waste collectors authorised by the local body; (h) 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; Bins for storage of bio-degradable wastes shall be painted green, those for storage of recyclable wastes shall be printed white and those for storage of other wastes shall be printed black; (i) establish waste deposition centres for domestic hazardous waste and give direction for waste generators to deposit domestic hazardous wastes at this centre for its safe disposal. Such facility shall be established in a city or town in a manner that one centre is set up for the area of twenty square kilometers or part thereof and notify the timings of receiving domestic hazardous waste at such centres; (j) ensure safe storage and transportation of the domestic hazardous waste to the hazardous waste disposal facility or as may be directed by the State Pollution Control Board or the Pollution Control Committee; (k) direct street sweepers not to burn tree leaves collected from street sweeping and store them separately and handover to the waste collectors or agency authorised by local body; (l) provide training on solid waste management to waste-pickers and waste collectors; (m) collect waste from vegetable, fruit, flower, meat, poultry and fish market on day to day basis and promote setting up of decentralised compost plant or biomethanation plant at suitable locations in the markets or in the vicinity of markets ensuring hygienic conditions; (n) collect separately waste from sweeping of streets, lanes and by-lanes daily, or on alternate days or twice a week depending on the density of population, commercial activity and local situation;

Table 1.2: Role of Central, State and Local Governments in Municipal Solid Waste Management [contd.]

LEVEL OF GOVERNMENT	ROLE
	(o) set up covered secondary storage facility for temporary storage of street sweepings and silt removed from surface drains in cases where direct collection of such waste into transport vehicles is not convenient. Waste so collected shall be collected and disposed of at regular intervals as decided by the local body; (p) collect horticulture, parks and garden waste separately and process in the parks and gardens, as far as possible; (q) transport segregated bio-degradable waste to the processing facilities like compost plant, biomethanation plant or any such facility. Preference shall be given for on site processing of such waste; (r) transport non-bio-degradable waste to the respective processing facility or material recovery facilities or secondary storage facility; (s) transport construction and demolition waste as per the provisions of the Construction and Demolition Waste management Rules, 2016; (t) involve communities in waste management and promotion of home composting, bio-gas generation, decentralised processing of waste at community level subject to control of odour and maintenance of hygienic conditions around the facility; (u) phase out the use of chemical fertilizer in two years and use compost in all parks, gardens maintained by the local body and wherever possible in other places under its jurisdiction. Incentives may be provided to recycling initiatives by informal waste recycling sector. (v) facilitate construction, operation and maintenance of solid waste processing facilities and associated infrastructure on their own or with private sector participation or through any agency for optimum utilisation of various components of solid waste adopting suitable technology including the following technologies and adhering to the guidelines issued by the Ministry of Urban Development from time to time and standards prescribed by the Central Pollution Control Board. Preference shall be given to decentralised processing to minimize transportation cost and environmental impacts such as- a) biomethanation, microbial composting, vermi-composting, anaerobic digestion or any other appropriate processing for bio-stabilisation of biodegradable wastes; b) waste to energy processes including refused derived fuel for combustible fraction of waste or supply as feedstock to solid waste based power plants or cement kilns; (w) undertake on their own or through any other agency construction, operation and maintenance of sanitary landfill and associated infrastructure as per Schedule 1 for disposal of residual wastes in a manner prescribed under these rules; (x) make adequate provision of funds for capital investments as well as operation and maintenance of solid waste management services in the annual budget ensuring that funds for discretionary functions of the local body have been allocated only after meeting the requirement of necessary funds for solid waste management and other obligatory functions of the local body as per these rules; (y) make an application in Form-I for grant of authorisation for setting up waste processing, treatment or disposal facility, if the volume of waste is exceeding five metric tones per day including sanitary landfills from the State Pollution Control Board or the Pollution Control Committee, as the case may be;

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Table 1.2: Role of Central, State and Local Governments in Municipal Solid Waste Management [contd.]

LEVEL OF GOVERNMENT	ROLE
	(z) submit application for renewal of authorisation at least sixty days before the expiry of the validity of authorisation; (za) prepare and submit annual report in Form IV on or before the 30th April of the succeeding year to the Commissioner or Director, Municipal Administration or designated Officer; (zb) the annual report shall then be sent to the Secretary -in-Charge of the State Urban Development Department or village panchayat or rural development department and to the respective State Pollution Control Board or Pollution Control Committee by the 31st May of every year; (zc) educate workers including contract workers and supervisors for door to door collection of segregated waste and transporting the unmixed waste during primary and secondary transportation to processing or disposal facility; (zd) ensure that the operator of a facility provides personal protection equipment including uniform, fluorescent jacket, hand gloves, raincoats, appropriate foot wear and masks to all workers handling solid waste and the same are used by the workforce; (ze) ensure that provisions for setting up of centers for collection, segregation and storage of segregated wastes, are incorporated in building plan while granting approval of building plan of a group housing society or market complex; and (zf) frame bye-laws and prescribe criteria for levying of spot fine for persons who litters or fails to comply with the provisions of these rules and delegate powers to officers or local bodies to levy spot fines as per the bye laws framed; and (zg) create public awareness through information, education and communication campaign and educate the waste generators on the following; namely:- (i) not to litter; (ii) minimise generation of waste; (iii) reuse the waste to the extent possible; (iv) practice segregation of waste into bio-degradable, non-biodegradable (recyclable and combustible), sanitary waste and domestic hazardous wastes at source; (v) practice home composting, vermi-composting, bio-gas generation or community level composting; (vi) wrap securely used sanitary waste as and when generated in the pouches provided by the brand owners or a suitable wrapping as prescribed by the local body and place the same in the bin meant for non- biodegradable waste; (vii) storage of segregated waste at source in different bins; (viii) handover segregated waste to waste pickers, waste collectors, recyclers or waste collection agencies; and (ix) pay monthly user fee or charges to waste collectors or local bodies or any other person authorised by the local body for sustainability of solid waste management.

Table 1.2: Role of Central, State and Local Governments in Municipal Solid Waste Management [contd.]

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

1.4.1.4.1 Guidance on State and Urban Local Body Institutional Linkages

Every state government and union territory shall constitute a state level advisory body through the urban development department within 6 months from the date of notification of SWM Rules, 2016. The state level advisory body shall meet at least once in 6 months to review all the matters related to implementation of SWM Rules, 2016 and implementation of state policy and strategy on MSWM, and to give advice to state government regarding necessary measures for expeditious and appropriate implementation of these rules. The copies of the review report shall be forwarded to all the prescribed authorities under the SWM Rules, 2016 for necessary action.

24. Annual report:-

(1) The operator of facility shall submit the annual report to the local body in Form-III on or before the 30th day of April every year.

(2) The local body shall submit its annual report in Form-IV to State Pollution Control Board or Pollution Committee and the Secretary-in-Charge of the Department of Urban Development of the concerned State or Union Territory in case of metropolitan city and to the Director of Municipal Administration or Commissioner of Municipal Administration or Officer in -Charge of Urban local bodies in the state in case of all other local bodies of state on or before the 30th day of June every year

(3) Each State Pollution Control Board or Pollution Control Committee as the case may be, shall prepare and submit the consolidated annual

report to the Central Pollution Control Board and Ministry of Urban Development on the implementation of these rules and action taken against non complying local body by the 31st day of July of each year in Form-V.

(4) The Central Pollution Control Board shall prepare a consolidated annual review report on the status of implementation of these rules by local bodies in the country and forward the same to the Ministry of Urban Development and Ministry of Environment, Forest and Climate Change, along with its recommendations before the 31st day of August each year.

(5) The annual report shall be reviewed by the Ministry of Environment, Forest and Climate Change during the meeting of Central Monitoring Committee.

25. Accident reporting-

In case of an accident at any solid waste processing or treatment or disposal facility or landfill site, the Officer- in- charge of the facility shall report to the local body in Form-VI and the local body shall review and issue instructions if any, to the in- charge of the facility.

1.4.2 MUNICIPAL SOLID WASTE MANAGEMENT PLAN: LINK TO SERVICE LEVEL BENCHMARKS

As a part of the on-going endeavour to introduce greater accountability among urban local bodies to improve urban services, the MoUD has prepared Service Level benchmarks (SLBs) at the national level for service provision in 4 key sectors – water supply, sewerage, municipal solid waste management and storm water management. Devolution of the 13th Finance Commission Grants to ULBs has been linked to their assessment and achievement of SLBs.

ULBs should assess their current compliance with prescribed SLBs and should determine milestones for achieving identified targets within a specified timeline

Current SLBs and future targets for improved service levels are to be furnished annually by ULBs to the concerned departments in respective States and notified in the Gazette. Release of performance related grants is contingent on the assessment of SLBs by the concerned state level department and the MoUD. Service Level Benchmarking for all 4 core sectors is one of the nine reform conditions (condition no.8) stipulated by 13th Finance Commission, to be fulfilled by the States and Urban Local Bodies every year, starting from Financial Year 2010-11 to 2014-15.

Monitoring performance and improvements is envisaged as the goal of the Service Level Benchmarking programme. Benchmarking should be used as a tool for undertaking objective performance analysis by ULBs to improve their activities. The benchmarking of services enables state

level agencies and local level service providers to initiate a process of performance monitoring and evaluation against agreed targets.

The following SLBs have been developed by MoUD for measuring and monitoring provision of solid waste management services by ULBs.

Table 1.3: Service Level Benchmarks for Solid Waste Management[7]

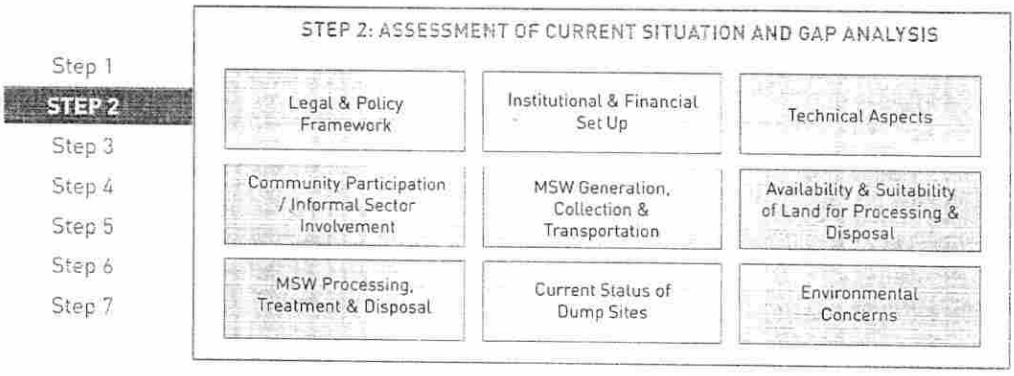
S.NO.	INDICATOR	UNIT & DEFINITION	VALUE
1.	Household level coverage of SWM services	As % of households and establishments that are covered by daily doorstep collection system	100%
2.	Efficiency of MSW collection	As % of total waste collected by ULB and authorized service providers versus the total waste generated within the ULB, excluding recycling or processing at the generation point	100%
3.	Extent of MSW segregation	As % of segregated waste from households and establishments (segregation should at least be at the level of separation of wet and dry waste at source)	100%
4.	Extent of recovered MSW	As % of waste collected (this is an indication of the quantum of waste collected, which is either recycled or processed)	80%
5.	Extent of scientific disposal of MSW	As % of waste disposed in a sanitary landfill sites versus total quantum of waste disposed in all sanitary landfills and dumping sites	100%
6.	Efficiency in redressal of customer complaints	As % of total number of SWM related complaints resolved in 24 hours versus total number of SWM complaints received within the period	80%
7.	Extent of cost recovery in SWM services	As % recovery of all operating expenses related to SWM services that the ULB is able to meet from the operating revenues of sources related exclusively to SWM	100%
8.	Efficiency in collection of SWM charges	Current year revenues collected as a % of the total operating revenues for the corresponding period	90%

Detailed guidance on the measurement and evaluation of the Service Level Benchmarks for SWM service provision are given in the SLB Handbook of the MoUD.

7 "Handbook of Service Level Benchmarking", Ministry of Urban Development (2008).

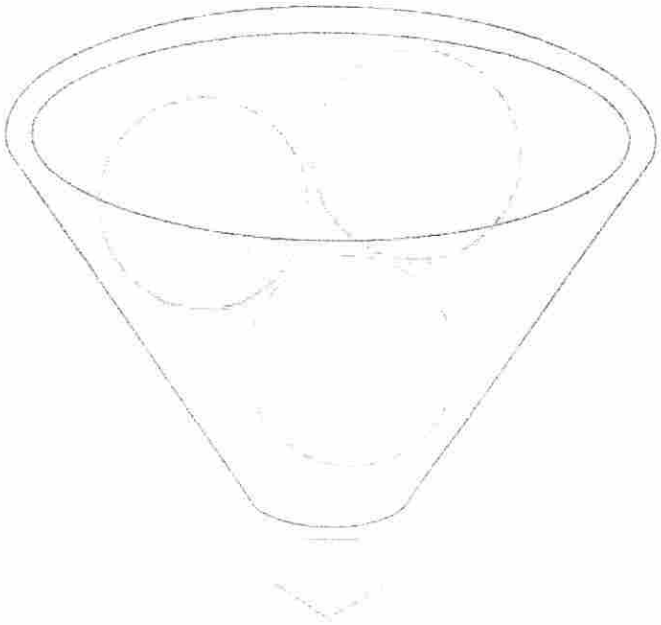
1.4.3 STEP 2: ASSESSMENT OF CURRENT SITUATION OR STATUS AND GAP ANALYSIS

Figure 1.4: Step 2 in Municipal Solid Waste Management Plan



The MSWM department in the ULB should collect baseline information that needs to be assessed as indicated in Table 1.4. Baseline information shall be gathered from ward level records, citywide MSWM records, and field investigations as required (Figure 1.5).

Figure 1.5: An Overview of Baseline Information Required for Strategic Planning

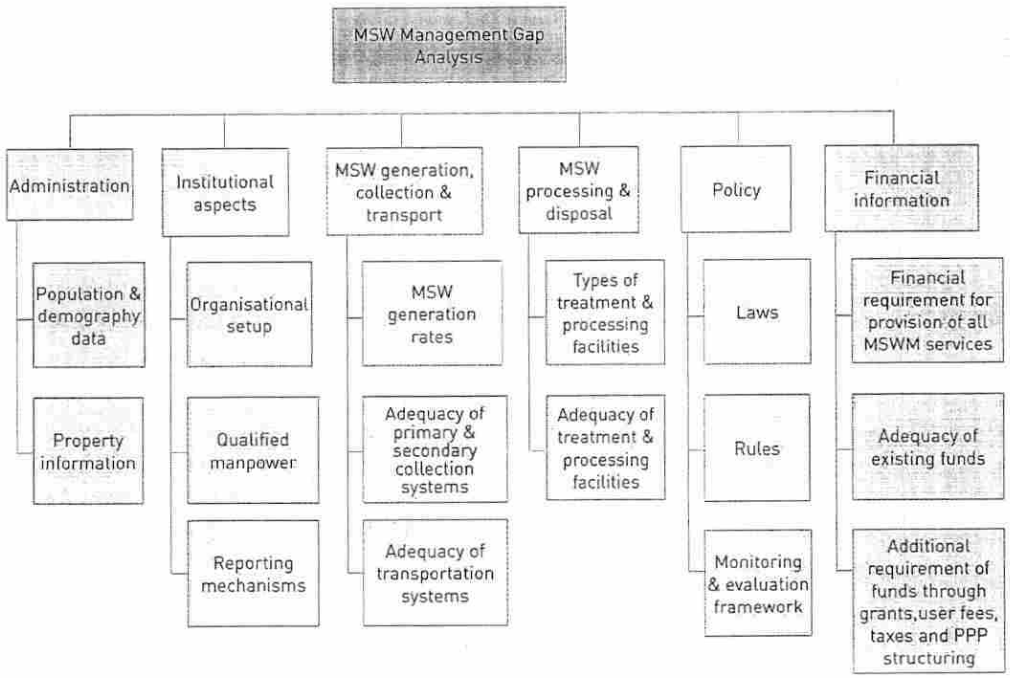


The main objective of the baseline study is to understand the existing solid waste system as accurately as possible; analyse system deficiencies in the context of SWM Rules, 2016; and utilise that information for further planning, implementation, and monitoring processes. Local conditions shall be considered while assessing the inadequacy of existing service and planning for the future with due consideration of local demography, physical location, growth objectives of the ULB, as well as social and environmental conditions.

1.4.3.1 GAP ANALYSIS

The assessment of information on the current status of waste management in the ULB in relation to the requirements of existing regulation, policies, guidelines, and identified service level benchmarks (SLBs) will result in an identification of key shortfalls in achieving the desired level of services and shall form the basis for preparing a plan to improve the MSWM system. Figure 1.6 illustrates a schematic diagram depicting the issues to be considered while assessing gaps in MSW service provision.

Figure 1.6: Considerations for Gap Analysis



An indicative list of specific information to be collected and analysed for establishing the baseline of SWM service provision is given in Table 1.4.

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Table 1.4: Matrix for Collection of Baseline Information (including statutory requirements as per SWM Rules, 2016 and SLBs)

INFORMATION AT CITY LEVEL	INFORMATION AT WARD LEVEL	IDENTIFICATION OF STAKEHOLDERS
Administration		
• Identify electoral and administrative wards and zones within the ULB • Prepare a detailed city map showing total area in km², ward boundaries, and city • level demographic details, roads, drainage network, and land use pattern • Depict on map areas served by door-to-door collection, community bin collection system, and areas not served • Details of jurisdiction area and decadal growth of the city in the last 3 decades • City level information on number of households, non-residential premises, institutional or bulk generators, industries and markets (information on a map) • Number of election or administrative wards • Details of existing monitoring and reporting system including a complaint redressal system	• Ward level population and demography details • Number and location of slums (notified and non-notified) and their population • Identify number of MSW generators in each ward (households, commercial establishments, institutional or bulk generators, industries, and markets) (information on a map) • Details of existing monitoring and reporting system including a complaint redressal system	
Institutional Aspects		
• Organisational structure of the ULB • Organisational structure of SWM department in the city with full details of incumbents and their numbers, roles, and responsibilities • Number and level of engineers with the municipal authority in relation to the SWM department • Number and level of sanitary workers employed by the ULB for street cleaning, drain cleaning, transportation, processing and disposal of waste (regular and contractual) • Provisions for workers (access to toilets, storage facility, linkages with community level crèches or anganwadis, PPE, etc.) • Sweeper/road length ratio, sweeper/supervisor ratio, sweeper/population ratio, sweeper/bin ratio • Details of MSWM tasks outsourced to external entities through various contracting procedures	• Ward level human resources details • Number of junior engineers at ward level • Number of chief sanitary inspectors or officers • Number of sanitary inspectors • Number of sanitary supervisors • Number of sanitary workers • Provisions for workers (access to toilets, storage facility, linkages with community level crèches or anganwadis, PPE, etc.) • Sweeper/road length ratio, sweeper/supervisor ratio, sweeper/population ratio, sweeper/bin ratio • Details of MSWM tasks outsourced to external entities through various contracting procedures	• Identification of operators in the city, extent of their coverage, the user fees levied by them, and level of their performance • List of known recyclers in the ULB • Approximate number of waste pickers and persons involved in the kabadi system within the ULB jurisdiction • Identification of NGOs, voluntary groups, SHGs involved in SWM

Table 1.4: Matrix for Collection of Baseline Information (including statutory requirements as per SWM Rules, 2016 and SLBs) [contd.]

INFORMATION AT CITY LEVEL	INFORMATION AT WARD LEVEL	IDENTIFICATION OF STAKEHOLDERS
Natural Environment		
• Climate, rainfall, temperature, wind speed and direction, dispersion conditions • Topography and drainage conditions • Land use and land cover • Soil type • Groundwater table • Surface water sources • Sensitive natural areas (mangroves, eco-sensitive zones)	• Climate, rainfall, temperature, wind speed and direction, dispersion conditions • Topography and drainage conditions • Land use and land cover • Soil type • Groundwater table • Surface water sources • Sensitive natural areas (mangroves, eco-sensitive zones)	
MSW Generation, Collection and Transportation		
• Total quantity of waste generation, waste generation rates, seasonal fluctuations (TPD) • Total quantity of MSW collected (TPD) • Extent of population practicing waste storage at source and waste segregation • Extent of waste recycling or recovery • Per capita waste collected per day • Details of primary waste storage facilities • Number and type of community bins and secondary storage depots, their location, and type of waste collected (segregated or nonsegregated) • Coverage of population in daily street sweeping • Extent of coverage of slums and informal settlements • Waste transportation: number of vehicles and types of vehicles for primary, secondary, and tertiary transportation (differentiated for main waste types) • Details and route map for waste transportation in the city with identified service areas for different routes or vehicles or door-to-door collection beats (information to be marked on a map) • Number of trips made by vehicles in each shift • Quantity of solid waste transported by each vehicle • Percentage of waste collected each day • Frequency of collection from street bins • Number and identification of nuisance spots in the city where waste is indiscriminately disposed of (information to be marked on a map)	• Quantity and characteristics of waste generated and collected per ward • Waste quantities from different generators (residential, commercial, institutional, markets, bulk generators and businesses) • Quantity of construction and demolition waste • Quantity of E-Waste • Quantity of Plastic waste • Quantity of Biomedical waste • Status of at source waste collection • Door-to-door waste collection beat mapping (information to be marked on a map) • Door-to-door staffing involved • Waste collection frequency • Details of number and type of vehicles used for transportation and transportation routes (information to be marked on a map) • Number and identification of nuisance spots in the ward where waste is indiscriminately disposed of (information to be marked on a map)	• Role and extent of informal sector (waste pickers or kabadi system) • Involvement of RWAs or SHGs in collection of recyclables • Role of market associations • Role of institutions like universities, cantonments, government offices, etc. • Role of commercial enterprises, hotel associations, etc.

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Table 1.4: Matrix for Collection of Baseline Information (including statutory requirements as per SWM Rules, 2016 and SLBs) [contd.]

INFORMATION AT CITY LEVEL	INFORMATION AT WARD LEVEL	IDENTIFICATION OF STAKEHOLDERS
• Number and type of bins for secondary collection • Number and type of handcarts used for primary collection		
MSW Processing, Treatment and Disposal		
• Presence or absence of waste treatment or processing and disposal facilities in the ULB (location to be marked on a map) • Land available (location and area) for centralised and decentralised systems for processing and treatment • Land available (location and area) for sanitary landfill and dumping waste (marked on a map) • Technology adopted in each of the facilities • Percentage of MSW treated daily through the compost plants (decentralised and centralised), both windrow composting and vermicomposting • RDF plants • Waste to energy plants • Special waste treatment facilities, if any • Quantity and characterisation of waste treated or processed in each facility • Quantity of products sold from each treatment or processing facility • Total quantity of MSW disposed at sanitary landfill (TPD) • Total quantity of MSW disposed at dumpsite (TPD) • Quantity and characteristics of rejects from each facility and their disposal mechanism • Capacity, design life, technology, environmental management systems in each of the processing or treatment facility • Waste disposal methods adopted • Number of dumpsites and sanitary landfills (location on a map) • Sanitary landfill facilities and dumpsites - current capacity, waste disposed each day, expected life of landfill, landfill facilities (location on a map)	• Existing decentralised waste processing and/ or disposal systems, their size, and technology adopted (information to be marked on a map) • Reject management systems from decentralised facilities • Material recycling facilities • Land available (location and area) for decentralised processing and treatment (information on a map) • Land available (location and area) for dumping waste (location and area marked on a map)	• Private sector, NGOs or RWAs or SHGs, civil bodies, individuals involved in MSW processing at decentralised and centralised levels and extent of their coverage
Policy		
• Mandates or provisions of national, state, regional laws or rules, regulations, and policies related to MSWM and status of their implementation • Existing monitoring and evaluation mechanism for assessing MSWM	• Ward level monitoring mechanism or regulations related to MSWM and status of their implementation	

Table 1.4: Matrix for Collection of Baseline Information (including statutory requirements as per SWM Rules, 2016 and SLBs) [contd.]

INFORMATION AT CITY LEVEL	INFORMATION AT WARD LEVEL	IDENTIFICATION OF STAKEHOLDERS
Financial Information		
• Annual revenue and capital incurred by ULB for MSWM (direct expenditure and contracting costs) • Costs per tonne of waste collected, treated, processed, and disposed • User charge prescribed for door-to-door collection service revenues (demand and collection) • Revenue generation from user charges or percent recovery • Revenue generation from resource recovery • Operation & maintenance costs for MSWM • Cost recovery for MSWM services • Revenue generation from sale of products from various processing and treatment technologies • Location and number of households paying user charges (location to be marked on a map)	• User charge prescribed for door-to-door collection service revenues (demand and collection) • Revenue generation from user charges or percent recovery • Location and number of households paying user charges (location to be marked on a map)	

1.4.3.2 DATA COLLECTION METHODOLOGY

Detailed information for assessing the adequacy of MSWM services may not be readily available with the ULB. Collection of data mentioned in Table 1.4 could overburden smaller ULBs. Therefore, efforts may be made to collect secondary data from previous surveys or studies undertaken for other purposes. Some data may also be available with service providers, city planning departments, etc. Essential information may also be collected from field level supervisors after imparting requisite training on the type and manner of data to be collected from their respective wards.

Availability of authentic data is a pre-requisite for strategic planning and implementation of MSWM Plan within a ULB

Primary data shall be collected only when authentic secondary data is unavailable. Primary data may be collected through conducting surveys and measurements at the point of generation using data collection formats.

1.4.3.2.1 Representative Data

Where the collection of primary data from the entire planning area is not possible, representative samples may be collected. The size of the representative sample shall be guided by consideration of the variations

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in demography and income levels in constituent areas and seasonal variations.

1.4.3.3 QUANTIFICATION AND COMPOSITION OF WASTE

As an essential requirement each ULB should assess the quantity and composition of waste generated to plan for and design MSWM systems effectively. The quantity and composition of MSW generated in the ULB determine collection, processing, and disposal options that could be adopted. They are dependent on the population, demographic details, principal activities in the city or town, income levels, and lifestyle of the community.

Waste generation is strongly dependent on the local economy, lifestyle, and infrastructure. It has been well established that waste generation of an area is proportional to average income of the people of that area. It is also observed that generation of organic, plastic, and paper waste is high in high income areas.

An assessment states that the per capita waste generation is increasing by about 1.3% per year. With an urban growth rate of 3.0%–3.5% per year, the annual increase in waste quantities may be considered at 5% per year. Impacts of increasing ULB jurisdiction should also be considered while assessing future waste generation rates.

Several studies were conducted by Central Pollution Control Board (CPCB) over the last 2 decades to arrive at waste generation details and composition of MSW generated in the country. Summaries of the several findings are listed below:

- 1996: The characterisation studies carried out by National Environmental Engineering Research Institute (NEERI) in 1996 indicate that MSW contains large organic fraction (30%–40%); ash and fine earth (30%–40%); paper (3%–6%); along with plastic, glass, and metal (each less than 1%). The calorific value of refuse ranges between 800 and 1,000 kilocalorie per kilogram (kcal/kg) and carbon-to-nitrogen (C/N) ratio ranges between 20 and 30. Study revealed that quantum of waste generation varies between 0.2 and 0.4 kg/capita/day in the urban centres and goes up to 0.5 kg/capita/day in metropolitan cities. The study was carried out in 43 cities of varying sizes, as detailed out in Table 1.5. The results were presented in a report published by NEERI "Strategy Paper on Solid Waste Management in India" (1996).

Table 1.5: Per-capita Waste Generation Rates from NEERI Study in 1996[8]

POPULATION RANGE (IN MILLION)	NO. OF CITIES SURVEYED	AVERAGE PER CAPITA VALUE (KG/CAPITA/DAY)
0.1 to 0.5	12	0.21
0.5 to 1.0	15	0.25
1.0 to 2.0	9	0.27
2.0-5.0	3	0.35
>5.0	4	0.50



It is essential to consider socio-economic conditions while planning, as they have a direct impact on per capita waste generation and composition.

- **1999-2000:** The study conducted by CPCB through Environment Protection Training and Research Institute (EPTRI) in 1999–2000 in 210 Class I cities and 113 Class II towns indicated that Class I cities generated 48,134 tons per day (TPD) of MSW while Class II towns generated 3,401 TPD of MSW. The study revealed that waste generation rate in Class I cities was approximately 0.34 kg/capita/day while the waste generation rate in Class II towns was found to be 0.14 kg/capita/day.
- **2004-2005:** NEERI's study "Assessment of Status of Municipal Solid Wastes Management in Metro Cities and State Capitals" in 2004–2005 assessed 59 cities (35 metro cities and 24 state capitals). Studies have revealed that waste generation rate varies from 0.12 to 0.60 kg/capita/day. Analysis of physical composition indicates that total compostable matter in the waste is 40%–60%, while recyclable fraction is 10%–25%. The moisture content in the MSW is 30%–60%, while the C/N ratio is 20–40.

Table 1.6: Physical Composition of Municipal Solid Waste[9]

YEAR	COMPOSITION (%)							
	Biodegradables	Paper	Plastic/ Rubber	Metal	Glass	Rags	Other	Inerts
1996	42.21	3.63	0.60	0.49	0.60	-	-	45.13
2005	47.43	8.13	9.22	0.50	1.01	4.49	4.016	25.16

- **2010-2011:** The survey conducted by the Central Institute of Plastics Engineering and Technology (CIPET) at the instance of CPCB has reported generation of 50,592 TPD of MSW in 2010–2011 in the same 59 cities.
- **2014-2015:** As per CPCB, 1,43,449 TPD of MSW was generated for 34 states and union territories during 2013–2014. The average rate of waste generation in India, based on this data, is 0.11 kg/capita/day. Out of the total waste generated, approximately 1,17,644 TPD (82%) of MSW was collected and 32,871 TPD (22.9%) was processed or treated.

8 National Environmental Engineering Research Institute Study (1996).
9 'Improving Solid Waste Management in India', Zhu., D. et.al., (2008). Available at: http://www.tn.gov.in/cma/swm_in_india.pdf

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Other studies and observations indicate that waste generation rate is between 200 and 300 gm/capita/day in small towns and cities with a population below 2,00,000. It is usually 300–350 gm/capita/day in cities with a population between 2,00,000 and 5,00,000; 350–400 gm/capita/day in cities with a population between 5,00,000 and 10,00,000; and 400–600 gm/capita/day in cities with a population above 10,00,000. However, these are only indicative figures which need to be verified while planning city specific MSWM systems.

1.4.3.3.1 Waste Quantification

Current practice: Waste generation rates are quantified by measuring the load of waste in collection vehicles either at a municipal or private weighbridge in the city. Alternately, the volumes of different vehicle used for transportation of waste are considered and a rule of thumb of 400–500 kilogram per cubic meter (kg/m^3) is applied for determining the quantity of waste transported per trip per type of vehicle. A summation of the quantities of waste transported by each vehicle type multiplied by the total number of trips to the landfill by similar vehicles determines the total quantity of waste transported in the ULB. The practice of an eye estimate of waste quantity transported is not reliable as many times trucks carrying waste are half full or carry light material.



Current Practice for Estimation of Quantity of Transported Waste

Total Waste Collected = Quantity of Waste Transported by Each Vehicle x No. of Trips

The quantity of waste measured at transfer stations or processing or disposal sites also does not accurately reflect waste generation rates, since these measurements do not include:

- waste disposed at unauthorised places, vacant lots, alleys, ditches; etc.;
- waste recovered by kabadi system;
- waste recovered by informal waste collectors or waste pickers from the streets, bins, and intermediate transfer points, etc.

10 Adapted from "Strategic Planning Guide for Municipal Solid Waste Management". Environmental Resources Management (ERM), (2000), prepared for the World Bank, SDC and DFID by Waste-Aware, London; Available at: http://www.worldbank.org/swm/erm/start_up.pdf

Sampling for Waste Quantification

Municipal solid waste is very heterogeneous in nature and its composition varies with place and time. Even samples obtained from the same place (sampling point) on the same day, but at different times may show totally different characteristics.

Long term Planning: For the purpose of long term planning, the average amount of waste disposed by a specific class of generators can be estimated only by averaging data from several samples collected continuously for 7 days at multiple representative locations within the ULB jurisdiction in each of the 3 main seasons (summer, winter, and rainy seasons). Waste quantities should be aggregated over the 7-day period, weighed, and averaged. These quantities can then be extrapolated to the entire urban local body (ULB) and per capita generation assessed.

This should be repeated once every 3–5 years at the time of the review of the MSWM plan.

Short term Planning: Select at least 100 representative sampling locations per 1,00,000 population including households of low, mid, and high income levels; commercial establishments; institutional generators; hospitals and health care establishments; small and medium-sized enterprises; hotels; function halls; vegetable markets; sports complexes or facilities; places of worship (temples, mosques, etc.); and other significant representative groups. Storage bags sufficient for 3–7 days can be distributed to each waste generator who may be advised to deposit all waste generated daily in the given bag which is to be handed over to the specified waste collector on the subsequent day in the morning; the bags so distributed may be collected daily for a minimum of 3–7 days continuously and weighed immediately after collection using a sensitive weighing machine. Record may be kept of the waste generated by different categories of waste generators. The waste collected from each category may thereafter be mixed categorywise and segregated component-wise, and each component may be weighed separately to arrive at the waste composition in different categories of waste generators. This representative waste quantity and quality when extrapolated to the entire ULB and divided by the population will give the per capita waste generation rates.

Quantifying Total Waste for Processing or Disposal

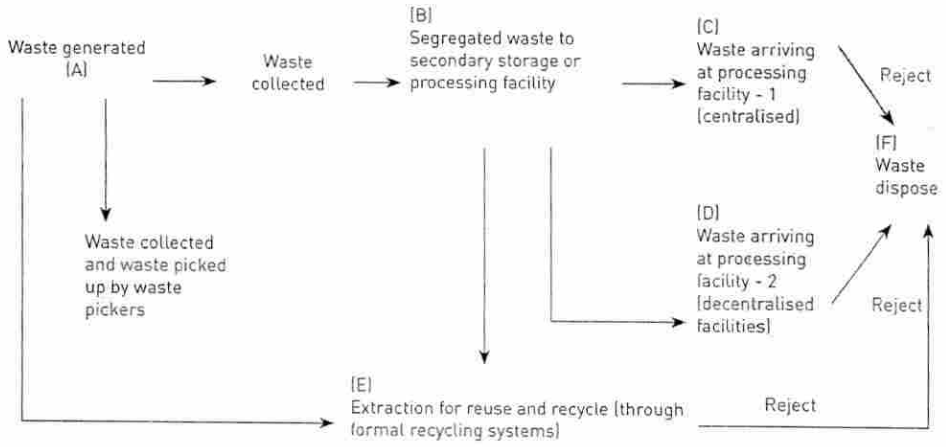
Municipal solid waste (MSW) in the Indian context does not include waste material such as newspapers, tins, bottles, etc. that are sold directly by waste generators to the informal sector and hence do not enter into the MSW stream.

Quantities of waste generated in the city need to be assessed to establish adequacy of existing systems and to plan for augmentation of treatment and disposal facilities. Waste moving through the system should be quantified at multiple locations to assess the actual quantities of waste available for processing and direct disposal.

Waste generated from households, markets, and other commercial establishments and institutions should be quantified; an appropriate sampling mechanism can be used (Sampling point A) given in the following figure. Entire waste collected from the city shall be weighed at weighbridges set up at transfer stations or en route to processing and disposal facilities.

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Waste Flow Diagram Depicting Points of Quantification[10]



Larger cities may have more than one transfer station. In smaller cities where there may not be any transfer station, the processing and disposal facilities may be the first point where waste from the entire city is deposited. The sum of the waste quantities recorded at transfer points or the quantity of waste deposited directly at the processing facility and landfill site shall indicate the quantum of MSW that is to be handled by the ULB (Sampling point B) on a daily basis. This figure cannot be taken as waste quantity generated in the city, since certain quantity of waste is picked up from the system by the informal sector or waste pickers to earn their living, or by the agency entrusted with waste collection before the waste reaches the processing or disposal site. Besides, some percentage of waste is not collected at all due to system deficiencies.

The total waste generated in the city is a sum of waste deposited at the processing facility, directly at the landfill site, waste segregated en route to processing and disposal site, and the waste not collected at all. It is therefore difficult to arrive at an exact figure of waste generation in the city

The following should be noted:

- Based on the processing or treatment scheme selected, segregated waste streams may be sent to a single integrated waste management facility or more than one facility, each handling a specific waste stream. Waste quantities that are processed by each of such facilities shall be measured (e.g., Sampling points C, D, E, F in waste flow diagram).
- By subtracting quantity B from quantity A, quantification of waste not entering into the municipal waste management stream can be assessed (waste not collected, littered, picked up by waste picker, or bought up by informal sector at the generator).
- A weighbridge should be placed at a suitable location to weigh waste before being transferred to different treatment or processing and disposal facilities.
- Quantities of rejects that are being sent to the landfill facility from each of the processing facilities shall also be measured. For instance, in the waste flow diagram above, a weighbridge at an appropriate location may be used to quantify waste going to points B, C, D, and F. Waste collected by decentralized collection centres has to be weighed at the decentralized facility (point D).
- Cities with population less than 2,00,000 should tie up with private weighbridges for daily weighment of waste being managed by the ULB.

1.4.3.3.2 Determining Waste Composition

MSW composition and characteristics vary considerably, not only between cities but also within a ULB; daily, seasonal, and temporal fluctuations are usually observed. MSW is heterogeneous in nature and consists of varied waste fractions, requiring multiple samples at multiple locations.

The quartering and coning method (Figure 1.7) is one of the best techniques for determining the composition and characteristic of municipal waste. The sample is reduced to a more manageable size as the actual classification is carried out by hand.

Selection of sampling sites is a critical first step in this process. The following aspects shall be considered:

- Waste sampling sites and frequency of sampling shall be in accordance with guidance given in Section 1.4.3.3.1.
- The sample collection sites should be representative and include all major sources of waste generation including residential areas (including slums), commercial, business, and market areas (vegetable market, meat market, slaughterhouse, grain market, etc.).
- Sample sites should also be representative of all income groups within the ULB.

Quartering and Coning Sampling Procedure:

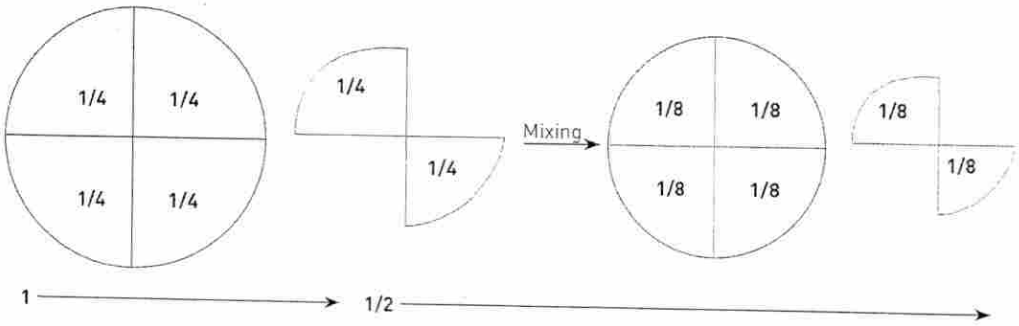
- Take 10 kg of municipal waste mixed from outside and inside of the waste pile, sourced from random entities in an identified sampling location.
- Samples from all heterogeneous sampling points shall be mixed thoroughly.
- The sample is placed as a uniform heap.
- The heap is divided into four portions using straight lines perpendicular to each other.
- Waste from opposing corners of the divided heap is removed to leave half of the original sample. The remaining portions are again thoroughly mixed and the quartering process is repeated until a desired size is obtained (10 kg of waste can be handled or segregated efficiently).
- The last remaining opposing fractions of waste shall be mixed and analysed for identifying physical and chemical properties of the waste.
- Chemical analysis of the waste sample follows the physical constituent analysis and shall be performed in a laboratory accredited by the Ministry of Environment, Forests and Climate Change (MoEFCC).[11]

Quartering and coning method is a well-established technique for waste characterisation

11 ist of accredited laboratories by Ministry of Environment, Forests and Climate Change (MoEFCC), (2013); available at http://www.envfor.nic.in/legis/env_lab.htm

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Figure 1.7: Characterisation of Municipal Solid Waste through Quartering Method[12]



Proportion of Waste Constituents: The size distribution of waste constituents in the waste stream is important because of its significance on the selection of appropriate collection, transportation, processing, treatment, and disposal practices. The waste characterisation method mentioned above shall be followed to assess proportions of waste constituents.

1.4.3.3.3 Physical Characteristics of Municipal Waste

1. Density of Waste

Critical parameters for selecting the appropriate processing technology are: waste quantity and characteristics, such as density, moisture, calorific value, toxicity etc.

The density of waste (mass per unit volume, kg/m^3) determines the storage and transportation volume requirements. MSW density in India is typically around 450–500 kg/m^3.

Impact of Density on Waste Transportation Choices

The efficacy of using compactor bins and refuse compactors is dependent on the initial density of waste. Low density wastes (e.g., packaging wastes, plastic waste) may be hauled most efficiently through the use of compactors, where a compaction ratio as high as 2.5:1 is achievable. Compactors offer little or no advantage and are not cost-effective for transportation of wastes with high densities (e.g., street sweeping waste). In general, compactors may be used for all municipal wastes, except inert wastes.

Method for Bulk Density Measurement

Materials and Apparatus:

- Wooden box of l m^3 capacity
- Wooden box of 1 ft^3 capacity
- Spring balance weighing upto 50 kg.

12 Adapted from "Toolkit for Solid Waste Management" JnNURM, (2012) and Manual on MSWM (First Edition), CPHEEO (2000) available at: http://jnnurm.nic.in/ toolkits-report-primers.html

Procedure: A composite sample of MSW collected from different parts of the heap should be taken in the smaller 1 ft^3 box and weighed with the help of a spring balance. After weighing, contents of this smaller box (1 ft^3) should be emptied into the bigger 1 m^3 box. This is repeated until the larger box is filled to the top. Once the larger box is filled, the weight of the waste is noted. The waste should not be compacted by pressure. Repeat the entire procedure thrice and take the average weight to arrive at the weight per cubic meter.



Municipal solid waste with high moisture content results in higher collection and transportation costs

2. Moisture Content

Moisture content of MSW is usually expressed as the weight of moisture per unit weight of wet material.

$$\text{Moisture Content (\%)} = \frac{\text{Wet weight} - \text{dry weight}}{\text{Wet weight}} \times 100$$

Note: Wet weight: initial weight of sample with moisture content
Dry weight: weight of the sample after drying the sample to remove moisture

A typical range of moisture content is 20%–45%, representing the extremes of waste characteristics in an arid climate and in the wet season of a region having large precipitation. Values greater than 45% are however not uncommon. Moisture increases the weight of MSW, and therefore the cost of collection and transportation also increase. To prevent an increase in weight, waste should be insulated from rainfall or other extraneous water.

Moisture content is a critical determinant in the economic feasibility of incineration processes since energy (i.e., heat) must be supplied for evaporation of water and in raising the temperature of the water vapour. Moisture content is generally found to be high in wastes containing a higher proportion of food wastes.



Determining calorific value of waste is important to determine the potential for recovering RDF from waste and its utilisation in cement, power, and waste to energy plants

3. Calorific Value

Calorific value of waste is defined as the amount of heat generated from combustion of a unit weight of the waste, expressed as kilojoule per kilogram (kJ/kg). The calorific value is determined experimentally using a bomb calorimeter, in which the heat generated from the combustion of a dry sample is measured at a constant temperature of 25°C. Since the test temperature is below the boiling point of water, the combustion water remains in the liquid state. However, during combustion the temperature of the combustion gases remains above 100°C, so that the water resulting from combustion is in the vapour state.

4. Bio-Chemical Characteristics

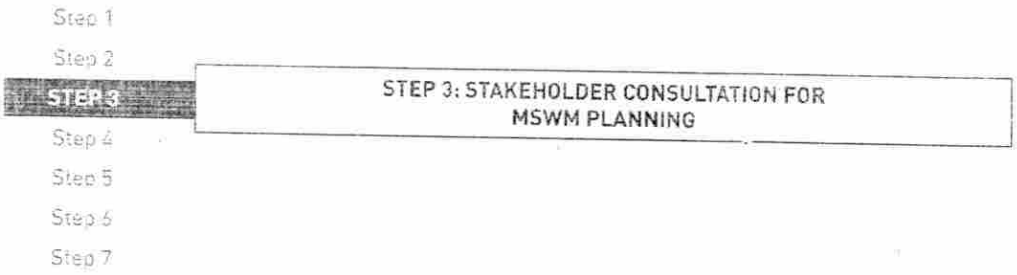
Bio-chemical characteristics of waste determine the suitability of specific treatment processes. ULBs should use this information to select the most appropriate treatment process

Chemical characteristics of waste are essential in determining the efficacy of any treatment process.

- **Chemical characteristics:** These include pH; nitrogen, phosphorus, and potassium (N-P-K); total organic carbon; C/N ratio; and calorific value.
- **Biochemical characteristics:** These include carbohydrates, proteins, natural fiber, and biodegradable factor.
- **Toxicity:** Toxicity profile of MSW includes heavy metals, persistent organic pollutants, pesticides, and insecticides. Toxicity characteristic leaching procedure (TCLP) is used for ascertaining the toxicity profile of MSW.

1.4.4 STEP 3: STAKEHOLDER CONSULTATION FOR MUNICIPAL SOLID WASTE MANAGEMENT PLANNING

Figure 1.8: Step 3 in the Municipal Solid Waste Management Plan



1.4.4.1 DEPARTMENTS INVOLVED IN MUNICIPAL SOLID WASTE MANAGEMENT PLANNING (INTERNAL STAKEHOLDERS)

Pro-active involvement of internal and external stakeholders helps in developing an inclusive and strategic MSWM framework

The main responsibility for preparing an MSWM plan lies with the ULB, specifically the SWM division. A core team or advisory team, also called the internal stakeholders, should be constituted for developing the MSWM plan.

1.4.4.1.1 Plan Preparation – Core Team

The core team or internal stakeholder group consists of the following:

1. Commissioner or chief executive of the ULB
2. Head of the SWM department
3. Environmental engineer in the SWM department
4. Head of the town planning department

5. Heads of the water supply, public health or sanitation, and sewerage departments
6. Head of the accounts department
7. Ward level officials in the SWM department, including sanitary inspectors, technical officers, and engineers

Specific responsibilities of each of these officials are given below:

- Commissioner or chief executive of ULB
  - Responsible and accountable for MSWM plan preparation and implementation
- Head of the MSW management department in the ULB
  - Responsible for establishing the baseline and analysing gaps in MSWM service provision
  - Responsible for coordinating various departments and stakeholders to be involved in development of MSWM plan
  - Responsible for assessing options and suggesting viable alternatives to be ratified by the stakeholders
- Environmental engineer (if appointed by the ULB) and ward level officials of the SWM department
  - Inform the planning process with field level consultations and information.
- Head of town planning department
  - Responsible for identifying viable locations for establishing SWM facilities and ensuring appropriate land use controls
- Heads of water supply, public health or sanitation, and sewerage departments
  - Explore potential cross-linkages and advise the MSWM plan process
- Head of accounts department.
  - Advice on potential revenues, costs, and implementing practices for appropriately recording SWM revenue and expenditure

Key persons to be consulted by core team before finalisation of the draft plan:

- Political head or mayor or chairman of ULB: Advising on the MSWM plan process with local level concerns and ensuring that the plan equitably addresses local MSWM issues

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- Representatives of the SWM cell at the state level and CMA/DMA level to ensure that the planning process is in line with policies and strategies of the state, and to ensure the potential of exploring opportunities for regional level planning for MSWM service provision
- District magistrate or collector of the district in which the ULB is located: Responsible for allocation of land, ensuring implementation of regional level strategies, and identifying synergies with other ULBs in the region
- Representative from State Pollution Control Board: Responsible for ensuring compliance with SWM Rules, 2016 and compliance with other related statutory provisions for establishing and operating MSWM facilities
- Heads of concerned parastatal agencies related to urban service provision or city planning and land use issues

1.4.4.1.2 Advisory Role

The municipal authority may also take advice from the following:

- Academicians and practicing professionals with SWM related expertise shall be involved.
- Where an environmental engineer is not hired by the ULB, an environmental engineer or planner may be co-opted in an advisory role.

1.4.4.1.3 External Stakeholders



Stakeholder Consultations to be held at least twice while preparing the MWSM Plan

The first step for the local body is to define a methodology for reaching out to all stakeholders in an equitable manner at various stages of the MSWM planning and implementation. Informing and involving the community and creating channels for all stakeholders to participate in decision making are all very important steps for successful implementation of SWM strategies.

Typical stakeholders for an MSWM system include households, businesses, industries, informal sector, local government, NGOs, community-based organisations (CBOs), self-help groups (SHGs), women's groups, secondary school and college students, or members of other institutions who may have a role to play in ensuring the involvement of the community.

Stakeholders are to be consulted at least twice during the MSWM plan preparation, initially in defining the objectives and goals of the plan and later (Step 6) to discuss the proposed plan and seek their inputs

and approval. The ULB may constitute a stakeholder committee for the purpose, with members representing all concerned groups. These groups would need to represent the interest of men, women, youth, and marginalised or vulnerable groups who are all part of the MSWM process. Specifically, the involvement of women's groups during the planning phase is essential.

The initial consultation process (Step 3) should identify the following:

- the ability and willingness of stakeholders to cooperate in the operation and management of the service;
- the demand of stakeholders for different type of services like door to door collection, source segregation, etc., and frequency of service;
- their attitude toward participating in experiments or pilot projects, particularly projects relating to source segregation, reuse, recycling of waste, and final treatment and disposal;
- their willingness to work with different sections of society, such as waste pickers, municipal workers, and entrepreneurs; and
- their willingness to pay for the services, the mode of payment, and the frequency of payment.

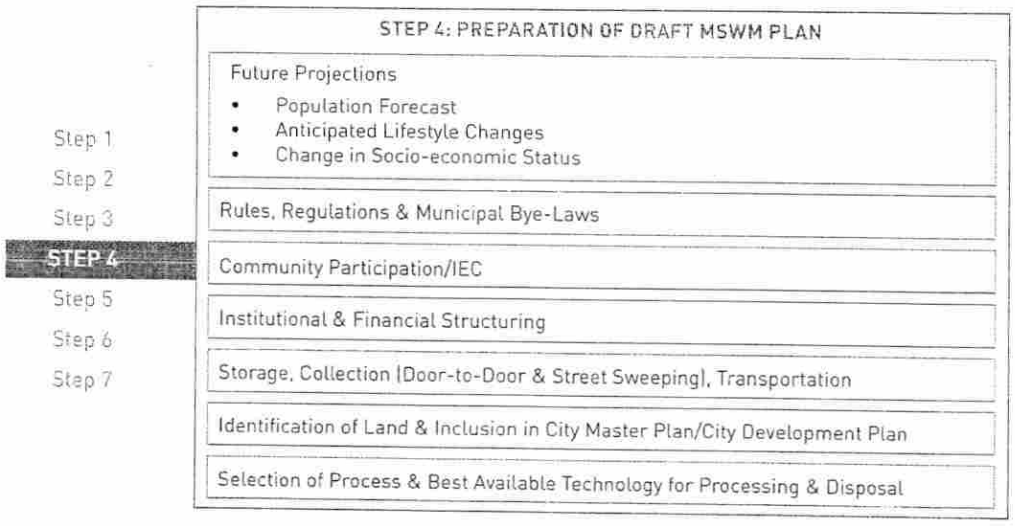
1.4.4.2 DEFINING THE GOALS AND OBJECTIVES OF THE MUNICIPAL SOLID WASTE MANAGEMENT PLAN

Once the framework at national, state, and ULB level is defined and the stakeholders mapped, the next step will be for the ULB and the stakeholder group to define the goals and objectives of the MSWM plan.

A municipal solid waste management plan (also known as integrated municipal solid waste management plan) is a ratified document that defines the goals and objectives of municipal solid waste management, to be achieved over specific planning horizons and which gives details of specific actions that need to be implemented to meet these objectives.

1.4.5 STEP 4: PREPARATION OF DRAFT MUNICIPAL SOLID WASTE MANAGEMENT PLAN

Figure 1.9: Step 4: Preparation of Draft Municipal Solid Waste Management Plan



MSWM Plan should be integrated with local term development plans, National policies and strategies. It is desirable to review the plan once every 2-3 years

The MSWM plan cannot be developed in isolation. It has to consider objectives of other planning processes in force in the ULB. Objectives of the master plan and the city development plan shall be considered. Linkages with the city sanitation plans and National Urban Sanitation Policy (NUSP) shall also be ensured.

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 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.

1.4.5.1 FUTURE PROJECTIONS

Estimating future waste generation quantities and composition is critical for developing MSWM 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:

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

While preparing a MSWM plan, the following design periods (time-frame) have to be decided depending on the plan's necessity:

(i) Short term plan: 5 years

(ii) Long term plan: 20-25 years

(iii)Mid term review between 2nd and 3rd year

Short term plan: 5 years
Long term plan: 20-25 years
Mid term review: between 2nd and 3rd year

1.4.5.1.1 Forecasting Waste Generation



Future waste generation = Per capita waste generation x Projected population

1.4.5.1.2 Population Projection

Population projection is dependent on factors governing future growth and development in the considered jurisdiction. Growth in all development sectors should be considered. Special factors causing sudden immigration or influx of population should also be foreseen to the extent possible. Population growth can be estimated using multiple methods which are suited for cities of different sizes and stages of growth:

i. **Arithmetic Increase Method:** If there has been a constant increase in population (in absolute numbers) over the past few decades, then for the purpose of future projection, arithmetic increase method could be used. In this method the increase of population per year/decade is calculated from past records and the average increase is added to the present population to find out population in next years/decade. This computation is suitable for historical, well settled and established cities.

Population projection using the arithmetic increase method:

Formula: $P = P_1 + k (t - t_1)$

Arithmetic rate of growth:

$$K_a = \frac{P_2 - P_1}{t_2 - t_1}$$

P = population for projected year

P_1 = population in year a (base year)

P_2 = current population

t_1 = base year

t_2 = current year

t = period of the projection in decades

k = population growth rate (constant)

Example: If population of a city is 5,000 in 1971 and 7,050 in 2011, then projected population for 2021 is 7,563 (round off).

P_1 = 5,000

P_2 = 7,050

t_1 = 1971

t_2 = 2011

K = (7,050-5,000)/ (2011-1971) = 51.25

P = 5,000 + (51.25)*(2021-1971) = 5,000 + 2562.5 = 7,562.5



Arithmetic increase method and geometrical increase method are the two most commonly used population projection methods

ii. **Geometrical Increase Method:** In this method the geometric mean of decadal averages is considered to be the rate of growth. This method is used for new and growing cities, which may have irregular growth patterns.

If the population growth rate is not available for a city, population growth trend has to be determined first. This could be done by comparing the population growth for the last 5 decades. If the decadal increase in population (in absolute numbers) is not constant, then the growth rate has to be determined first.

Population projection using the geometrical increase method is calculated using the equation:

Formula: $P_b = P_a (1+r)t$

P_b = population of the year for which projection is to be made

P_a = population of the base year

r = the rate of growth divided by 100

t = the number of years between 'a' and 'b'

Example: If population (2011) of a city is 1,000 with a growth rate of 1.8%, then projected population for 2021 is 1,195.

$P_{2021} = P_{2011} \times (1 + 1.8/100)^{10}$

$= 1,000 \times 1.195$

$P_{2021} = 1,195$

In case decadal increase in population is not constant, then the growth rate has to be determined first

Determination of Decadal Population Growth Rate (Geometric)

The population for (5 decades):

YEAR	CENSUS POPULATION	GROWTH RATE
1971	5,000	
1981	6,095	2%
1991	7,430	2%
2001	9,146	2.1%
2011	11,250	2%
2021	13,590	

Formula for calculating growth rate:

$r = \{(P_{1981} / P_{1971})^{1/t} - 1\} \times 100$

(here t = 10)

r = growth rate

After finding out the average growth rate (in percent), future projection could be done using the growth rate in the geometric increase method, as described above.

iii. Incremental Increase Method: In this method the increment in arithmetical increase is determined based on the past decades, and the average of that increment is added to the average increase.

Population projection using the incremental increase method is calculated using the equation:

Formula: $P_n = P_0 + n_x + n(n+1)/2 \times Y$ where

P_n = Population after (n) decades from present (i.e last known census)

P_0 = Population in base year

n = Period of projection in decades

X = Average increase of population of known decades

Y= Average of incremental increases of the known decades

iv. **Graphical Method:** The graph between time and population is plotted from the available data and the curve is plotted. There are two approaches that could be adopted:

   a. **Graphical method based on single city:** In this method the population curve of the city (i.e., present population vs. past decades) is smoothly extended for getting future value. This extension has to be done carefully. The line of best fit may be obtained by the method of least squares.

   b. **Graphical method based on cities with similar growth pattern:** In this method the city in question is compared with other cities that have already undergone the same phases of development, which the city in question is likely to undergo. Based on this comparison, a graph between population and decades is plotted.

v. **Decreasing Rate of Growth Method:** This method is applicable only in cases where the population growth rate shows a downward trend. In this method it is assumed that growth rate decreases, and the average growth rate decrease is calculated. Then the percentage increase is modified by deducting the decrease in growth rate.

vi. **Logistic Method:** The 'S'-shaped logistic curve for any city gives complete growth trend right from the beginning to the saturation limit of population.

1.4.5.2 PER CAPITA WASTE GENERATION

Per capita waste generation rates are to be established for each city based on the procedure specified in section 1.4.3.3.

1.4.5.3 RULES, REGULATIONS AND MUNICIPAL BYE-LAWS

The ULB shall consider all existing national and state rules and policies, identified in Step 1 and Step 2 of the planning process. Local bye-laws governing waste management, if any, shall also be considered. The framework for the plan shall be defined by these existing directives. The plan shall, at a minimum, seek to meet the objectives of all such policies and guidance. If applicable, due consideration shall be given to any legal directives on specific service provision, which may be time bound.

1.4.5.4 PLANNING FOR AN INSTITUTIONAL STRUCTURE (TO BRIDGE THE GAPS)

For planning an efficient and advanced MSWM system, it is essential to have an efficient institutional structure besides having adequate infrastructure and equipment. MSWM is both a managerial problem

and a technical issue. An effective institutional setup capable of designing, implementing, and monitoring the MSWM system needs to be established within the local authority. Currently, in many small and medium towns, sanitary inspectors look after MSWM. Whereas in many of the cities, the health officer, usually a medical doctor who does not have adequate exposure to technical and logistic practices in MSWM, heads the SWM department. It is therefore strongly recommended that ULBs should have an SWM cell or SWM department having staff with technical and managerial skills specific to MSW management.

It is crucial to institutionalize within the ULB a dedicated SWM department or cell having staff with technical and managerial expertise specific to MSW management

The ULB shall follow their respective state government norms for staffing the SWM department (please refer to Annexure 2 for former Andhra Pradesh's staffing for SWM departments in ULBs).

However, in view of developments in the SWM sector, the Supreme Court then appointed an expert committee to look into all aspects of SWM. With a view to improve the situation, the Supreme Court's expert committee report on SWM recommended hiring professionals in MSW services to scientifically manage the waste issues. It is also recommended that in the cities where health officers are looking after MSWM or part thereof, in addition to their principal function of taking preventive health measures, they may be gradually made free from this responsibility and replaced by public health or environmental engineers.

The recommendations from the expert committee report are given below:

1.4.5.4.1 Towns below 1 Lakh Population

- One experienced Junior Engineer, if the population is more than 50,000 or in places with high floating population.
- One qualified sanitation diploma holder or Chief Sanitary Inspector or as Sanitary Officer if the population is more than 50,000.
- One qualified Sanitary Inspector per 50,000 population.
- One qualified Sanitary Sub-inspector per 25,000 population.
- One Sanitary Supervisor per 12,500 population.

1.4.5.4.2 Cities between 1 and 2.5 Lakh Population

- One experienced graduate engineer or Equivalent Health Officer.
- One experienced Junior Engineer per 1 lakh population.
- Qualified sanitation diploma holder Chief Sanitary Inspector or Sanitation Officer to look after the collection, transportation, processing and disposal of waste: 1 per 1 lakh population or part thereof; or 1 per 2 Sanitary Inspectors, whichever is less.

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- Qualified sanitation diploma holder Sanitary Inspector: 1 per 50,000 population or part thereof; or 1 per 80 sweepers, whichever is less.
- Qualified sanitation diploma holder Sanitary Sub-inspector: 1 per 25,000 population or part thereof; or 1 per 40 sweepers, whichever is less.
- Sanitary Supervisors (a person who can read, write, and report): 1 per 12,500 population or part thereof; or 1 per 20 sweepers, whichever is less.

1.4.5.4.3 Cities between 2.5 and 5 Lakh Population

- Public Health or Environmental Engineer or Civil Engineer having training in environmental or public health engineering in the Grade of Assistant Executive Engineer to be in charge of SWM department.
- Public Health or Environmental Engineer in the grade of Assistant Engineer to look after the transportation, processing and disposal of waste.
- One experienced Junior Engineer, per 2.5 lakh population.
- Chief Sanitary Inspector or Sanitary Officers to supervise storage, street sweeping, and primary collection of waste per 1 lakh population.
- Sanitary Inspectors, Sanitary Sub-inspectors, Sanitary Supervisors as per yardstick indicated in Section 1.4.5.4.2 above.

1.4.5.4.4 Cities between 5 and 20 Lakh Population

- Public Health or Environmental Engineer or Civil Engineer having training in environmental or public health engineering of the level of Executive Engineer to be in-charge of SWM department.
- Public Health or Environmental Engineer or Civil Engineer having training in environmental or public health engineering of the level of Assistant Executive Engineer per 5 lakh population.
- Public Health or Environmental Engineer or Civil Engineer having training in environmental or public health engineering of the level of Assistant Engineer per 2.5 lakh population.
- One experienced Junior Engineer, per 2.5 lakh population.
- Chief Sanitary Inspector or Sanitary Officers, Sanitary Inspectors, Sanitary Sub-inspectors and Sanitary Supervisors as per yardstick indicated in Section 1.4.5.4.2 above.

1.4.5.4.5 Cities between 20 and 50 Lakh Population

- Public Health Engineer or Environmental Engineer or Civil Engineer having training in environmental or public health engineering of the level of Superintending Engineer to be the Head of SWM Department.

- Public Health or Environmental Engineer or Civil Engineer having training in environmental or public health engineering of the level of Executive Engineer. One Executive Engineer per 20 lakh population or part thereof.
- Rest of the supervisors and staff as per the yardstick already indicated in Section 1.4.5.4.2 to 1.4.5.4.4 above.

1.4.5.4.6 Cities above 50 Lakh Population

- Public Health Engineer or Environmental Engineer or Civil Engineer having training in environmental or public health engineering of the level of Chief Engineer to be in charge of SWM department.
- Superintending Engineer per 40 lakh population or part thereof.
- Rest of the officers, supervisor's etc. as per yardsticks already indicated in Section 1.4.5.4.2 to 1.4.5.4.5 above.

Health and Solid Waste Management Wings Differentiated in Andhra Pradesh

The Government of Andhra Pradesh, in order to focus on achieving the objectives of the Municipal Solid Waste (Management & Handling) Rules, 2000, has initiated several programs and initiatives. Strengthening capacity within urban local bodies (ULBs) to plan for and execute all actions along the solid waste management (SWM) chain has been given priority. The Commissioner & Director of Municipal Administration has issued orders in June 2013 to all district collectors and municipal commissioners to create two separate wings in the ULBs and to clearly demarcate the roles of health and SWM functionaries. Further, ULBs have been asked to stop outsourcing activities of the SWM and health departments, as these departments are now differentiated and are being staffed appropriately. Over 150 environmental engineer posts in various cadres have been sanctioned until 2013 to manage the SWM wing.

1.4.5.5 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.



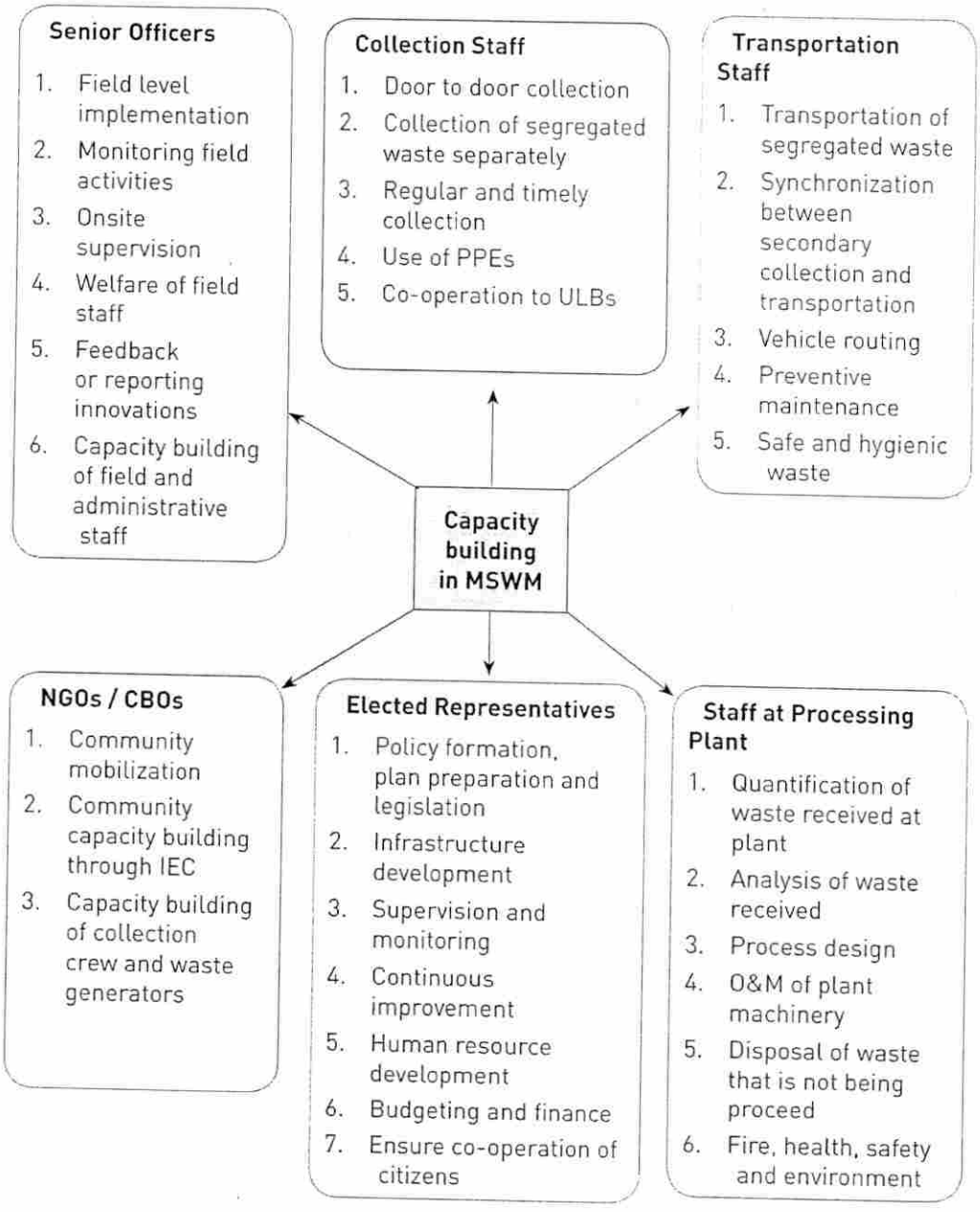
Capacity building of staff is essential for enhancing their skills in monitoring MSWM service provision

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. Figure 1.10 explains various capacity building approaches that can be adopted for different stakeholders based on the ULB's requirements.

Figure 1.10: Capacity Building Approaches for Different Stakeholders[13]

Training and capacity building activities for MSW staff include:



- **Special training:** The following should be trained: (i) unqualified staff and sanitation workers; (ii) ground level staff like sanitary supervisors (or equivalent); and (iii) sanitary inspectors, junior engineers, and senior officers. All officers and supervisors must be trained in skills required for an effective and efficient MSWM sector

13 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

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 for officers and supervisors at least once every 5 years.
- **Study visits:** Learnings can be enhanced by visiting institutions or places where good practices have already been well 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.

1.4.5.6 FINANCIAL IMPLEMENTATION STRUCTURE

1.4.5.6.1 Overall Cost Assessment (Full Cost Assessment)

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. This important task within the planning process is to ensure financial viability of the MSWM system and its sustainability in the long run.[14,15]

Municipal authorities need to be aware of the full costs and returns of the proposed MSWM system

ULBs generally fund their MSWM activities through a combination of government grants and internal revenues from property tax and non-tax revenues; some ULBs finance projects through public private partnership (PPP) arrangements. Very few ULBs resort to taking loans for MSWM services. Revenues from MSWM service provision and expenditure on various components of MSWM are usually not properly accounted for. Segregated financial information pertaining to MSWM service is required to assess the financial viability of service provision.

Full cost accounting (FCA) (Figure 1.11) provides a systematic framework for identifying and evaluating all costs associated with the integrated waste management options for ULBs as mentioned above.

MSWM services are traditionally financed through a combination of government grants and revenues

- **Front-end costs:** These include the pre-operative investments and expenses necessary to implement MSW services.
- **Capital costs:** These include one-time fixed costs for plant and machinery and any cost of capital.
- **Operating costs:** These include daily expenses of managing MSW, refurbishment costs, and operation and maintenance (O&M) costs.

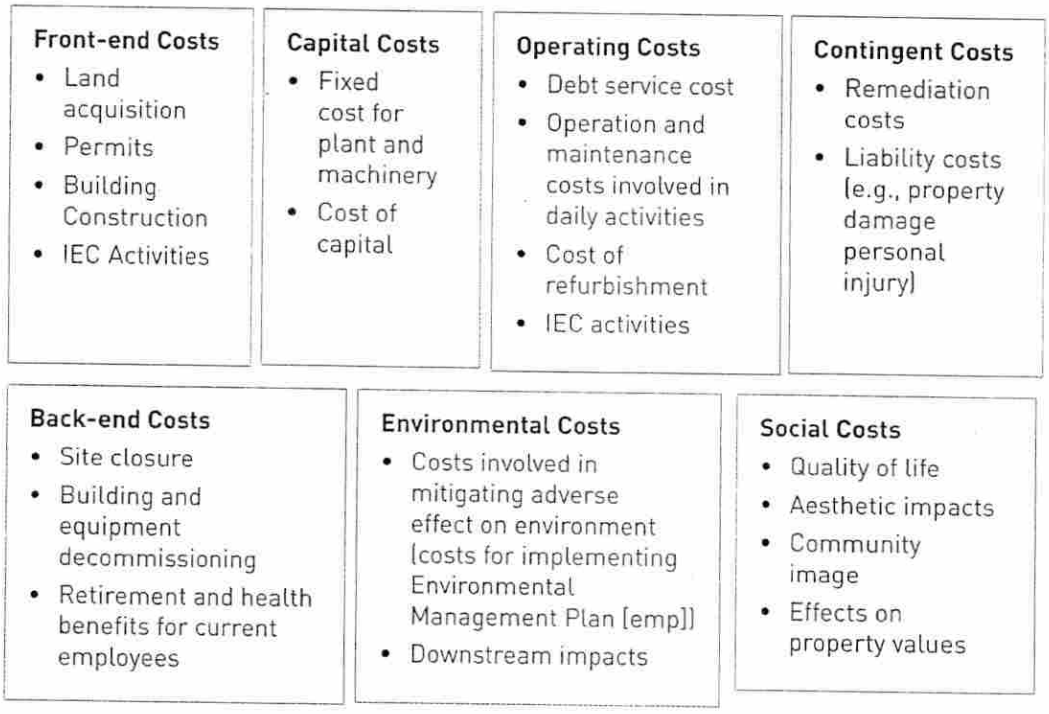
14 "Full Cost Accounting for Municipal Solid Waste Management: A Handbook", EPA, (1997), available at: http://www.epa.gov/waste/conserve/tools/fca/docs/fca-hanb.pdf

15 "Analysis of the Full Costs of Solid Waste Management for North Carolina Local Governments", DEHNR, (1997), available at http://infohouse.p2ric.org/ref/ 01/00369.pdf

- **Back-end costs:** These comprise expenditure required to wrap up O&M of MSW facilities at the end of their useful lives.
- **Contingent costs:** These include costs that might or might not be incurred at some point in the future, e.g., remediating future release of pollutants.
- **Environmental costs:** These are the implications on the environment that might occur due to MSW transportation, treatment, and disposal activities (e.g., costs for mitigating contaminated soil, polluted surface and groundwater bodies, and poor air quality due to indiscriminate burning of MSW).
- **Social costs:** These are costs incurred to mitigate adverse impacts on health and well-being of local community, on account of improper MSWM. In India, such impacts are generally not compensated. Impacts of MSW storage depots, as well as MSW treatment and disposal facilities on the health, quality of life, and value of property in the neighbourhood are considered. An assessment and consideration of these impacts is required before selecting waste management options, even though they are not easily quantifiable.

Figure 1.11: Elements of Full Cost Accounting

FCA reflects the real costs of the MSWM system:
- Front-end costs
- Capital costs
- Operating costs
- Contingent costs
- Back-end costs
- Environmental costs
- Social costs



These categories together cover the life cycle of MSW activities from the "cradle" (Front-end costs) to "grave" (back-end costs). FCA provides accurate and complete information on the real costs of managing municipal solid waste. It tends to uncover hidden and overlooked costs and allocates all costs to the specific activity. This helps decision-makers

to compare present and proposed services accurately, predict future costs reliably and evaluate privatisation options thoroughly.

Other Advantages of Full Cost Accounting

- ULBs can use FCA as a planning tool for preparing budgets and determining future direction.
- FCA helps the ULBs to examine various financial scenarios and their resulting impacts in the future.
- FCA can also be used while analysing costs in the long term.
- FCA results can also be used for maintaining transparency between the ULBs and the general public. The results can be presented to the public through media (e.g., newspaper). However, FCA does not address non-monetary costs and benefits like social costs and public expectations. Results from FCA should be considered in conjunction with non-monetary costs to help ULBs to make better informed decisions for MSWM.

Description of elements of full cost assessment: The following section provides schemes on how to calculate and document the total costs of a stand-alone fully compliant MSWM system.

Front-end Costs: Front-end costs include pre-operative activities that are required before implementing any MSWM system (e.g., investigation costs such as topographical surveys; geotechnical, geological, hydrogeological investigations; environment impact assessment; etc.). Table 1.7 gives an overview of front-end costs involved in a typical MSWM system.

Table 1.7: Indicative Front-end Costs in a Typical Municipal Solid Waste Management System

SL. NO	DESCRIPTION	NOS.	UNIT RATE	AMOUNT
1	Obtaining permit for land			
2	Topographical survey			
3	Geotechnical investigation			
4	Geological investigation			
5	Hydrogeological investigation			
6	Waste characterisation			
7	Waste quantification			
8	Detailed design			
9	Environmental impact assessment			
10.	Others			

Capital Costs: Capital costs are one-time fixed costs associated with a project which may include the price of purchased assets such as land, vehicles, equipment, or other supplies. The capital costs involved in MSWM systems can be further divided based on activities:

- **Collection and transportation costs:** These include purchase of collection tools, storage bins, transportation vehicles, construction of transfer stations. An indicative format for assessing capital costs for collection and transportation is given in Table 1.8.
- **Processing and disposal costs:** These include cost of land buildings, plant machinery, process equipment, material handling equipment, pollution control equipment (electrostatic precipitators, bag filters, and other dust control equipment), transport vehicles, material recovery facilities, construction of sanitary landfill, laboratory facilities, rainwater drainage management, electrical equipment, backup of power, green belt, etc. An indicative format for assessing capital costs for processing and disposal is given in Table 1.9.

Table 1.8: Indicative Format for Assessing Capital Costs for Collection and Transportation System for Municipal Solid Waste Management

S. NO	DESCRIPTION	DTD	SS & DC	SC & T	CM	TOTAL (A)	15% CONTINGENCY (B)	UNIT RATE (INR) (A+B)	AMOUNT
1	Pushcart bins (6 per pushcart)								
2	Pushcarts								
3	Tricycle								
4	Tricycle bins (8 per tricycle)								
5	Auto tipper (1 m^3)								
6	Metal tray, metal plate								
7	Tipper trucks								
8	1.0 m^3 container with strips (dumper bins)								
9	3.0 m^3 skips (dumper bins)								
10	4.5 m^3 skips (dumper bins)								
11	Dumper placers								
12	Refuse compactors								
13	Drain cleaning or jetting machine								
14	Mechanized sweeper trucks (large or small)								
15	Others								

(DTD: Door to Door, SS&DC: Street Sweeping and Drain Cleaning, SC&T: Street Collection and Transportation, CM: Cleaning of Markets)

Table 1.9: Indicative Format for Assessing Capital Costs for Establishing Processing and Disposal Systems for Municipal Solid Waste Management

S.NO.	DESCRIPTION	NOS.	UNIT RATE	AMOUNT
1	Land			
2	Buildings			
3	Process equipment (trommel, sieves, separators)			
4	Material handling (conveyors, loaders, elevators)			
5	Pollution control equipment			
6	Transport (tippers, tractors)			
7	Material recovery facility			
8	Sanitary landfill			
9	Rainwater management (drains, ponds)			
10	Diesel Generator set, transformer yard, cables			
11	Weighbridge			
12	Security			
13	Office, management information system, or laboratory			
14	Others			

Operation & Maintenance Cost: Operations and maintenance (O&M) cost is an ongoing cost and shall include all costs incurred in daily operation of the facility. It shall include labour and salaries; administrative and management cost; maintenance of vehicles and equipment; fuel or tyres; etc. Table 1.10 gives an overview of estimated O&M cost incurred in MSWM.

Table 1.10: Indicative Format for Assessing Capital Costs for Collection and Transportation System for Municipal Solid Waste Management

S.NO	DESCRIPTION	QUANTITY	UNIT RATE (RS)	TOTAL AMOUNT (RS)
I	Collection and transportation vehicles and equipment			
	All equipment (metal tray, brooms, personal protective equipment [PPE], etc.)			
	Fuel			
	Vehicle maintenance cost (%) of vehicle cost			
	Cost of spares, tires, etc.			
	Others			

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Table 1.10: Indicative Format for Assessing Capital Costs for Collection and Transportation System for Municipal Solid Waste Management [contd.]

S.NO	DESCRIPTION	QUANTITY	UNIT RATE (RS)	TOTAL AMOUNT (RS)
II	Salaries of workers for collection and transportation			
	Supervisor			
	Sweepers, loaders, sanitary workers			
	Driver			
	Others			
III	Salaries of workers at processing and disposal facility			
	Plant in charge			
	Plant supervisors			
	Fitters			
	Electrician			
	Vehicle maintenance-in-charge			
	Stores-in-charge			
	Landfill-in-charge			
	Weighbridge operator			
	Office-in-charge			
	Yard operation-in-charge			
	Others			
IV	Salaries of laboratory staff			
	Quality assurance chemist			
	Other lab staff			
	Others			
V	PPE			
	Face mask			
	Gum boot			
	Hand gloves			
	Uniform			
	Others			

Some of the other costs that need to be considered are:

- **Working capital costs:** These include interest on at least 2 months receivables and revenue from tipping fee, electricity sale, compost sale, and any other product sold. In addition, at least 2 months O&M costs have to be built in.
- **Finance costs:** These include depreciation, interest on debt, income taxes, sinking fund for refurbishment, insurances, bank guarantees, post-closure monitoring, etc.

1.4.5.6.2 Financial Viability of Municipal Solid Waste Management System

MSWM should be planned in a manner that it meets all statutory requirements. The level of sophistication could vary depending on the financial capability of the municipal authority. Sustainable design and implementation of systems should be ensured. MSWM projects should be made viable by ensuring cost recovery through levy of user fees from the beneficiaries, prescribing appropriate fees or tipping fees for the services rendered, sale of end products from the processing of waste, allocation of funds from municipal internal resources and government grants, viability gap funding from the government (if any), and introducing public private partnerships (PPPs) for efficiency and attracting private sector investments.

Financial viability of the MSWM Plan can be ensured through consideration of several cost recovery mechanisms: user fees, sale of end products, municipal funds and grants from State and Central Governments, loans and funding from private sector through PPPs

MSWM services are sustainable only if they are financially viable on a stand-alone basis. Therefore, the assessment of financial viability is an important step in planning MSWM system. The deficit in funding planned services, if any, should be estimated. Table 1.11 gives a format for assessing deficits over a time period.

Table 1.11: Format for Assessing Financial Deficits for Provision of Municipal Solid Waste Management Services

S. NO	DESCRIPTION	YEAR 01 (RS)	YEAR 02 (RS)	YEAR 03	YEAR....	YEAR 20 (RS)
1	Total cost					
2	Revenue					
	Deficit (total cost-revenue)					

Variable user charges are based on the quantity of waste generated and the level of service provision

1.4.5.6.3 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.[16,17]

The traditional sources of financing MSWM activities include:

- local taxes, e.g., property tax, water tax, conservancy tax, development fee, etc.;

16 "Environmental Fiscal Reforms in India: Where and How?", GIZ and TERI (2011).
17 "Economic Instruments in the Waste Management Sector", GIZ (2010).
Available at: http://www.giz.de/de/downloads/gtz2010-en-foes-economic-instruments-waste-management.pdf

1960

To enhance the tax base cross subsidisation and higher charges for commercial, bulk generators etc. should be considered. Moderate rate, least exemptions and wider coverage of all classes of tax payers will fetch higher revenues

- user charges;
- rents from properties, license fees, and other non-tax revenues;
- grants from state and central government, e.g., Swachh Bharat Mission, state finance commission grants;
- 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);
- loans from international agencies, e.g., Asian Development Bank (ADB), Japan Bank for International Cooperation (JBIC), German Development Bank (KfW) and the World Bank;
- PPPs;
- Municipal bonds or debentures;
- revenue from sale of products from waste processing plants (if owned by the ULB);
- tipping fees from the private operator.

(a) Property Taxes

Traditionally, property tax in India is the single largest internal source of revenue to the ULBs, contributing as much as 25%–30% to their total revenue. Government grants are another major source of revenue, mainly utilised for paying wages to employees and for undertaking specific projects. Most of the ULBs use a sizable part of the property tax to support MSWM activities. However, since the assessment and collection of property tax is poor, ULBs are unable to allocate adequate funds for MSWM services. Further, the lumpsum approach of the property tax does not impose any incentive for at-source waste minimisation as discussed in Section 2.1 of Part II. Rationalisation of the property tax is required to ensure financial sustainability of these services.

(b) User Charges[18]

The following basic principles may be considered by ULBs for levying user or service fee for MSWM services.

- **"Polluter pays" principle:** Those responsible for waste generation should pay for its collection and safe disposal.
- **Proportionality:** The user fees should be in proportion to the quantity of waste generated and level of service provided to waste generators. Households generate much less waste as compared with commercial, institutional, and industrial establishments; and among the households, the poor generate less waste as

18 "Economic Instruments in the Waste Management Sector", GIZ (2010). Available at: http://www.giz.de/de/downloads/gtz2010-en-foes-economic-instruments-waste-management.pdf

compared with the rich households. Therefore, variable rate may be prescribed for different categories of waste generators keeping in mind their waste generation potential. At least three categories of service charge may be prescribed for:

i. households;

ii. commercial, institutional, industrial waste generators; and

iii. bulk waste generator such as hotels, function halls, restaurants, and large commercial, institutional, and industrial establishment, etc.

- **Capacity to pay:** Affordability of the taxpayer may be kept in mind while fixing user charges. A fair service charge tariff will facilitate better compliance. Moderate rate, least exemptions, and wider coverage of all classes of taxpayers will fetch higher revenues.

The following criteria may be considered for enhancing the tax base in an ULB:

- **Subsidy for the poor:** The element of cross-subsidisation may be introduced to give relief to the poor and disadvantaged to ensure that they are not deprived of basic services.
- **Higher rates from nonresidential establishments:** Higher rates may be prescribed for commercial, institutional, and industrial establishments and bulk waste generators as they produce substantially more waste than households and usually have a better capacity to pay.
- **Willingness to pay:** People are usually willing to pay for a good service. However, it is desirable to ascertain their willingness to pay for different levels of services. Citizens may prefer a higher level of service and be willing to pay more for the same. This consultation will promote better compliance.
- **Introducing higher service fees:** From an assessment of the current scenario of MSWM service fees levied on ULBs, it does not seem practical to immediately introduce higher rates of service fees that may be required to make MSWM services self-sustaining. User fees may be increased gradually, synchronous with the provision of MSWM services. Efforts should be made to reach the level of full sustainability in 5 years. The service fee structure may be so devised that it is commensurate with the level of service provided and may be increased gradually with improved level of services, increasing the level of acceptability among citizens and ensuring their compliance. As an immediate action, SWM service fees may be increased by ULBs to cover the O&M cost in 3 years. Within the same ULB, where the level of service differs in different wards or areas, differential rates may be charged in



Efficient administration of service fee depends on 3A's:

- Accountability
- Acceptability
- Affordability

1962

different areas in accordance with the level of service. Uniform rates may be applied to currently underserved areas, when full\ coverage is provided to these areas. However, services to the poor may continue to be subsidised, even when full service levels are achieved in such areas.

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

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

Steps for Determining Service Fee

While determining SWM service fee, the capital, O&M, institutional, political and social arrangements should be considered

Determining MSWM fee involves several considerations such as (i) capital and O&M cost of services, (ii) number and type of waste generators, (iii) level of service to be provided, (iv) willingness and ability to pay for the service, (v) levels of targeted subsidy, (vi) required establishment cost of the institutional arrangement for service delivery and cost recovery, etc. Evidence of the rationale used for defining MSWM fees could be a key factor in securing political commitment to regulate and enforce user fee collection.

The following steps may be taken by ULBs to determine service fee structure:

1. Understand tariff or fee base.
2. Set norms of tariff fixation.
3. Communicate with consumers.
4. Set method of collection of SWM service fees.

Step 1: Understand tariff or fee base: The first step of tariff setting is to understand the target for base of MSWM tariffs. ULBs need to understand the number and type of waste generators to estimate volumes and types of waste generated and MSWM expenditure. ULBs also need to identify service options. These considerations will form the basis for determining the tariff rate.

The following analysis is required to estimate levels and costs of service provision which are required for determining tariffs for different levels of customers:

a) Classifications of waste generators

Classify waste generators into different categories such as households, commercial, and institutional establishments and determine their numbers. This will help the ULBs in understanding the number and type of waste generators to be served and the frequency of service required. The following information may therefore be gathered from each of the waste generator groups:

- Household consumers
  - Current number of households in each settlement area such as ward
  - Status of collection service in different types of settlements such as door-to-door collection, community bin collection, or none
  - Frequency of collection
  - Level of service desired by the households; and willingness of the households to practice the 3R approach (reduce, reuse, recycle), to segregate the waste at source, to do home composting, etc.
  - Willingness to pay and ability to pay
- Commercial and institutional establishments
  - Number of shops and establishments
  - Number of institutions (offices, schools and colleges, temples)
  - Hospitals, hotels, restaurants, guesthouses, etc.
  - Number of industries (manufacturing industries)
  - Status of collection service such as door-to-door collection, community bin collection, or none
  - Frequency of collection
  - Level of service desired
  - Willingness to practise 3Rs and segregate the waste at source
  - Willingness to pay and ability to pay

The data may be analysed and classified into different groups such as: (i) poor and non-poor households; (ii) small and medium shops and establishments (less than 200, 500, 1000 ft^2 in area); (iii) large commercial establishments (more than 1,000 ft^2); and (iv) bulk waste generators.

1964

b) Estimates of waste generation:

It is essential to have a fair estimate of the amount of waste generated in the city or town that will help in estimating the staffing and the vehicles and equipment required for primary collection, transportation, treatment, and disposal of waste.

- **Households:** ULBs should collect data on domestic waste generated per capita per day by different households in the city and its composition (organic and inorganic waste). Generally, higher income households generate more non-biodegradable and recyclable waste such as packaging materials, glass, metal, etc.
- **Non-residential premises:** ULBs should collect data on waste generated by shops, offices, workshops, hotels, marriage halls, malls, restaurants, etc.; and on non-hazardous health care and industrial waste generated daily in the city.
- **Bulk waste generators:** ULBs should collect data on estimated waste from public places, parks and gardens, large hotels, commercial establishments, non-residential complexes, vegetable and fruit markets, meat and fish markets, daily street cleaning and drain cleaning activities, and unauthorised disposal sites in the city.

The data will help in scientifically determining the variable rates for different categories as mentioned above. It will also give an indication of the actual cost incurred by the ULB in providing services. The scientific method for estimating waste generation rates in a city is given in section 1.4.3.3.1 of this chapter.

c) Cost estimates

An analysis of costs for various levels of service provision is necessary to determine the fee structure. Cost components for MSWM services are the following:

- Collection
  - Types of collection vehicles and technology used
  - Staffing required for providing collection service
  - Capital cost of storage bins, collection vehicles
  - Cost of fuel, labour, materials, safety measures, maintenance, personal protective equipment (PPE), depreciation
  - Cost per tonne of waste collected per day
  - Overhead costs

- Transportation
  - Transportation cost from door-to-door collection site to the treatment or disposal site; or from community bins, transfer stations, or material recovery facility (MRF) to treatment or disposal site
  - Cost of transportation vehicles and equipment required
  - Cost of transfer station
  - Cost of fuel, labour, maintenance, safety measures, PPE, depreciation
  - Cost per tonne of waste transported
  - Overhead costs
- Processing
  - Type of processing technology adopted
  - Cost of construction of processing facility
  - Cost of O&M of the processing facility
  - Residual financial burden on the ULBs, including tipping fee (if PPP mode is adopted)
  - Cost per tonne of waste treated
  - Overhead costs
- Disposal
  - Land cost or lease cost
  - Sanitary landfill construction cost
  - Vehicles and equipment cost
  - Environmental protection costs in affected areas
  - Sanitary landfill O&M cost
  - Labour, fuel, amenities cost
  - Closure, monitoring & rehabilitation costs, capital and recurring cost of per tonne waste disposal
  - Overhead costs
- Administrative overheads
  - Daily office or staff expenditure
  - Billing and revenue collection charges
  - Public awareness
  - Information system and data collection or management information system (MIS)
  - Overhead costs

1966

d) Service options

Service levels selected to cater to user's requirements, e.g., types of tools, equipment, and vehicles to be used; frequency of service to be provided; etc. will determine the cost of service. ULBs need to decide on the level of service it desires to provide keeping in mind the cost of services and its capability to recover the cost. Service levels need to be determined prior to fixing service fee. The followings are the options for the ULB:

- Consumers
  - Residential consumers in urban areas: Door-to-door collection of MSW from households on a daily basis may be considered necessary.
  - Non-residential consumers:
    a. Door-to-door collection from commercial establishments and offices or curbside collection on a daily basis may be considered as an adequate service level.
    b. For bulk waste generators such as hotels, restaurant, and large complexes, waste collection service can be given on a demand basis. The service levels may be determined contractually keeping in mind the amount and type of waste generated.
    c. For vegetable and fruit market waste and construction waste generating sites, the ULB should provide waste storage containers and transport them on a regular basis as per contractual terms.

- Public Places
  - ULB is required to clean all public places and roads in residential and commercial areas, including street sweeping and cleaning of surface drains.
  - Special cleaning services could be provided on chargeable basis during or after special events in public places.

Step: 2 Norms of fee fixation

Key considerations for prescribing a fee structure for provision of MSWM services:

- Surveys have indicated that urban poor generate about 100 g/capita, whereas the rest generate above 200 g/capita/day. This justifies the variable charges for the different strata of society. Because they generate less quantity of waste and have lower capacity to pay, urban poor may be charged 50% lower fees than other income groups on the basis of equity.

Criteria for Giving Subsidy to Urban Poor

Identification of urban poor is essential to enable access to urban services at a subsidized rate. The following process may be followed by the ULBs for identifying poor and vulnerable sections of the community to administer lower MSWM charges:

The economic status of families may be determined based on the type and size of dwelling units or localities and level of basic service provided to them. As a rule of thumb, people living in slums and informal settlements, devoid of basic services, may be considered to be eligible to pay lower rates of service fee. Besides slum dwellers, residents in dwelling units smaller than 25 m^2 could also be given the benefit.

- The commercial, institutional, and industrial establishments generate larger quantities of waste. The rate could be kept higher for large commercial establishments and bulk waste generators, considering the large quantity and volume of waste generated by them.
- A minimum of 50% of door-to-door collection costs (including O&M costs) should be recovered from households initially and 100% in case of non-residential premises.
- ULBs may charge higher rates in areas with higher levels of service and should aim at achieving 100% cost recovery within 3 years. In case of institutional, commercial, and industrial buildings, 100% O&M cost recovery may be made from the very beginning.

Rationale for Determining Tariff for Door-to-door Collection Service

- 100% O&M cost recovery: institutional, commercial, and industrial waste
- 50% O&M cost in beginning and 100% in 3 years: general households
- 25% O&M cost in beginning and 50% in 3 years: poor households

Norms for Tariff Determination for Door-to-door Collection

- Tariff for nonresidential premises based on the size of the premises:
  - Up to 1,000 ft^2 (small tenements): Rs A
  - 1,001–2,000 ft^2 : Rs A x 2
  - 2,001–4,000 ft^2 : Rs A x 3
  - More than 4,000 ft^2 : Rs A x 4
- Bulk waste generators and vegetable, fruit, meat, fish markets: Fees fixed on the basis of volume and quantity of waste generated per day; fees should recover 100% of the O&M cost and should consider number of units served (in case of markets)
- No fee may be collected for cleaning and collecting waste from public places. Revenue from the general tax may be used to cover these costs.

1968

Step 3: Communication with consumers

To gain popular acceptance of MSWM service fee by the users, it is important that the process of determining the fee is transparent and communicated to all stakeholders. ULBs may organise public consultation to have citizens' views on the proposed service fee structure and levy of lower rates on the poor. This will facilitate better acceptance and payment of user fees.

Step 4: Mechanisms for recovery of municipal solid waste management user charges

Presently, the use of economic instruments for recovery of SWM costs in India is not well established, although some instruments are used to a limited extent. However, the use of environmental fiscal reform through appropriate economic instruments for financing MSWM can fill some of the gaps that have been identified by the ULBs. Some of the possible methods for recovering MSWM charges are tabulated below in Table 1.12.

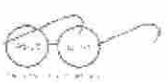


Table 1.12: Mechanisms for Recovery of Municipal Solid Waste Management User Charges[19]

MECHANISM	ADMINISTRATIVE COSTS: TAX AND DATA COLLECTION , MONITORING , IDENTIFICATION OF USER CHARGES	SOCIAL EFFECTS: VERTICAL AND HORIZONTAL EQUITY; LINKAGES WITH ABILITY TO PAY	ENVIRONMENTAL EFFECTS: LINKAGES TO WASTE GENERATION AND INCENTIVE TO REDUCE WASTE	REVENUE GENERATION AND POTENTIAL COST RECOVERY	POLITICAL AND PUBLIC ACCEPTANCE
• Levy of SWM tax along with property taxes, determined on the basis of the unit area base system (ABS) (household or commercial establishments).	• Shift to ABS will result in simple and transparent tax administration system. • making monitoring easier. • This will result in clear identification of small and large waste generators and their categories. • This will facilitate collection of SWM charges along with annual property tax, thereby minimising cost of tax recovery.	• Cross subsidisation can reduce the tax burden of poorer households. • This can be horizontally equitable if amount paid is linked to the service levels and the quantity of waste generated.	• Generation based solid waste tax would lead to bulk waste generators paying higher charges than smaller generators.	• Solid waste tax can only be revised along with property tax, which is revised 5 yearly. • This will depend on the existing collection efficiency of property tax which is very low, but is expected to increase with the shift to unit ABS of property taxation.	• Unit ABS is already accepted and currently in place in many states. • Any increase in SWM tax rates will need to be justified and will require political support for implementation.

19 "Environmental Fiscal Reforms in India: Where and How?", GIZ and TERI (2011).

1970

837

Table 1.12: Mechanisms for Recovery of Municipal Solid Waste Management User Charges [contd.]

MECHANISM	ADMINISTRATIVE COSTS: TAX AND DATA COLLECTION , MONITORING , IDENTIFICATION OF USER CHARGES	SOCIAL EFFECTS: VERTICAL AND HORIZONTAL EQUITY; LINKAGES WITH ABILITY TO PAY	ENVIRONMENTAL EFFECTS: LINKAGES TO WASTE GENERATION AND INCENTIVE TO REDUCE WASTE	REVENUE GENERATION AND POTENTIAL COST RECOVERY	POLITICAL AND PUBLIC ACCEPTANCE
• Levy of separate solid waste user charges and using direct collection or "pay as you throw systems".	• This will add to the cost of tax administration as a separate arrangement and will have to be made for collection of user fee. If the responsibility of collection of user fees is passed on to the PPP partner, the municipal administration cost may reduce but actual cost may not as collection cost may be added by the contractors in their tipping fees. Besides, the concessionaires, not having legal powers may not be in a position to collect from defaulters and this will necessitate enforcement measures by the local authorities to recover dues from defaulters. • "Pay-per-bag" systems may provide incentives to minimise waste generation or littering. This system can be implemented with adequate checks and balances. • Measuring waste may be a problem.	• This can be vertically and horizontally equitable if amount paid is linked to the unit area based service levels and the quantity of waste generated. • This can be vertically equitable if charges levied vary with socio-economic status: reduced rates for poor households and higher rates for rest.	• This provides incentives for waste reduction and supports the proportionality principle (the more you generate, the more you pay).	• Collection efficiency will be important in determining the cost recovery. • Administrative costs for direct collection need to be determined. • Flat rate charges and variable rate charges generate less variability in revenue. • If based on service level or on quantity of waste delivered, this may encourage illegal dumping, since people may not want to pay higher charges.	• This needs political support in introducing user fees in addition to property tax. The user fee structure needs to be designed scientifically, and increasing the charges from year to year could be difficult.

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Table 1.12: Mechanisms for Recovery of Municipal Solid Waste Management User Charges [contd.]

MECHANISM	ADMINISTRATIVE COSTS: TAX AND DATA COLLECTION , MONITORING , IDENTIFICATION OF USER CHARGES	SOCIAL EFFECTS: VERTICAL AND HORIZONTAL EQUITY; LINKAGES WITH ABILITY TO PAY	ENVIRONMENTAL EFFECTS: LINKAGES TO WASTE GENERATION AND INCENTIVE TO REDUCE WASTE	REVENUE GENERATION AND POTENTIAL COST RECOVERY	POLITICAL AND PUBLIC ACCEPTANCE
• Levy of user charge linked to utility (water and electricity) bill.	• This can be an efficient and cost-effective system in recovery of user charges, as defaulters will have a fear of disconnection of utility service in case of failure to pay. Administration cost will also go down substantially as user fees will get collected monthly or bimonthly along with utility charges. This will also result in maintaining a cash flow to ensure timely payment to the service provider. • Willingness of concessionaire is necessary to undertake this responsibility on payment of a small fee; administration cost of ULB will thus be very low. • Some cost may be incurred in the transfer of funds from the ULB to the concessionaire.	• Will be horizontally and vertically equitable.	• Provides no incentives for waste reduction but does have inbuilt equity.	• Collection efficiency of user fees will increase substantially and help ULBs in paying the concessionaire on time and make PPP service sustainable .	• Linking of the MSWM charge to the already existing utility billing system will require negotiations with utility company. • Political and public acceptance may be a problem.

1972

(c) Municipal resources that include taxes and duties

Traditionally, property tax in India has been the main source of revenue for ULBs to finance municipal services including MSWM. Rationalisation of the property tax is required to ensure financial sustainability of these services.

(d) Grants from central or state government

It has been widely recognised that ULBs are unable to meet the expenditure for their activities solely by internal resources. Hence, ULBs require substantial financial support from the central and state government in the form of grants and funds. Some of the grants and funds available to ULBs are:

- finance commission grants;
- central government grants (e.g., JnNURM, Swachh Bharat Abhiyan); and
- state finance commission grants allocated by the state to local authorities once every 5 years to support administrative, governance, and municipal service delivery.

(e) Subsidies:

The Ministry of New and Renewable Energy (MNRE) has been promoting waste to energy projects—refuse derived fuel (RDF), biomethanation, biogas, and gasification—by providing financial incentives to proponents. The incentives are given to both private and public sector entrepreneurs and investors. The subsidy has been Rs15 million–Rs30 million per MW. For commercial projects, financial assistance is provided by way of interest subsidy to reduce the rate of interest to 7.5% capitalised with an annual discount rate of 12%. The assistance or subsidy is routed through financial institutions.

- Financial assistance up to 50% of capital cost of the project limited to Rs 3.00 crore per MW is provided to the project proponent for demonstration projects.
- In addition to the above, financial incentive at Rs. 15.00 lakh per MW is given to municipal corporations or ULBs for supplying the garbage free of cost at the project site and providing land on a long term lease (30 years and above) at a nominal rent.
- State nodal agencies are given an incentive at Rs. 5.00 lakh per MW of power for promotion, coordination, and monitoring of projects.

- There is also a provision for financing 50% of the preparation cost of detailed project reports (DPRs) or techno-economic feasibility reports, subject to a maximum of Rs. 2.00 lakh per report to the project proponent.

The Ministry of Environment and Forests and Climate Change (MoEFCC) and the Ministry of Agriculture (MoA) have subsidised compost plants up to 50% of the capital cost. The purpose of the subsidies has been to promote technologies which might otherwise not be taken up on purely financial grounds.

(f) **Loans from capital market or from government or financial institutions**

ULBs can also approach capital markets either directly or through an intermediary. The ULBs can also take advantage of funding for SWM from financial institutions which charge relatively lower rates of interest. Some of the financial institutions include the following:

- Housing and Urban Development Corporation (HUDCO)
- Infrastructure Development Finance Company (IDFC)
- Infrastructure Leasing and Financial Services (IL&FS)
- National Bank for Agriculture and Rural Development (NABARD)
- Indian Renewable Energy Development Agency (IREDA)
- Industrial Development Bank of India (IDBI)
- Industrial Finance Corporation of India (IFCI)
- Commercial banks, suppliers, creditors, and private venture capital funds

Private sector participation is a beneficial option for financing municipal services while ensuring improved service delivery

(g) **Loans and grants from bilateral and multilateral Donors**

ULBs could also consider the opportunity of funds from bilateral and multilateral donors like ADB, KfW, the World Bank, etc. for soft loans and grants for infrastructure projects, after due approval from the State. States could also access these funds and provide them to the ULBs.

(h) **Public private partnerships**

Private sector joining hands with the public sector has become essential for providing MSWM services and creating infrastructure for collection, transportation, treatment, and disposal of waste, resulting in efficient maintenance and cost-effective provision of services.

1974

The success of PPPs depends on the three necessary conditions of competition, transparency, and accountability

Private sector participation (PSP) brings in efficient technology, financial resources, trained staff, managerial autonomy, and efficiency in operation at a relatively low cost along with accountability and flexibility in bringing about a change as and when required.

Public private partnership has distinct advantages and challenges which must be taken into consideration while embarking on the PPP mode of service delivery. The advantages include flexibility, increased efficiency, and contestability:

Flexibility:

- the private sector can easily hire qualified staff members and pay the salaries as per expertise.
- salaries and bonuses can be linked to staff performance, thereby providing incentives for efficiency and good work.
- employee can be easily terminated when performance is unsatisfactory.
- administration is more effective due to fewer bureaucratic responsibilities.
- there is less political interference with private sector involvement.
- decision-making process is faster and simpler.

Increased efficiency:

- new equipment or spare parts for equipment maintenance can be easily acquired.
- the private sector is more open to technology and expertise.
- the private sector has easy access to financial resources for new investments.
- full cost accounting is used.
- incentives for good performance and efficiency are offered.

Regular monitoring and reviewing of performance of the private entity against predefined performance criteria by the ULBs is important for the success of PPP projects.

Contestability:

Competition between the private and public sectors is effective in improving cost-effectiveness.

Some of the challenges for effective PPP implementation include:

- performance monitoring,
- customer satisfaction, and
- accountability to the beneficiaries for services rendered.

1975

The ULB should ensure that the private sector player is selected through a transparent selection process after carefully prescribing minimum qualification and experience needed to perform the function effectively and the contract documents are prepared professionally. The ULB also has an obligation to ensure that the private sector partner adheres to the local, regional, and national legal requirements which entail workers' rights, workers' equitable remuneration, and other legal requirements or factors such as bonuses, maternal or paternal leave, annual leaves, clauses for termination with proper notice periods, setting up of staff committees, sexual harassment committees (now mandated by law), and other labour rights based units.

Management of PPPs is another critical issue, which will ultimately determine the success of the project. A well-defined action plan, including a plan to monitor specific indicators is essential to evaluate the performance of any project. The ULB should have appropriate inhouse capacity to regularly review the performance of all PSP or PPP projects. Further details on contract monitoring are included in section 5.4.7 of Part II.

(i) **Municipal bonds and debentures**

This is a good source of raising finance from the market and very popular in several developed countries. Tax-free municipal bonds can be issued for raising finances from the market for infrastructure development. Such bonds can be issued by ULBs having good financial health and good credit rating to attract investors to invest in municipal bonds. The amount invested is redeemable after a specific period with a definite rate of interest. Presently, the concept of municipal bonds is at a nascent stage in India and only a few ULBs with a large and buoyant revenue base (credit rating) have been successful in raising funds through them (e.g., Ahmedabad has raised funds several times through tax-free bonds and have been able to raise money for infrastructure development very swiftly).

Ahmedabad Municipal Corporation is one of the pioneering cities to issue municipal bonds and debentures

(j) **Revenue from sale of products derived from waste processing**

ULBs can minimise expenditure by seeking PSP. For waste processing, private sector entities can be entrusted with the responsibility of processing the municipal waste at their own cost, by allowing them to set up the waste processing facilities on municipal land and giving them the agreed quantity of waste at designated site for a fixed contract period. ULBs may set up such facilities at their own cost and carry out its O&M through expert agencies and earn revenues from the sale of end products like compost, RDF, or electricity.

1976

(k) Tipping fee, solid waste tax

This could be another source of revenue. The fee may be prescribed for large waste generators for processing and disposal of their waste at the landfill. This could be in the form of fixed monthly fee for providing access to the processing and disposal facility.

1.4.5.6.4 Deficit Management

The ULB should endeavour to recover 100% of the total costs of services as estimated above through levy of user charges on "polluter pays" principle. This should include costs of door-to-door collection, transportation, processing, and final disposal of waste at the landfill. The cost of street sweeping, its transportation, and disposal should be met from the municipal general budget. Since it may not be immediately achievable to recover the costs of service indicated above through user fees, however it is important to initiate the process of recovering at least 100% of the cost of collection and transportation (O&M costs only) through levy of user fees within 3 years; subsequently the user fees may be gradually raised to cover the gap in recovery of processing cost and O&M costs. Table 1.13 indicates a format for recording the revenue required to bridge the financial viability of providing MSWM services.

Table 1.13: **Format for Assessing the Gap and Bridging the Financial Deficit for Municipal Solid Waste Management Services**

S. NO	DESCRIPTION	YEAR 01	YEAR 02	YEAR 03	YEAR	YEAR 20
1	Deficit					
2	Target % to be met by user fee					
3	Municipal fund					
4	State subsidy or other sources					

Mechanisms for collecting user fees need to be put in place, and the user fee collection system should be institutionalised. If necessary, the Municipal Act 1872, needs to be suitably amended to enable these actions. A detailed cost recovery report should be prepared covering the whole gamut of MSWM. The ULB should allocate only the required resources as planned and attempt to work within the earmarked and identified resources. Any excess staffing or vehicles available or deployed should be phased out, resulting in a reduction of actual costs.

1.4.5.7 ANALYSIS OF APPROPRIATE PUBLIC PRIVATE PARTNERSHIP CONTRACT MODELS

ULBs should first assess whether they are able to provide MSWM services on their own or will need to outsource due to considerations of limited capacity, staffing, and other resources. In the latter case, the services to be outsourced should be deliberated upon and defined in sufficient detail and should fit into the larger MSWM plan for the ULB. ULBs may contract private service providers for specified solid waste collection, transportation, treatment, processing, and disposal services.

A contract between a public and private entity is an arrangement between two parties where the private party is paid a fee for investing in necessary infrastructure, vehicles, and equipment or for managing an existing asset or business as well as providing the desired services. Management contracts transfer limited responsibilities and risk to the private party, whereas contracts like design–build–own–operate–transfer (DBOOT) put significant responsibility on the contractor. The contracts have to be structured in a way that they bridge the financial and institutional gap which ULBs cannot fill easily from internal resources and capabilities.

ULBs should play a critical role in monitoring various contractual arrangements to avoid risks associated with contracts

Contracting models should be performance-based and the payments made to private partners should be linked to outputs reflecting the service quality levels which are predefined in the contract.[20]

Table 1.14: Key Characteristics of Contracts in Municipal Solid Waste Sector[21]

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.

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

1978

Table 1.14: Key Characteristics of Contracts in Municipal Solid Waste Sector [contd.]

MSW MANAGEMENT & OPERATION	CHARACTERISTICS	RELEVANT CONTRACT MODELS	IMPLEMENTING ULB
Processing / disposal	• Capital intensive • Technically skilled staffing required • Experience of technology deployed	Concession contracts (Design Build Operate [DBO], Build Own Operate (BOO), Design Build Own Operate Transfer (DBOOT)	Surat, Pune, Delhi, Hyderabad, Coimbatore, etc.

Table 1.14 summarises relevant contracts for specific MSWM activities. While each of the operations have a distinct scope and can be handled under separate contracts, various models exist for efficient MSWM, which revolve around a combination of these operations. Some of the possible combinations of contracts include:

1. separate contracts for collection, transportation, processing, and disposal activity (four contracts);
2. collection and transportation contract, processing contract, and disposal contract (three contracts, as in Shimla);
3. collection and transportation contracts in one package and processing and disposal contracts in another package (two contracts, as in Bengaluru); and
4. one integrated contract for all four activities (as in Raipur, Guwahati, Jodhpur, Lucknow, Kanpur, Allahabad, etc.).

Each of the above options has certain advantages and disadvantages and may be adopted with checks and balances in the contracts to minimise the risks. In each successive model, the level of responsibility on the private player is relatively higher, with the fourth model allocating the highest responsibility to the private entity. The ULB plays the role of a client and a monitoring agency. Through this model, a high degree of accountability and better compliance is achieved, as the private agency is a professional player liable to the ULB.

The Government of India in cooperation with ADB elaborated a "Toolkit for Public Private Partnership frameworks in Municipal Solid Waste Management"[22] which supports ULBs within a four-step approach to establish a PPP system adequate to the conditions in the respective city. It is strongly recommended to apply this toolkit for establishing a 'hand-tailored' PPP system.

22 Toolkit for Public Private Partnership frameworks in Municipal Solid Waste Management Volume I–III. Ministry of Urban Development (MoUD).

Table 1.15: Contracting Models and Private Sector Responsibilities[23]

OPTION	GENERAL CHARACTERISTICS	AIM OF HAVING PRIVATE SECTOR PARTICIPATION	OPERATIONS AND MAINTENANCE	CAPITAL INVESTMENT AND ASSET OWNERSHIP	RESPONSIBILITY	CONTRACT DURATION
Service Contract	The private sector provides a clearly defined service to the public partner.	Increase efficiency of particular public service	Shared	Public	Public	1-2 years or 5-8 years
Management Contract	The private partner is responsible for operating and maintaining the system.	Increase efficiency of service, with improved management structures	Private	Public	Public	3-5 years
Design-Built-Operate (DBO)	The private contractor is responsible for designing, constructing, and infrastructure developments.	Enhance commitment level because of full responsibility	Private	Public	Shared	5-8 years
Lease	The private partner is fully responsible for operation and maintenance.	Increased responsibility	Shared	Public	Public	8-15 years
Build-Own-Operate (BOO)	The private partner builds a facility that is based on a defined design and owns and operates it. The private partner charges a tipping fee to recover its cost.	To transfer the responsibility of investment and management in a cost-effective manner with all risks on the private partner	Private	Private	Private	15-30 years

23 Adapted from Cointreau-Levine (1994); International Consortium, GTZ-ERM-GKW (2004); World Bank (2004)

1980

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Table 1.15: Contracting Models and Private Sector Responsibilities [contd.]

OPTION	GENERAL CHARACTERISTICS	AIM OF HAVING PRIVATE SECTOR PARTICIPATION	OPERATIONS AND MAINTENANCE	CAPITAL INVESTMENT AND ASSET OWNERSHIP	RESPONSIBILITY	CONTRACT DURATION
Build-Own-Operate-Transfer (BOOT)	The private partner builds a facility that is based on a defined design and owns and operates it. The private partner charges a tipping fee to recover its cost. The private company then transfers asset to the public partner.	Obtain private sector investment with operating and management risks on the private partner and eventual asset transfer to the public.	Private	Private	Private	15-30 years
Build-Operate-Transfer (BOT)	The private partner is responsible for constructing, financing and operating the facility during the contract period. After the contract period, the facility is transferred to the public.	To transfer all risks to the private partner	Private	Private	Private	20-30 years
Concession (including fee collection)	The private partner is fully responsible for operation, maintenance and investment.	To create competition in the market	Private	Private	Private	25-30 years

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1.4.5.8 PLANNING FOR CENTRALISED AND DECENTRALISED FACILITIES

Conventionally, MSWM systems were planned for and implemented at the city level, with centralised systems catering to the entire ULB.

Resource, technology, and capital-intensive MSWM services are best planned and executed at the city level; centralised systems are preferred for waste processing and treatment plants like RDF plants and municipal sanitary landfills, which can benefit from economies of scale and for easy management and environmental monitoring.

Decentralised waste management systems or community level waste management systems reduce the burden of handling large volumes of MSW at a centralised location, with a corresponding reduction in costs of transportation and intermediate storage. Especially for decentralised facilities, their success depends on segregated doorstep collection. All decentralised schemes should be assessed for long term sustainability and their impact on the overall MSWM system of a city should be identified and considered while planning for citywide waste management facilities.

Interactive planning along with the community is required to decide the extent of centralised and decentralised MSWM systems for continued efficiency.

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

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



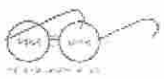
Decentralised systems require a higher degree of commitment from the community, as their participation is crucial in ensuring the sustained performance of these systems

1.4.5.8.1 Role of Decentralised Municipal Solid Waste Management Systems

Decentralised waste management systems or community level waste management systems reduce the burden of handling large volumes of MSW at a centralised location, with a corresponding reduction in costs of transportation and intermediate storage.

Decentralised MSWM solutions are suitable in the following scenarios:

- Suitable land for waste management facilities (composting organic waste, recyclable sorting facilities) is available in neighbourhoods;



- There is no local resistance against siting the plant;
- Local expertise or non-government organisations (NGOs) handhold the process in an environmentally acceptable manner;
- Municipality has in-house capacity of effectively monitoring decentralised systems;
- Markets for compost and recyclables are accessible;

Some of the advantages of decentralised MSWM are the following:

- Decentralised systems allow for lower level of mechanisation than the centralised solutions. They provide limited income and job opportunity for informal workers and small entrepreneurs;
- Decentralised options can be tailor made for the local waste stream, climate, social, and economic conditions;
- Decentralised systems reduce the cost incurred for the collection, transportation, and disposal of waste by the ULBs;

However, some of the limitations to the implementation of decentralised waste management systems include:

- scarcity of land in most urban neighborhoods;
- lack of availability of technically qualified staff to ensure scientific and hygienic operations;
- difficulty in ensuring periodic check on product quality; and
- difficulty in ensuring financial viability of decentralised projects, specifically when qualified staffing is required.

While planning for decentralised systems, adequate care should be taken to ensure that these systems are an integral part of the larger MSWM plan of the city. Other centralised waste processing and treatment systems should not consider waste volumes which are already being processed and treated in decentralised facilities.

Local material recovery and recyclable sorting facilities, decentralised compost plants, biomethanation (biogas) plants, vermicomposting, windrow composting, and bin-composting are all easy to establish at the community or institutional level. Sizes can vary from small backyard composting to plants processing 3–20 tonnes per day (TPD) of organic waste. Material take-back and recycling facilities can also be established at the local community level to increase efficiency of collection.



Dry waste collection centres run by various agencies in Bengaluru in coordination with the Bruhat Bengaluru Mahanagara Palike (BBMP) are decentralised bulk sorting and processing facilities. Waste managers perform secondary and tertiary sorting of the waste here before finally selling it to recycling centers. Bulk collection through informal sector results in larger returns and more jobs opportunities.

Decentralised Waste Management System for Apartment Complexes- A Public Private initiative in Kochi

Year of start: 2007

Main players: Cochin Municipal Corporation (CoC), Confederation of Real Estate Developers' Associations of India (CREDAI)

Approach: Kochi witnessed rapid urbanisation in the last decade with various developmental and infrastructural projects, and consequently faced the problems of waste management and its disposal. The garbage crisis of 2007 deteriorated the condition of Kochi, as the city had no dedicated site for waste disposal. In order to address the problem of garbage disposal in residential colonies with focus on health, hygiene, and safety, CoC carried out a joint initiative with Kerala Builders Forum later called CREDAI. To manage solid waste, the following approaches were adopted in highrise apartments to implement an eco-friendly solid waste management system:

- A suitable technology was identified and approved by Clean Kerala Mission, Government of Kerala. In 2007, CoC implemented this decentralised system of waste management in few apartment complexes on a trial basis.
- Strategy was planned and formulated and a dedicated team for implementation of the decentralised system was set up for the-high rise apartments.
- CoC set up source segregated door-to-door collection system of waste in each of the apartment complexes.
- Bio-bin system was established to process biodegradable waste to produce and utilize the compost on-site within the apartment complex.
- A recycling and plastic shredding unit was established by CoC and managed by CREDAI.
- Dry or recyclable material was collected and sold to generate revenue for the CREDAI workers.
- CoC promoted regular skill development and awareness programs for the workers and citizens through print and mass media.

Outcome:

- Currently, 350 apartment complexes in Kochi are covered under this initiative.
- Decentralised system in apartment complexes led to employment opportunities for economically weaker sections, especially women, for operationalising and monitoring the unit.
- Monitoring was effective and complaint redressal (e.g., during unit failure) was timely.

1984

Success Factors

- Legal framework making the system mandatory for all apartment complexes
- Proactive role of CoC to decentralize waste management within all apartment complexes and regular monitoring by the officials
- Capacity building of the workers
- Regular monitoring by CREDAI at the premises

Overall Sustainability

The initiative of CREDAI in the apartment complexes is a self-sustainable working model showcasing the viability of decentralised waste management systems. On-site operation and maintenance of the composting system as well as other expenditures are being met by the collection of user charges at the rate of Rs. 100–150 and by the sale of recyclables. In order to further strengthen and ensure sustainability of the system, Local Self Government Department (Government of Kerala) issued an order in 2012 making it mandatory for all apartments, through the building associations or firms, to manage waste within the apartment complexes using different technologies for composting and for sale of recyclable material.

Source: CoC.



Bhabha Atomic Research Centre (BARC) has developed Nisargruna technology for generating biogas from organic waste. Small plants operating 0.5–5.0 tonnes per day (TPD) can be set up at an affordable cost at decentralised locations or large institutions, markets, etc. More than 150 plants are operational in the state of Maharashtra and few other states.

1.4.5.8.2 Management and Monitoring of Decentralised Municipal Solid Waste Facilities

A decentralised facility at the household level need not be registered; however, all other decentralised facilities operating more than 1 TPD of waste should be registered with the local authority. Appropriate norms for operation and maintenance (O&M) should be prescribed for the facility, which should be monitored by both the local authority and the pollution control board.

Decentralised MSWM facilities may be funded through community-based cooperatives, local NGOs, PPP mode or municipal funds. Community ownership of decentralised systems is critical for their success and continued operation. The four management models for decentralised waste management systems are tabulated in Table 1.16. The relevance of different models is dependent on local conditions and cultural backgrounds. All the decentralised models are equally beneficial to the ULB by reducing overall waste management costs.

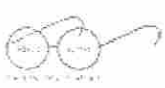


Table 1.16: Management Models for Decentralised Waste Management[24]

OPTIONS	PURPOSE	MAIN ACTORS	ROLE OF CITY GOVERNMENT OR MUNICIPALITY	ADVANTAGES	CONSTRAINTS
Model 1: Municipality owned–Municipality operated	• Reducing cost of transportation, centralised treatment, and disposal of waste in landfills • Local employment opportunity	• Municipality	• Investment provider • Implementing and monitoring agency	• Cost saving in transportation, centralised processing, and disposal of waste • Profitable use of waste • Job opportunities for the unemployed youth • Entrepreneurship development	• Lack of suitable land • Objection from the neighbourhood • Occasional problems of odour • Operating inefficiency and lack of marketing potential • Lack of coordination between departments regarding the use of the compost products within the ULB
Model 2: Municipality owned–community operated	• Community involvement in management of primary waste collection and treatment • Capital cost borne by local body • Local employment opportunity • Entrepreneurship development • Nonprofit seeking model	• Municipality, local community, NGOs RWAs	• Making capital investments • Supporting communities in finding or allotting land • Collection and disposal of residual waste • Monitoring agency	• Cost saving in transportation and centralised processing and disposal • Profitable use of waste • Job opportunities for the unemployed youth • Entrepreneurship development • Reduction in municipal burden due to community participation. • Improvement of MSWM through voluntary participation	• Lack of community awareness and interest in decentralised project • Lack of informal leader among the community to lead the cause of the project • Lack of skilled labour and entrepreneurs

24 Adapted from: "Decentralised Composting for Cities of Low and Middle Income Countries" pp 33. Waste Concern, (2006), Dhaka, Bangladesh.

1986

853

Table 1.16: Management Models for Decentralised Waste Management (Contd.)

OPTIONS	PURPOSE	MAIN ACTORS	ROLE OF CITY GOVERNMENT OR MUNICIPALITY	ADVANTAGES	CONSTRAINTS
Model 3: Municipality owned–privately operated	• Profit seeking model • Full cost recovery (from collection fees and compost sales) • Cost reduction through lower transportation and disposal costs	• Municipality, Private secto, NGO	• Funding capital expenditure • Identify and allot land for composting, • Contracts out the operation and maintenance • Monitors performance of contractors	• Reduction of municipal burden of waste management through private sector participation • Know-how and efficient management through private sector • Partnership with private entrepreneurs	• Lack of community awareness and interest • Need for a reliable and skilled partner with sense of entrepreneurship • Inefficient contract management
Model 4: Privately owned–privately operated	• Profit seeking enterprise based on compost market conditions (Income is generated through sale of products like compost and through collection of charges)	• Private sector	• Selecting a private operator through a transparent process • Formulation of transparent regulations for PPP • Cooperation in supply of raw waste and disposal of residues • Synchronising centralised and decentralised systems	• Reduction of the municipal burden of waste management through private sector participation • Investment of funds and know-how through private investors • Partnerships with private entrepreneurs • Creation of employment and business opportunities	• Lack of private land • Lack of vital compost markets

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Decentralised Model of Integrated Municipal Solid Waste Management in Saharanpur, Uttar Pradesh

Year of Start: 2006

Location: Saharanpur, Uttar Pradesh

Main Players: Muskan Jyoti Samiti (MJS), Saharanpur Municipal Corporation (SMC), Imperial Tobacco Company of India Limited (ITC).

Approach:

Saharanpur is one of the growing urban centres of the western region of Uttar Pradesh, with a population of more than seven lakh (0.7 million). The city generates huge amounts of municipal solid waste, but SMC was unable to provide adequate and efficient services. This led to the joint initiative by MJS and ITC to provide an integrated waste management facility comprising of segregation, collection, transportation, processing, and disposal of municipal solid waste. Economic viability, environmental sustainability, and continuity are key features of the initiative. During the course of the intervention, MJS facilitated formation of a labour cooperative society, which is now managing the entire operation. The approaches adopted under this initiative are briefly discussed below:

- A well-defined system that reduces burden of municipal solid waste disposal by 80%–90% is established.
- Effective and efficient collection and transportation mechanism is enforced, which includes collection of partly segregated waste and transportation of waste directly for processing.
- Primary segregation of waste into wet, dry (recyclables), and inert is carried out at household level, while secondary segregation takes place at processing site.
- A dedicated team of 112 people is set up for ensuring a smooth functioning of the system. Each waste collector covers 200–225 households and reports to the supervisor in-charge.
- Routing of each vehicle is optimized so that the collected garbage is directly transferred from trolley to truck to avoid spillage of waste.
- Organic waste is processed into manure through windrow composting for garden waste, and aerobic and drum composting for organic waste from households.
- Tie up with the recycling units or vendors is established for selling of recyclable waste, proper maintenance of logbook, as well as laboratory testing of compost to ensure its quality.
- For smooth system functioning, the supervisor-in charge does regular inspection and maintenance of attendance register of workers.
- User charges are introduced to ensure public participation and financial sustainability of the overall system.
- The Labour Cooperative Society is wholly owned and managed by waste collectors and workers. The cooperative provides front-end waste management services that include door-to-door collection, composting, and recycling.

1988

Profit from Waste

- Approximately 2,078 tonnes of waste is collected from 9,000 households in 2013–2014.
- The waste comprises 1,437 tonnes (69%) organic, 376 tonnes (19%) recyclable, and only 248 tonnes (12%) inert.
- 360 tonnes of organic manure is produced from the collected organic waste.
- The initiative has created direct employment for 112 persons from economically weaker sections.
- Besides covering entire operational cost, the initiative has also generated 12.5% of operational profit in the reference year.

Outcomes

- Overall improvement is achieved in the environment and aesthetic value of the city.
- About 360 tonnes of organic manure is made available for local farmers. It directly contributes in reducing the usage of chemicals in agriculture and in saving of about Rs. 90.00 lakh, which would otherwise have been spent on purchase of chemical fertilisers.
- The system has reduced burden of waste disposal by 88%, and thus also contributes in saving valuable land, fuel, and other costs.

Success Factor

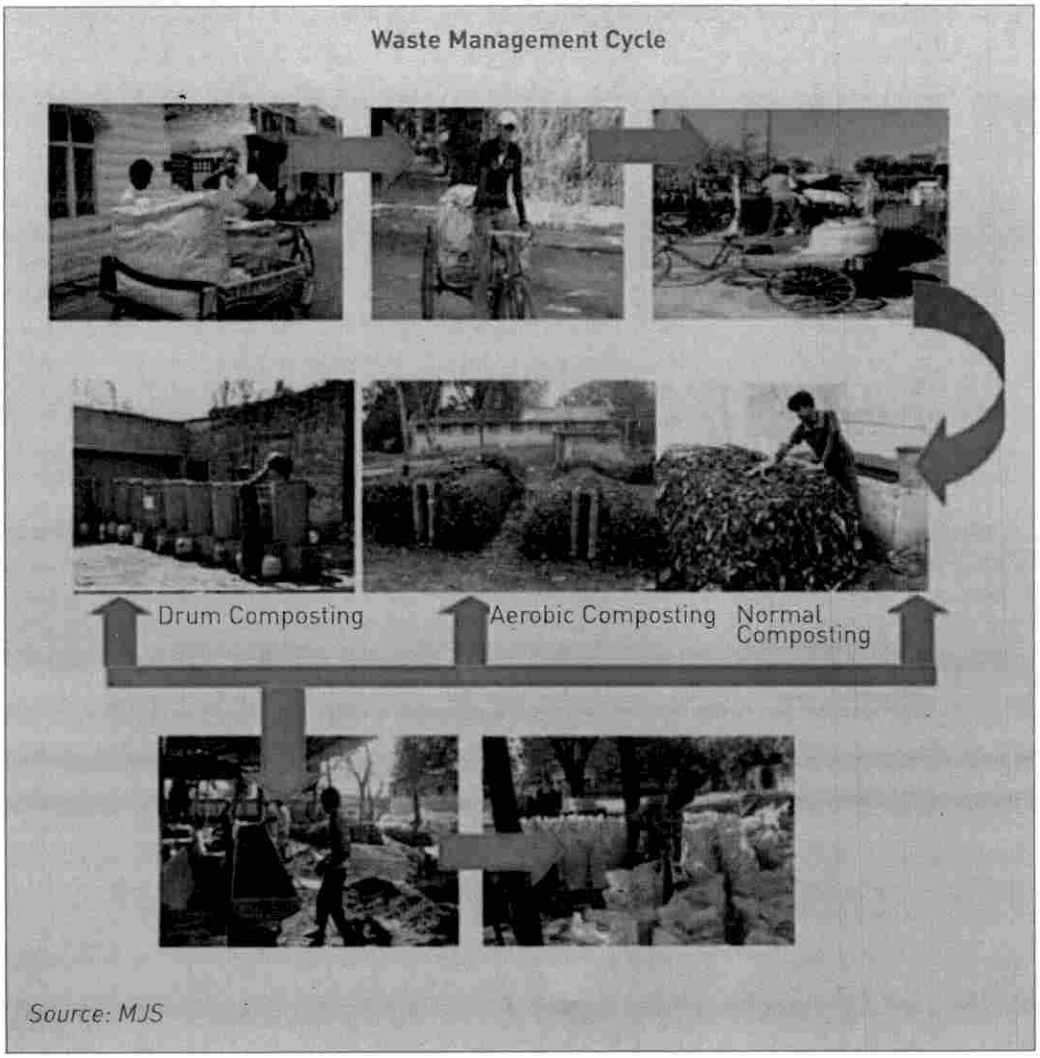
- More than 90% of households directly covered by waste collection.
- Decentralised system.
- Strategic assessment of the existing situation and planning for the collection and safe disposal of the waste.
- Regular monitoring by the team in-charge for ensuring smooth functioning of the system.
- Capacity building of the workers.
- Willingness of citizens to pay a stipulated amount as solid waste collection service.

Overall Sustainability

The integrated waste management initiative of MJS is a self-sustainable model, showcasing the viability of decentralised waste management systems. The operation and management costs are recovered from the user charges collected at Rs. 20–30 per household as well as from the income from sale of recyclable material and manure produced from processing of organic waste.

ITC provided the initial investment as seed money for carrying out this initiative. The SMC, Government of Uttar Pradesh, and Uttar Pradesh State Industrial Development Corporation have provided land for the processing unit and a mini truck for transportation of waste, further strengthening the system.

1989



1.4.5.9 ARRANGEMENTS FOR INFORMAL SECTOR INTEGRATION

The informal sector, constituting of both kabadi system and waste pickers, plays an important role in the MSWM value chain by recovering valuable material from waste. It helps reduce environmental impacts by improving resource recovery and reducing disposal requirements. The integration of the informal sector into the formal SWM system will contribute to the reduction of the overall system costs, provide support to the local recycling industry, and create new job opportunities. The waste pickers have significant expertise in sorting municipal waste and are an asset for processing and material recovery facilities.

The informal sector (kabadi system and waste pickers) is the backbone of the MSWM value chain in India, recovering nearly 50% of recyclables generated by households

1990

Integrating the Informal Waste Sector: Policy Directives

The integration of the informal waste sector into formal waste management systems is made possible through a set of formal or informal arrangements between waste pickers or organisations of waste pickers or organisations working with waste pickers and the local authorities, in their operational area. The integration process would typically result in the accrual of social benefits to waste pickers."[25]

Some of the salient features of the policies or regulations pertaining to municipal solid waste management (MSWM) as they relate to the informal waste management sector are the following:

- National Environment Policy, 2006. It acknowledges the informal waste sector and states, "Give legal recognition to, and strengthen the informal sector systems of collection and recycling of various material. In particular enhance their access to institutional finance and relevant technologies."
- National Action Plan on Climate Change, 2009. It stresses the need for giving legal recognition to the informal sector, which it recognizes as the "backbone of India's highly effective recycling system."[26]
- National Labour Commission, 2002. It "recognises the useful role played by the scrap collectors both in helping recycling activities as well as in maintaining civic hygiene. It is, therefore, essential that they should be protected from insecurity of various forms. The measures that could be thought of in this regard are providing identity cards, receipts for transactions, minimum wages when they are employed by contractors or other employers, health facilities, creation of welfare funds, prohibition of child labour from the activity and the likes. The Commission fully endorses the suggestions made by the United Nations Development Programme (UNDP) and the International Labour organisation (ILO)."[27]
- SWM Rules, 2016 recognises the role of informal sector in waste management, and emphasise on establishing a system for integration of these waste collectors in order to facilitate their participation in SWM.

Progressive regional legislation that facilitates integration of the informal waste sector into formal systems has been made in some of the Indian states like Maharashtra.

Developing formalized material recovery systems is capital intensive. Therefore, informal sectors, if existing, should be encouraged, while ensuring environmental, health and safety safeguards

There are various political, legal, cultural, and social conditions that determine the best possible approach to informal sector integration. Local, regional, and national legislative frameworks for informal workers should be considered.

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

25 Adapted from Recycling livelihoods – Integration of the Informal Recycling Sector in Solid Waste Management in India Chikarmane, P. L. Narayan, and B. Chaturvedi (2008) and study prepared for GTZ 's sector project "Promotion of concepts for pro-poor and environmentally friendly closed-loop approaches in solid waste management" (unpublished).

26 National Action Plan on Climate Change (2009).

27 Second National Labour Commission (2002). Ministry of Labour, Government of India.

- organising informal sector into recognised membership-based associations or cooperatives, with true representation of women as part of their leaders and members;
- recognising these associations for MSWM service delivery;
- creating a policy framework for informal waste sector recognition and an inclusive framework to facilitate their participation in the delivery of service;
- promoting social security and health benefits to members of these associations;
- encouraging informal sector, NGO, and CBO through linkage to National Urban Livelihoods Mission;
- providing low-interest loans to organisations of waste pickers seeking to bid for tenders and contracts;
- providing exemptions on fees and deposits for participation of informal sector associations in bidding for MSWM contracts;
- providing basic amenities and facilities for the informal workers to work effectively such as timely wages and bonuses, proper facilities for women to be able to leave their children during work and linkages with community centres or anganwadis, safety and security including PPE, proper redressal mechanisms (for formal complaints, sexual harassment, etc.);
- encouraging informal sector involvement in waste collection and sorting services;
- reserving land in development plans for decentralised processing of biodegradable wastes and collection of recyclables; and
- supporting capacity development programs for informal sector associations (see box below).

Scope for Informal Sector Integration in Municipal Solid Waste 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-back facilities supported by adequate and appropriate skill enhancement arranged for by the urban local body (ULB) or other concerned departments
- Waste sorters in processing facilities (e.g., at the sorting conveyor)

Capacity Building and Training of Informal Sector for Providing Municipal Solid Waste Management Services

- Improvement of managerial skills (business management, accounting, marketing, negotiation skills)
- Maintenance of work ethics and organisation or team work
- Training in sorting, processing, recycling techniques, and value added services
- Formalisation requirements for waste worker organisations
- Environmental and health aspects of waste management activities
- Occupational hygiene and safety
- Business support services linked to large scale formal recycling industries

1.4.5.10 SEGREGATED COLLECTION (DOOR-TO-DOOR COLLECTION, STREET SWEEPING AND DRAIN CLEANING), STORAGE AND TRANSPORTATION

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, constuction & 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.

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.

Details on segregated collection and transportation, and choice of containers and transportation systems are given in Section 2.2 and 2.3 of Part II.

1.4.5.11 IDENTIFICATION OF LAND AND INCLUSION IN CITY MASTER PLAN OR CITY DEVELOPMENT PLAN

Availability of suitable, encumbrance-free land within the ULB's jurisdiction for waste processing and treatment facilities is the biggest challenge faced by the ULBs, which requires detailed deliberation (as mentioned in Table 1.17).

Planning for MSW treatment and processing facilities should begin with the identification of suitable land duly allowing adequate buffer areas, as indicated in Table 1.17. The city master plan and town planning or spatial planning maps should identify and reserve such land for MSWM facilities. The requirement of land is to be calculated based on a tentative assessment of possible disposal options available to the ULB. Land clearance from concerned authorities for establishment of MSWM facilities is to be obtained by the ULB at the earliest possible instance, thereby avoiding inadvertent delays during the implementation process. Siting of MSW processing and disposal facilities should be based on environmental considerations.

Table 1.17: Criteria for Identifying Suitable Land for Sanitary Landfill Sites

S.NO	PLACE	MINIMUM SITING DISTANCE
1	Coastal regulation, wetland, critical habitat areas, sensitive eco-fragile areas and flood plains as recorded for the last 100 years	Sanitary landfill site not permitted within these identified areas
2	Rivers	100 m away from the flood plain
3	Pond, lakes, water bodies	200 m
3	Non-meandering water (canal, drainage, etc.)	30 m

Table 1.17: Criteria for Identifying Suitable Land for Sanitary Landfill Sites [contd.]

S.NO	PLACE	MINIMUM SITING DISTANCE
4	Highway or railway line, water supply wells	500 m from center line
5	Habitation	All landfill facilities: 500 m
6	Earthquake zone	500 m from fault line fracture*
7	Flood-prone area	Sanitary landfill site not permitted
8	Water table (highest level)	The bottom liner of the landfill should be 2 m above from the highest water table
9	Airport	20 km**

km = kilometer; m = meter; MSW = municipal solid waste; TPD = tonne per day;

* The urban local bodies in seismic zone 4 and zone 5 should consult the seismic fault map before finalizing the site for the sanitary landfill to ensure that seismic factors are taken into consideration in determining the stability of the landfill structure.

** In a special case, landfill site may be set up within 10–20 km away from the airport or airbase after obtaining no objection certificate from the civil aviation authority or air force as the case may be.

1.4.5.12 PROCESS SELECTION AND BEST AVAILABLE TECHNOLOGY FOR PROCESSING AND DISPOSAL

ULBs should carefully assess unproven technologies and consult the SPCBs to avoid becoming testing grounds for yet to be commercially established technologies

Designing and implementing new waste management systems and optimising existing ones should consider aspects of resource recovery, environmental soundness, financial sustainability, stakeholder involvement and institutional capabilities, in addition to technical and technological appropriateness of systems for handling and disposing waste. This implies that the selection of best MSWM options for a particular ULB goes far beyond a technology selection.

The selection of waste management processes and technology shall be based on the five-tier ISWM hierarchy, which is explained in Section 1.2 of this chapter. The corresponding illustration of the ISWM hierarchy is reiterated in Figure 1.1 for easy reference.

The selection of technology should be based on defined selection criteria and local conditions, subject to a detailed due diligence study. The criteria are listed in Table 1.18 and applied to a number of common strategy and technology options.

In cases where municipal authorities feel challenged to ensure appropriate selection processes, they may seek external expertise to ascertain the most viable solutions.

Table 1.18: 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 Location[29,30]	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)						

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

Table 1.18: 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/presorted 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.

Table 1.18: 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
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

36 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%

Table 1.18: 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
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.

Table 1.18: 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
FINANCIAL CRITERIA							
Indicative Capital Investment[37]	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 biodrying 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

37 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

Table 1.18: 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.
ENVIRONMENTAL CRITERIA							
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.	-

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

Table 1.18: 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
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

Table 1.18: 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

Further detailed information on the different technologies and their implementation requirements are to be found in sections 3.2 to check 3.5 of chapter 3 of Part II of this manual.

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1.4.5.13 PLANNING FOR EFFECTIVE COMMUNITY PARTICIPATION THROUGH INFORMATION, EDUCATION AND COMMUNICATION

An efficient waste management program, regardless of the strategy, requires significant cooperation from waste generators and active community participation.

Information, education, and communication (IEC) is a multilevel tool for promoting and sustaining risk-reducing behaviour change in individuals and communities. The decision to adopt new ideas or behaviour is the result of a complex process and takes place only over a period of time Development and implementation of an IEC campaign involves planning and implementing a comprehensive, strategic set of interventions and activities to change behaviour at many levels to achieve the objectives of the MSWM plan.

Strategic planning, significant cooperation and support from the community is essential for successful implementation of the MSWM plan

Awareness and education campaigns are essential to bring about a behavioural change among the citizens in managing their waste. The IEC campaign should not only target households, shops, and commercial and institutional premises, but also all other stakeholders such as municipal officials, elected representatives, schools, non-government organisations (NGOs), the informal sector, media, etc. to ensure their participation in managing city waste by discharging their role effectively.

An IEC campaign is not a single time activity; on the contrary, depending on the stage of planning or implementation, constant communication with the community and all relevant stakeholders is necessary.

IEC campaigns need to be sustained through regular and targeted messages involving different stakeholders

A sustained campaign of targeted messages, relevant to the ongoing planning or implementation phase specific to each considered social group, will result in bringing about a significant change in behaviour patterns.

Community Participation as an Accelerator for Efficient Municipal Solid Waste Management

Communities should:

- actively participate in waste reduction, reuse, and recycling;
- stop littering the streets, drains, open spaces, and water bodies;
- practice segregation of waste at source into biodegradable (wet) and nonbiodegradable (dry) waste, ensuring that other wastes belonging to the 'special' category are handed over separately;
- participate in primary collection of waste through resident welfare associations (RWAs), self-help groups (SHGs), non-government organisations (NGOs), or individual waste collectors by paying for the services;
- encourage and assist in local composting and recycling initiatives; and
- promote effective provision of municipal solid waste management (MSWM) services for low-income populations.

1.4.5.13.1 Communicating the Municipal Solid Waste Management Plan

Successful implementation of the MSWM plan is dependent on its ownership by multiple actors. Periodic and timely dissemination of various facets of the MSWM plan would bring a significant change in human behaviour. This in turn will improve the standard of cleanliness in the city and give a better quality of life to the citizens.

Rapid assessment of the existing MSWM situation in city's ward or community enables ULBs to identify key community behaviour patterns that could aid or impede the implementation of the plan. The communication campaign should seek to change undesirable practices and strengthen complimentary habits.

Strengthening and clarifying the roles of key actors within and outside the ULB should be a key outcome of a communication plan (Table 1.19).

All households, commercial establishments, and other institutional premises have to be reached through IEC campaign to cooperate with the municipal authority in managing their waste. This can be achieved through intermediaries such as resident welfare associations (RWAs), community-based organisation (CBOs), non-government organisations (NGOs), self-help groups (SHGs), and social organisations along with the elected representatives and municipal officials. Impacts of gender vulnerability and issues of poverty are essential dimensions that must be considered in all communications.

Modes of communication chosen for the IEC campaign should be accessible by the target audience, easily replicable, and cost-effective. Several modes of communication should be simultaneously used to communicate the plan. The integrated use of multiple modes increase the coverage, frequency, and impact of communication messages.

Typical Modes of Communication

Print Medium:

While the print medium is more appropriate for the literate class, visual impact of the print medium should also be used to reach out to all sections of the community. For the illiterate, messages can be conveyed pictographically in print. The messages conveyed should be clear and easily comprehensible. Messages on product reuse, recycling, and disposal can be printed on all products used by the community.

Table 1.19: Stages of Municipal Solid Waste Management Plan Implementation – Objectives and Target Audience

MSWM ISSUE	TARGET AUDIENCE	OBJECTIVE
Generation	All waste generators in the city including informal settlements and floating population	• Reduce amount of waste generated • Promote reuse and recycling
Littering	Community	Prevent open littering by communicating penalties for littering
Burning of waste	ULB staff, community, floating population (focus on informal workers, low income group localities)	• Prevent burning of waste as a disposal option • Dissuade and prevent open burning of waste for heating (in cities with harsh winters)
Waste segregation	All waste generators: households, commercial establishments, institutions, ULB staff	• Communicate importance of waste segregation in ensuring sustainable management of waste, performance of processing and treatment systems, and health and environmental aspects
Door-to-door collection	• Waste generators serviced by door-to-door collection (e.g., households, commercial establishments, markets, institutions, etc.) • ULB staff, NGOs, RWAs, etc. responsible for door-to-door collection	• Provide information on level of segregation required • Provide information on waste collection schedule for different waste fractions (where applicable) • Provide information on timings of collection
Secondary collection	• Agencies involved in transportation of waste • Sanitary inspectors and other MSWM department staff	• Ensure segregated transportation of waste as per MSWM plan • Ensure adoption of best practices, efficient transportation of waste to avoid illegal dumping and malpractices
Transportation	Agencies involved in transport of waste, sanitary inspectors and other solid waste management department staff involved in providing or monitoring these services	• Ensuring segregated transportation of waste as per MSWM Plan • Ensuring adoption of best practices to ensure efficient transportation of waste, avoiding illegal dumping and mal-practices in waste transportation
Waste treatment or processing	• Community • MSWM department staff • Agencies, NGOs, and formal and informal recyclers • involved in solid waste processing oof treatment	Dissemination the following: • Information on need for segregation for improved efficiency of waste treatment and processing • Information on planned treatment and processing facilities • Information on environmental safeguards in MSWM treatment and processing • Information on monitoring requirements • Periodic information on analysis of monitoring data
Waste disposal	• Community • MSWM department staff • Agencies, NGOs, and formal and informal recyclers involved in solid waste disposal	• Disseminate the following: • Information on waste disposal plans of the ULB • Information on environmental safeguards in MSWM disposal facilities • Information on monitoring requirements • Periodic information on analysis of monitoring data

Audiovisual Medium:

Audiovisual communication has a large coverage and long-lasting impact; it has proven successful in influencing attitudes and motivating behaviour change. A sustained campaign on sanitation and hygiene-related issues is possible through partnerships with local radio and TV stations. The electronic media tends to overcome all barriers of illiteracy. Catchy jingles on specific issues tend to grab the attention of the audience and have a higher recall compared with conventional advertisements.

Internet:

Interactive websites can prove to be an effective mode to communicate with children, college students, and the working class. Interactive websites focused on sanitation and hygiene can be hosted by the local authority. Such websites should:

- highlight services offered by the local authority;
- showcase extended producer responsibility (EPR) initiatives;
- include frequently asked questions (FAQ) in question and answer format;
- accept queries or comments;
- provide information about various waste management workshops in the city;
- host existing waste regulations in a form easily understood by common people;
- host a facility for lodging complaints;
- highlight innovative waste management or waste to resource initiatives;
- provide links to research for more information on certain waste-related topics, which can keep on changing according to the stage of the MSWM plan implementation in the local authority;
- provide guidance documents and case studies of best practices; and
- provide inventory of recyclers and waste management solution providers, as applicable.

Social Media:

Social media is being effectively used by progressive ULBs for interacting with the community and communicating city level waste management practices. ULBs, through their presence on interactive social media such as Facebook and Twitter, encourage the community to report on specific issues, include visual representations of issues, communicate with the community in real time, and provide updates once the issue is resolved. Such tools assist ULBs in easy and quick identification of local issues and encourage fast resolution of issues.

Interpersonal:

Interpersonal communication involving persuasive dialogues and discussions with individual members of the household especially during door-to-door visits has been the most effective communication tool within the IEC framework. Local SHGs, slum level federations, town level federations, and sanitation workers should be involved in such communication.

Interpersonal communication is the most effective communication tool, e.g., individual counselling, community level interaction, motivation sessions, small group discussions, peer education, and door-to-door visits

Sanitation workers involved in door-to-door collection have proven to be the most important link in sustaining the efforts for segregating waste e.g., Pune and Kochi. All new residents coming to a city should be educated in the MSW system prevalent in the city as they tend to spoil the segregation chain due to lack of knowledge.

Others:

Organising rallies, walkathons, or local contests will raise media interest and help carry sanitation messages to communities. Possible formats like Swachhta Shapath (cleanliness pledge), Cleanliness Drive, and other similar events may also be used to raise awareness. Special annual events can be created to refresh awareness or to award communities or households for their performance. Tools of communication like musical or dance dramas, puppet shows, street plays, etc. may also be used.

Awareness activities for school children bring about the longest impact and result in quickly visible and sustained changes in the society. Children are active communicators and have convincing powers. It is also easier to modify behaviour of children through information sharing, increasing knowledge base, and motivation. Regular meetings should be held with school authorities for organising school activities on hygiene and sanitation issues. Appropriate activities as per age and class of children may be taken up in schools. Activities which engage both young boys and girls should be encouraged, as these activities contribute significantly to healthy socialisation. Negative gender roles and stereotypes must be discouraged.

School children should be primary targets of IEC campaigns, as they are major agents of societal change

Once the target group and mode of communication is selected, a detailed action plan—including an exact timeframe, stakeholders, financial outlay, and proposed outcomes of the awareness campaign— should be developed, implemented, and monitored. The ULBs can use the work plan to monitor activities and the progress of its awarenessraising campaign. Resources (institutional and financial) should also be identified to support plan implementation. The programme should be monitored through an assessment of indicators for behavioral change and other targeted impacts.

2008

Developing Capacities for Implementing Awareness-Raising Campaigns

The following are some ways to develop capacities of urban local body (ULB) staff, non-government organisations (NGOs), self-help groups (SHGs), and other communitybased organisations (CBOs) for implementing awareness-raising campaigns:

- Indicate the issues to be covered as per social and cultural needs or requirements.
- Draft messages for selected media.
- Field-test draft material and finalize material with selective target groups (including women, youth, and children).
- Train the field workers or ULB staff.
- Train NGOs and SHGs in facilitating municipal solid waste management (MSWM).
- Monitor progress in the field.

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

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

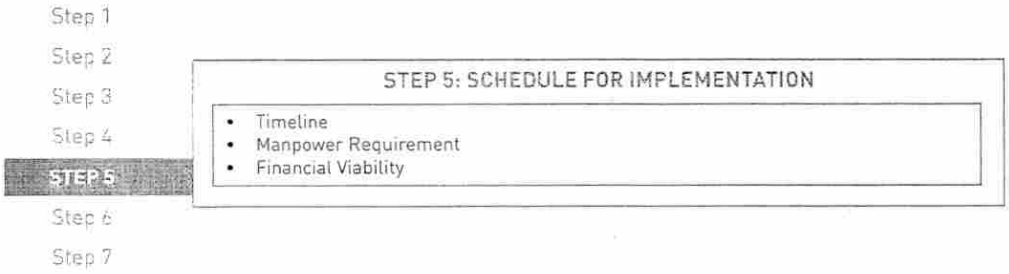
- Dance, drama, puppetry, and street plays can be used as part of long term strategies.
- These can also be used for information dissemination in residential colonies.
- Short films clearly indicating do's and don'ts with respect to municipal solid waste management can be prepared for the benefit of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

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

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

1.4.6 STEP 5: SCHEDULE FOR IMPLEMENTATION

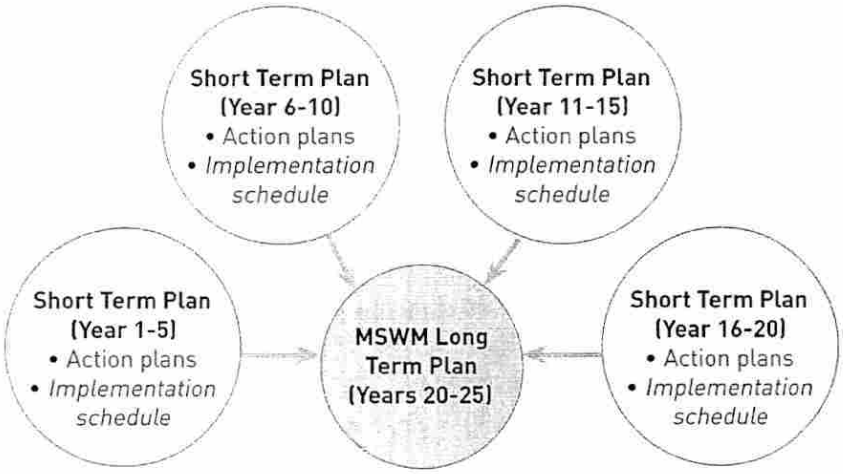
Figure 1.12: Step 5: Schedule for Implementation



The MSWM Plan should address short term (5 years) and long term planning periods (20-25 years). The short term plan should lead to the achievement of the long term plan. Each short term plan should be reviewed every 2-3 years, to ensure higher success of implementing all plan activities. Based on the identification of service levels to be achieved during the short term, a detailed time plan should be prepared for actions to be undertaken in each year. The implementation plan should also include a detailed estimate of required human resources and investments.

Short term (5 years) plans should contribute to the achievement of the long term plan

Figure 1.13: Components of the Municipal Solid Waste Management Plan



Long term (20–25 years) plan typically constitutes 4–5 short term planning cycles

The long term plan should be further drilled down to identify short term action plans associated with time lines for implementation. Each long term plan will typically consist of 4–5 short term planning cycles. Actions to be undertaken in each of these planning cycles should be clearly identified.

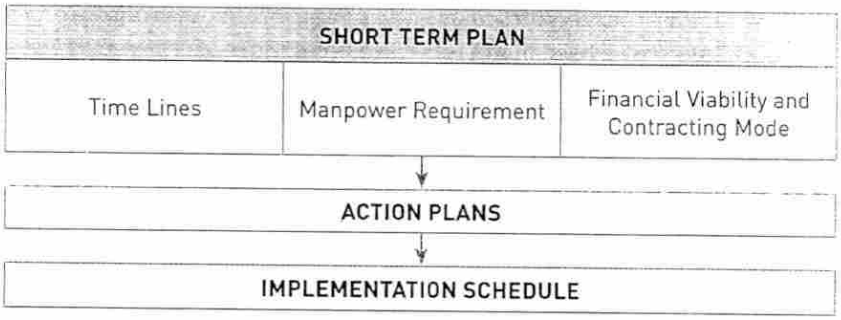
The five-year short term plan (Figure 1.14) may be broken up into specific action plans covering various aspects such as institutional

strengthening, community mobilisation, waste minimisation initiatives, waste collection and transportation, treatment and disposal, and other policy changes as may be deemed necessary. The financial outlay required for each action plan should be elaborated, and sources of finance ascertained in the planning phase. Financial planning also has a direct impact on the contracting mechanisms to be adopted.

Multiyear actions should be further elaborated yearly, with a cost attached to each year's implementation. Clear definition of the roles of various stakeholders and adequacy of requisite staffing should be ascertained.

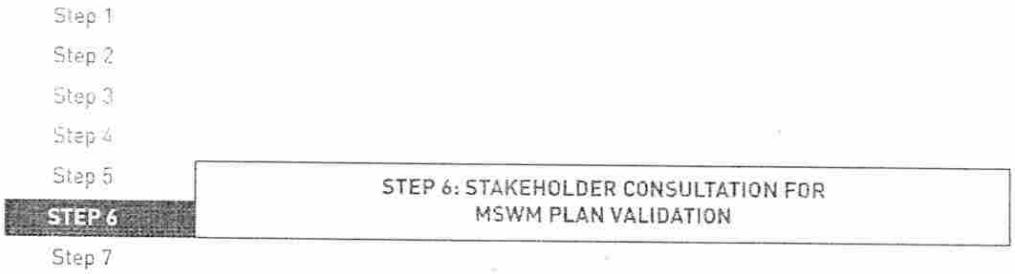
ULBs may need to enhance the technical capacity of MSWM staff to execute the MSWM plan in a financially viable and sustainable manner. A detailed yearly and equitable staffing capacity and training requirement should be prepared, and any identified gaps should be filled before action plan implementation.

Figure 1.14: Components of a Short term Plan



1.4.7 STEP 6: STAKEHOLDER CONSULTATION FOR MUNICIPAL SOLID WASTE MANAGEMENT PLAN VALIDATION

Figure 1.15: Step 6: Stakeholder Consultation for Municipal Solid Waste Management Plan Validation



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The draft MSWM plan, complete with action plans and an implementation schedule, is to be presented to and accepted by the stakeholder committee which provided inputs to the draft plan (Step 3 of the planning process).

Based on the feedback of the stakeholder team, further revisions to the plan may be required.



City council ratification of the MSWM plan, along with an agreed implementation schedule, is vital for future implementation

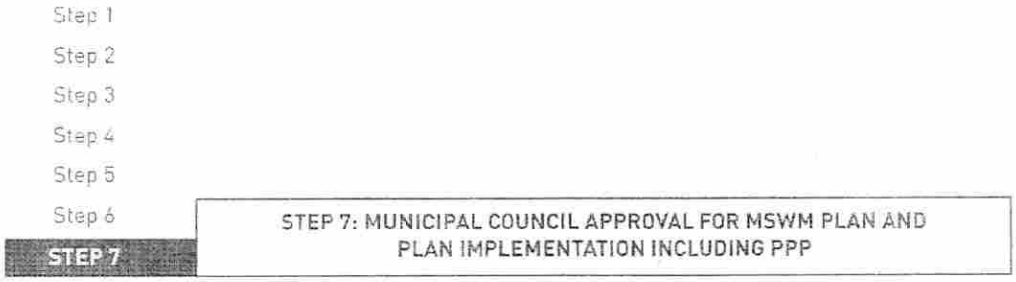
1.4.8 STEP 7: MUNICIPAL COUNCIL APPROVAL FOR MUNICIPAL SOLID WASTE MANAGEMENT PLAN AND PLAN IMPLEMENTATION INCLUDING PUBLIC PRIVATE PARTNERSHIP

After due consideration of the recommendations of the stakeholder committee, the revised plan is to be submitted to the city council of the ULB or equivalent body for its validation and adoption as an official plan.

The city council should concur with the provisions of the plan including proposed tariff and revenue collection mechanisms, modes of engagement of private sector, implications on existing and proposed municipal staff, and proposed locations of waste management facilities.

Changes to any of these elements of the plan would have larger implications on the viability of the plan and should be duly noted and addressed before finalisation of the plan. The final plan should be clearly communicated and presented to the council for final ratification.

Figure 1.16: Step 7 in Municipal Solid Waste Management Plan



Subsequent chapters give details of technical aspects required for developing and implementing an MSWM plan. Further details of plan implementation and monitoring of service provision are detailed in Chapter 5 and Chapter 6.

2012

1.4.9 ACTION POINTS FOR AWARENESS GENERATION THROUGH INFORMATION, EDUCATION, AND COMMUNICATION ACTIVITIES FOR MUNICIPAL SOLID WASTE MANAGEMENT PLAN IMPLEMENTATION BY THE URBAN LOCAL BODY

Stakeholders include households, businesses, industries, informal sector, the local government, NGOs, CBOs, SHGs, women's groups, school and college students, and members of other relevant institutions

Citizen's involvement in MSWM plan preparation through a formalised stakeholder committee is necessary. Ensuring community participation can be done through:

- willingness of stakeholders to cooperate in the operation and management of MSWM services;
- awareness on the type of service and frequency;
- knowledge of source segregation (number of waste fractions, issues of collection of recyclables, reuse, etc.);
- awareness of final treatment and disposal information;
- inclusion of different sections of society such as rag pickers, municipal workers, and entrepreneurs; and
- dissemination of information on service charges or user fees, the mode of payment, and the frequency of payment.

2013

2014

2

Technical Aspects: Segregation, Collection and Transportation

2016

IN THIS SECTION

2.1	Waste Minimisation (At Source Reduction and Reuse)	127
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2. TECHNICAL ASPECTS: SEGREGATION, COLLECTION AND TRANSPORTATION

2.1 WASTE MINIMISATION (AT SOURCE REDUCTION AND REUSE)

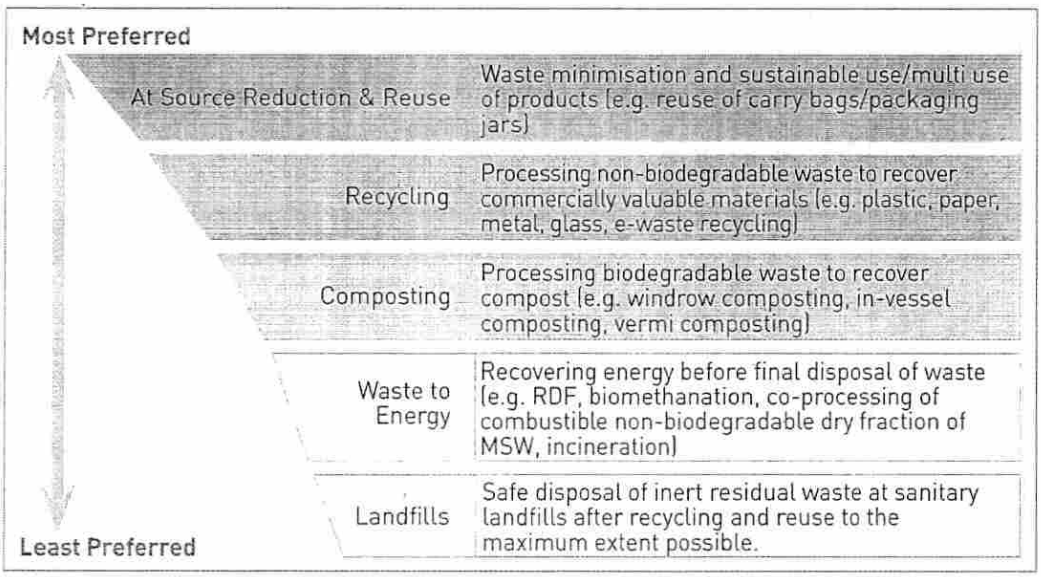
2.1.1 SOLID WASTE MANAGEMENT RULES, 2016 - REQUIREMENTS ON WASTE MINIMISATION

As per the SWM Rules, 2016, the ULB should create public awareness for minimising waste generation and reusing waste to the extent possible. Source reduction is the most preferred tier in the ISWM hierarchy because of its potential to directly reduce the quantity of waste generated and hence reduce associated financial and environmental costs.

2.1.2 WASTE MINIMISATION IN INTEGRATED SOLID WASTE MANAGEMENT HIERARCHY

The ISWM (Integrated Solid Waste Management) hierarchy of waste management prioritises waste minimisation (reduction at source and reuse) as the most preferred waste management strategy (Figure 2.1).

Figure 2.1: Waste Minimisation in the ISWM Waste Hierarchy[1]



Waste minimisation results in reducing the amount and toxicity of the wastes produced. Minimisation is the most preferred waste management strategy in the hierarchy as it reduces the quantity of waste to be handled, the cost associated with its handling, and its environmental impacts.

Waste minimisation includes activities that reduce waste generated as a result of product creation and use. It also encompasses those activities that increase product durability, reusability and reparability

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

2018

2.1.3 NEED FOR AND BENEFITS OF WASTE MINIMISATION

Of the 1,43,449 tonnes per day (TPD)[2] of MSW generated in 2014–2016 in India, 40%–60% is organic and 10%–20% recyclable. The associated cost for processing and disposing is 80%[3]. This is assuming that 20% is recycled and does not enter the MSW stream to be processed. This waste, at an average cost of Rs. 1,000 per tonne, is approximately Rs. 10.7 crore per day. Waste minimisation results in savings, which accrue through avoided collection, treatment, and disposal costs.

Reduction in the use of environmental and material resources accrues as a result of waste minimisation programmes. In addition, the rapidly decreasing land bank in urban areas, rising costs of procuring land for processing and disposal, and associated environmental impacts are all significant reasons to promote waste minimisation. Disposal of waste results in large scale emissions of greenhouse gases like methane and carbon dioxide. Waste minimisation would lead to a reduction in greenhouse gas emissions and associated climate change impacts.

2.1.4 STRATEGIES FOR WASTE MINIMISATION

Waste minimisation strategies require policy interventions at the National, State and local level, depending on the type of the intervention and the scale at which the intervention needs to be initiated for effective implementation. For example introduction of the national deposit system on beverage packaging, buy-back mechanisms for reusable or recyclable packaging material, promoting the use of refill containers etc. Initiatives which require a behaviour change in the community need to be supported by consistent awareness programmes.

2.1.4.1 WASTE MINIMISATION STRATEGIES REQUIRING A NATIONAL OR STATE LEVEL DIRECTIVE

Source reduction could include various strategies such as EPR, tax incentives and eco-labelling. Establishment of eco industrial parks with adequate emphasis on recycling industries can support source reduction

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 hazardous waste components like e-waste), reuse (e.g., deposit–refund systems for bottles), recycling (e.g., for used cars), and storage and treatment (e.g., for batteries). EPR programmes require a national or state level directive. They are commonly made mandatory through legislation, but can also be adopted voluntarily (i.e., retail take-back programmes).

2 Status report on MSWM (2014-15).
3 This is assuming that 20% is recycled and does not enter the MSW stream to be processed.

2019

The advantages of EPR systems include:

- reduction in natural resource demands of packaging and product containers;
- creation of incentives for environmentally friendly product designs;
- reduction in waste disposal costs for ULBs;
- provision of a monetary incentive to the consumer to return the product or package; and
- creation of infrastructure for collection and recycling of material.

EPR is currently practised for waste fractions generating from electronics, batteries, packaging, and consumer durables (e.g., home appliances, electronics, and home and office furniture) for their appropriate and safe disposal. EPR policies are usually legislated at state and national levels.

Typical EPR tools include:

- Deposit refund systems
- Quotas
- Product bans
- Product charges
- Collection systems

Typical EPR Tools[4]

Deposit–refund systems. These are required in the beverage container deposit legislation or "bottle bills". Producers charge the consumers an additional disposal fee, which is refunded upon receiving the used container. In the beverage industry, the manufacturers collect from the consumers used glass bottles and aluminium cans (e.g., soft drink cans and glass bottles and large mineral water containers) and refund the deposit. The manufacturers also take back lead acid batteries through the deposit–refund system. In 2003, Germany introduced a mandatory deposit–refund system for certain one-way beverage packaging, which is defined as ecologically disadvantageous, to discourage this packing in the market.

- **Quotas**. Government authorities stipulate that a certain percentage of product content or packaging should be from recycled material. For instance, Germany has set a requirement in its previous packaging ordinance that 72% of beer and soft drink containers should be refillable. If the quota is not achieved, a mandatory deposit system will be enforced. Through an amendment of the ordinance, most beverage one-way containers are subject to the mandatory deposit system.
- **Product bans**. The threat of product bans motivates producers to phase out undesirable materials, design for recyclability, and ensure high rates of reuse or recycling. For example: In Sweden, the voluntary deposit system for aluminium cans results in achieving the government mandated recycling rate. The driver behind Sweden's successful voluntary deposit system for aluminium cans is the "can ban" that may ensue if the rates fall below the recycling rate set by government.
- **Product charges**. Product charges influence the choice of materials used. An eco-tax levied on polyvinyl chloride (PVC) in Belgium increased the cost and reduced consumption of this polymer.

"Godrej" has a 'No Packaging Policy' for refrigerators'. The company ensures that the packaging, in which the appliance is delivered, is taken back by the supplier and reused

4 "Extended Producer Responsibility: Container Deposit Legislation Report", Zero Waste New Zealand (2002). http://www.zerowaste.co.nz/assets/Reports/Beveragecontainers.pdf

2020

- **Collection systems**. Producers and the retail trade can be made responsible for taking back packages and used products such as batteries and compact fluorescent lamps (CFLs). Germany, in 1991, adopted the first packaging ordinance which makes industry responsible for collecting packages.

In India, the informal sector (kabadi system or scrap dealer) is largely involved in collection of recyclables and material recovery. EPR initiatives, which encourage informal sector participation in collection of recyclables from consumers, benefit from the increased collection efficiency that this sector is able to achieve, which may then result in lower supply chain costs (collection costs).

Additionally, the National or State Government can promote initiatives which would encourage adoption of waste minimisation oriented practices:

- Promotion of voluntary action by encouraging business groups to reduce volumes of packaging, while maintaining the requisite strength.
- Authorising urban local bodies to frame rules and local bye-laws and enact local ordinances banning use or sale of certain types of products and packaging that cannot be reused, repaired, recycled, or composted. National or State level legal frame work and policy should also mirror such ordinances, to better enable local authorities to enforce such ordinances, laws and rules.
- Develop eco-labeling standards based on potential for waste reduction due to product packaging and potential for recycling and reuse.
- Promote development of eco-industrial parks, which are industrial areas where in material and resource exchange synergies, are established between businesses and industries. Such parks might operate facilities for recycling and product reuse processes.

Shimla City was able to effectively enforce a full ban on plastic carry bags only when the Government of Himachal Pradesh passed a legislation on banning their use. The state government has also enforced a ban on non-biodegradable packaging for 25 kinds of edible foodstuff, forcing perishable food manufacturers to adopt biodegradable packaging.

2021

2.1.4.2 WASTE MINIMISATION INITIATIVES REQUIRING URBAN LOCAL BODIES SUPPORT

- Promoting and implementing awareness and education programmes addressing different stakeholders e.g., residential, commercial and industrial educational programmes that increase public awareness and participation, in at source reduction programmes.
- Developing and promoting at source reduction programmes in the community, e.g. domestic composting programmes that reduce the volume of food waste, leaves and garden trimmings entering the collection system.
- Campaigns for reducing the use of specific non-recyclable, non-reusable or toxic material. Practicing and promoting material substitution where possible. (Promoting the use of rechargeable batteries instead of single use batteries)
- Bans within local authorities' jurisdiction (see also National or State level initiatives above) through replacing disposable materials and products with recyclables and reusable materials and products (e.g. banning the use of plastic bags).
- Green procurement and take back programmes, whereby the suppliers of a product to the municipality are responsible for providing a take back programme and to promote the recycling of e.g. computer monitors, auto oil, batteries, paper etc. Procurement programmes in the government and businesses should be designed to give preference to recyclable products.
- Local businesses should be encouraged to reward consumers for returning recyclable products or products which are toxic (e.g. batteries). EPR programmes by manufacturers are a pre-requisite to these initiatives. (see Section 2.1.4.1 of Part II).
- Educational and on-site business and industry assistance programmes should be promoted that advise businesses on how to use materials more efficiently and reduce waste generation.

Examples of Onsite Business Assistance Programmes

- Reducing office paper waste by making training manuals and personnel information available electronically and by implementing a formal policy to print double sided for all draft reports and, if possible, all final documents.
- Improving product design to use less material.
- Redesigning packaging to eliminate excess material while maintaining strength.
- Working with customers to design and implement a packaging return programme .
- Switching to reusable transport containers.
- Purchasing products in bulk

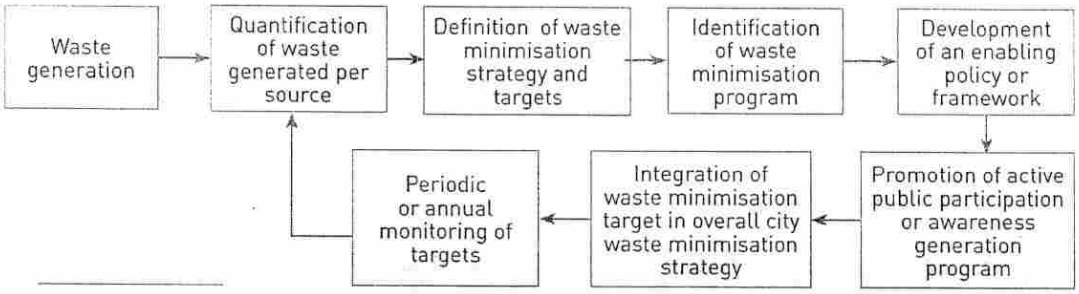
- Supermarkets and retail stores are often some of the most effective partners for a municipal waste minimisation programme. These provide a central & consistent point for consumer education, packaging reduction projects and collection centers for recyclable waste.
- Promoting materials exchange and reuse programmes that divert material from the waste streams which will eventually go to the landfills, e.g., programmes which link sellers of used furniture with potential second hand furniture buyers.
- Establishing incentives for at-source reduction through the principle of "pay as you throw", supported by bye-laws. Urban local bodies can collect variable solid waste management charges, based on the quantities being disposed per household and establishments. Variable rates can be fixed for pre-defined ranges of waste quantities, progressively increasing with waste generation rates. This would also imply that the ULB has the resources to record waste generation quantities. This system will function successfully only if the progressively increasing tariff is restrictive enough to prevent waste generation.

In many international communities, household waste disposal fee is directly proportional to the quantity of waste disposed, helping achieve segregation at source

2.1.5 DEVELOPING A WASTE MINIMISATION PROGRAMME IN URBAN LOCAL BODIES

Waste minimisation programmes should be spearheaded by ULBs, not only to ascertain a cohesive and coordinated approach, but also to ensure that the requisite backward linkages (e.g., segregated collection of recyclables) and forward linkages (e.g., market linkages for recycling and reuse) are developed along the material supply chain to support re-processing of material, which would otherwise enter the municipal waste stream. Recycling industries, EPR initiatives, and various other initiatives including local businesses are critical to the success of these programmes. Planning for waste minimisation programmes should be a part of the overall municipal solid waste management (MSWM) planning process as described in detail in Section 1.2 of Part II. The typical process for developing a waste minimisation programme (Figure 2.2) requires the ULBs to do the following:

Figure 2.2: Developing a Waste Minimisation Programme[5]



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

2023

- Identify and quantify main contributors to the waste problem. Local waste information data system is required.
- Define sectoral waste minimisation potentials and targets (residential waste, organic market waste, institutional waste, MSW from business establishments and hospitals, etc.).
- Identification or adoption of programmes targeted at producers and generators. Programmes should be well-defined, considering viable and efficient collection and recycling systems, and supported with required municipal bye-laws to ensure implementation.
- Develop an institutional mechanism with all relevant stakeholders to facilitate implementation. Identification and registration of scrap dealers and recyclers is a pre-requisite to assess the viability and sufficiency of recycling facilities in the ULB.
- Examine environmental and health-related issues when assessing the suitability of recycling facilities in close coordination with the State Pollution Control Board (SPCB) committees.
- Assess the capacity to implement the programme and seek external expertise if required.
- Promote active awareness raising campaigns, advertising the targets, programmes, and modes of involvement of stakeholders. Targeting school children and women groups and actively engaging with the business community are essential.
- Integrating waste minimisation targets in the overall waste management strategy of the city.
- Monitor periodically the midterm targets and ensure an annual review of targets and achievements. Review stakeholder responsibilities and strengthen institutional arrangements.

2.1.6 ENSURING FEASIBILITY OF WASTE MINIMISATION PROGRAMMES

Waste minimisation programmes should always be supported by expertise (either in-house or contractual), institutional mechanisms, market linkages, access to robust recycling technologies, as well as regulatory and penal provisions, if needed. Actively involving all stakeholders right from the target setting and planning process is a prerequisite for implementing waste minimisation initiatives. Involvement of the state government to pass certain ordinances may also be required, depending on the nature of the programme. A strong local leadership, like the ward councillor or a local champion, is usually the driving force behind the success of such initiatives.



For a successful waste minimisation programme, technical expertise, institutional mechanisms, market linkages and regulatory and penal provisions are pre-requisites

2024

2.2 SOURCE SEGREGATION

BASIC waste segregation:
- Wet waste (kitchen waste)
- Dry waste (recyclables)
- Domestic hazardous waste

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. Indirectly, source segregation also impacts climate change and has many other advantages which are discussed in the section below.

2.2.1 SOLID WASTE MANAGEMENT RULES, 2016 - REQUIREMENTS ON SOURCE SEGREGATION

As per the SWM Rules, 2016:

Clause 4 Duties of waste generators:-

(1) Every waste generator shall-

(a) segregate and store the waste generated by them in three separate streams namely bio-degradable, non bio- degradable and domestic hazardous wastes in suitable bins and handover segregated wastes to authorised waste pickers or waste collectors as per the direction or notification by the local authorities from time to time;

(b) wrap securely the used sanitary waste like diapers, sanitary pads etc., in the pouches provided by the manufacturers or brand owners of these products or in a suitable wrapping material as instructed by the local authorities and shall place the same in the bin meant for dry waste or non- bio-degradable waste;

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

(d) store horticulture waste and garden waste generated from his premises separately in his own premises and dispose of as per the directions of the local body from time to time.

(2) No waste generator shall throw, burn or burry the solid waste generated by him, on streets, open public spaces outside his premises or in the drain or water bodies.

(3) All waste generators shall pay such user fee for solid waste management, as specified in the bye-laws of the local bodies.

(4) No person shall organise an event or gathering of more than one hundred persons at any unlicensed place without intimating the local body, at least three working days in advance and such person or the organiser of such event shall ensure segregation of waste at source and handing over of segregated waste to waste collector or agency as specified by the local body.

(5) Every street vendor shall 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 shall deposit such waste at waste storage depot or container or vehicle as notified by the local body.

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

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

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

2026

Clause 15 Duties and responsibilities of local authorities:-

(b) arrange for door to door collection of segregated solid waste from all households including slums and informal settlements, commercial, institutional and other non residential premises. From multi-storage buildings, large commercial complexes, malls, housing complexes, etc., this may be collected from the entry gate or any other designated location;

(g) direct waste generators not to litter i.e throw or dispose of any waste such as paper, water bottles, liquor bottles, soft drink canes, tetra packs, fruit peel, wrappers, etc., or burn or burry waste on streets, open public spaces, drains, waste bodies and to segregate the waste at source as prescribed under these rules and hand over the segregated waste to authorised the waste pickers or waste collectors authorised by the local body;

(h) 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; Bins for storage of bio-degradable wastes shall be painted green, those for storage of recyclable wastes shall be printed white and those for storage of other wastes shall be printed black;

(i) establish waste deposition centres for domestic hazardous waste and give direction for waste generators to deposit domestic hazardous wastes at this centre for its safe disposal. Such facility shall be established in a city or town in a manner that one centre is set up for the area of twenty square kilometers or part thereof and notify the timings of receiving domestic hazardous waste at such centres;

(k) direct street sweepers not to burn tree leaves collected from street sweeping and store them separately and handover to the waste collectors or agency authorised by local body;

(m)collect waste from vegetable, fruit, flower, meat, poultry and fish market on day to day basis and promote setting up of decentralised compost plant or biomethanation plant at suitable locations in the markets or in the vicinity of markets ensuring hygienic conditions;

(n) collect separately waste from sweeping of streets, lanes and by-lanes daily, or on alternate days or twice a week depending on the density of population, commercial activity and local situation;

(p) collect horticulture, parks and garden waste separately and process in the parks and gardens, as far as possible;

(ze) ensure that provisions for setting up of centers for collection, segregation and storage of segregated wastes, are incorporated in building plan while granting approval of building plan of a group housing society or market complex; and

Clause 15 1(2.b) Storage of segregated solid waste at source:-

(zg) create public awareness through information, education and communication campaign and educate the waste generators on the following; namely:-

(iv) practice segregation of waste into bio–degradable, non-biodegradable (recyclable and combustible), sanitary waste and domestic hazardous wastes at source;

(vi) wrap securely used sanitary waste as and when generated in the pouches provided by the brand owners or a suitable wrapping as prescribed by the local body and place the same in the bin meant for non- biodegradable waste;

(vii) storage of segregated waste at source in different bins;

(viii) handover segregated waste to waste pickers, waste collectors, recyclers or waste collection agencies;

ULBs should ensure that source segregated waste is collected and also transported separately

2.2.1.1 SEGREGATION OF MUNICIPAL SOLID WASTE AT SOURCE

As directed by SWM Rules, 2016:

Clause 4 1) Duties of waste generators-every waste generator shall:-

a) segregate and store the waste generated by them in three separate streams namely bio-degradable, non -biodegradable and domestic hazardous wastes in suitable bins and handover segregated wastes to authorised waste pickers or waste collectors as per the direction or notification by the local authorities from time to time;

b) wrap securely the used sanitary waste like diapers, sanitary pads etc., in the pouches provided by the manufacturers or brand owners of these products or in a suitable wrapping material as instructed by the local authorities and shall place the same in the bin meant for dry waste or non- bio-degradable waste.

After achieving BASIC segregation, ULBs should aim to move toward BASIC+ segregation

Clause 15 Duties and responsibilities of local authorities:-

i) establish waste deposition centres for domestic hazardous waste and give direction for waste generators to deposit domestic hazardous wastes at this centre for its safe disposal. Such facility shall be established in a city or town in a manner that one centre is set up for the area of twenty square kilometers or part thereof and notify the timings of receiving domestic hazardous waste at such centres.

Clause 17 Duty of manufacturers or brand owners of disposal products and sanitary pads and diapers:-

(3) Manufacturers or brand owners or marketing companies of sanitary napkins and diapers shall 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.

(4) All such manufacturers, brand owners or marketing companies shall educate the masses for wrapping and disposal of their products.

As per biomedical rules, 2016, biomedical waste generated in households during healthcare activities shall be segregated as per these rules and handed over in separate bags or containers to municipal waste collectors. Urban Local Bodies shall have tie up with the common bio-medical waste treatment and disposal facility to pickup this waste from the Material recovery facility (MRF) or from the house hold directly, for final disposal in the manner as prescribed in Schedule I part 2 of the Biomedical Waste Rules, 2016.

Waste should be stored at the source of waste generation until it is collected for disposal by ULB staff or appointed contractors. It is essential to segregate wastes into wet (kitchen waste); dry (recyclables and other waste); and domestic hazardous waste (CFL, tube light, etc.). This is commonly referred to as BASIC segregation. Segregation of MSW needs to be linked to primary collection of waste from the doorstep and given high priority by the ULBs. Unless door-to-door collection of segregated waste and transportation of segregated waste is practiced by the ULBs, source segregation by waste generators will not be successful and remain a meaningless exercise.

The local community should be educated and encouraged to perform the following actions to ensure collection of segregated waste:

- At the household level, MSW should be segregated into wet, dry, and domestic hazardous waste fractions, at a minimum, and stored in separate containers.
- Waste should be placed at the doorstep before the appointed time of collection.
- Domestic hazardous waste (e.g., batteries; used CFLs; tube lights; chemical, paint, and insecticide containers; etc.) should be handed over separately to the waste collectors or at the domestic hazardous waste deposition centers for safe disposal as specified by the municipal authority or through the relevant retail trade (e.g., for batteries).

2029

- Sanitary waste (e.g., diapers, sanitary napkins, tampons, incontinence sheets and any other similar waste) should be wrapped securely in the pouches and handed over separately to the waste collectors on a daily basis. Upon collection of sanitary waste, it is should be preferably disposed in biomedical or MSW incinerators, as applicable to the local context or as directed by the SPCB.
- However, for efficient collection and disposal of sanitary waste, it should be wrapped in the pouch provided by the manufacturer and put in separate bags and handed over separately on daily basis to the waste collector in order to minimise the manual handling of sanitary waste. Once collected separately, it should be sent either directly to the biomedical waste incineration facility or to Material Recovery Facility (MRF) for collection and then sending to the biomedical waste incinerator when sufficient quantities are collected, as per the arrangement of the city.

The Bruhat Bangalore Mahanagara Palike (BBMP) has set up domestic sanitary waste collection centres in 22 wards, where citizens may deliver such waste marked with a red cross to enable further segregation in addition to other dry recyclable waste. The collected waste is then sent for disposal in municipal sanitary landfills or biomedical or MSW incinerators.

Corporation of Panaji collects the sanitary waste in yellow plastic bags, separately and on a daily basis and sends them to the material recovery facility. When sanitary waste is collected in sufficient volumes at the material recovery facility, it is sent to the biomedical waste incinerator at the Goa Medical College.

Duties of Municipal Authorities:

1. Ensure primary and secondary collection and transportation of segregated waste streams consisting of at least three fractions (wet, dry, and domestic hazardous wastes). These wastes should not be mixed during collection and transportation.
2. Segregate wastes further (BASIC+segregation) once three-bin segregation is achieved (Table 2.1).
3. Establish collection systems (e.g., community pick-up points or delivery systems through the retail trade) for domestic hazardous waste and special waste. Wastes may be collected from these facilities once in 15 days or as found appropriate by the ULB.
4. Ensure that domestic hazardous waste and special waste are handled as directed by the State Pollution Control Board or committees.

2030

Table 2.1: Indicative List for Segregation of Household Wastes[6]

BASIC SEGREGATION					
Wet waste (green bin)	**Dry waste (Blue bin)**				**Domestic Hazardous[7]**
	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)

6 Adapted from Manual on Municipal Solid Waste Management (First Edition), Central Public Health and Environmental Engineering Organisation (CPHEEO), 2000, Ministry of Urban Development.

7 To be stored and disposed separately.

2031

A Journey Towards a Successful Waste Management System Leading to a Landfill-less City

Location: Panaji

Year of Start: 2003

Main Players: Corporation of the City of Panaji (CCP), school and college staff and students, resident welfare associations (RWAs), local leaders and celebrities

Approach: Panaji, the capital of Goa, is a city with a strong cultural heritage. Apart from being a popular tourist destination, it is also an administrative centre and commercial hub for the state. Under the strong political will and administrative leadership of the Municipal Commissioner, a comprehensive city revitalisation campaign was launched to improve sanitary conditions and solid waste management (SWM). The "Bin Free in 2003" campaign was part of the "Together for Panjim" initiative. Under this initiative, the following strategies were adopted to significantly improve the SWM system.

Technical Strategy:

- Community bins were substituted by trolley bins as an intermediate stage of transfer.
- Modifications were made in the hydraulic arm of the garbage trucks to enable transfer of waste from the trolley bin into the truck without manual intervention.
- Segregation at source was initially introduced as wet and dry segregation (two bins). As of 2015, source segregation is undertaken in eight clear waste streams (wet, paper, plastic bags, metals or glass, non-recyclable, tetrapacks, cardboard, and plastic bottles) with designated colour coding for the waste fractions.
- Household bins with screw on lids were designed to prevent spillage of garbage by stray animals when households keep waste outside for collection.
- Material recycling stations were established within colonies for further segregation of dry waste.
- Decentralised composting units were constructed for converting wet waste into manure for community usage. Hotels were also asked to install decentralised composting units in their premises.
- Tie-ups were made with various recycling units for selling bulk segregated wastes.
- Extended producer responsibility (EPR) initiatives were adopted through innovative measures like
  - tie-ups with local dairies for paying residents a specified amount for returning washed empty plastic milk bags at the local dairy booths; and
  - tie-up with Tetra Pak (company) for buyback of empty tetrapacks.
- Co-processing of plastics and other dry fraction rejects in the cement industry:
- Two baling machines (1 ft x 1 ft and 1 m x 1 m) for bailing dry fractions or plastic waste for different cement plants were designed. Bailed waste was sent to four different cement plants, 250 km–600 km from the CCP, for co-processing.
- Hazardous wastes like batteries and tube lights were segregated and, once sufficient quantities were obtained, transported to the treatment, storage, and disposal facility (TSDF) in Karnataka.



Segregation of dry waste into 8 streams



Composting units in housing societies

- E-waste and thermocol were collected separately, but currently no tie-ups exist between them.

Institutional Strategy:

- A SWM cell was formed in the CCP, headed by a Waste Management Officer.
- The field services were headed by a Sanitary Inspector who was in charge of 15 supervisors to oversee the waste collection and transportation of each zone.
- Intensive monitoring was carried out by the corporation staff.
- Centralised complaint redressal system was established with a 24-hour helpline to clear any uncollected or unattended garbage. Quick response vehicle was designated for the purpose.
- Adequate health and safety measures were provided to the sanitary workers.

Public Communication Strategy:

- To initiate the segregation process at the household level, green and black bins were provided to the residents at subsidised rates.



Segregated transport

- For increasing community participation in this drive, the Municipal Commissioner and the Waste Management Officer organised meetings to disseminate the details of

the management system, its functioning, and the segregation of waste at household level.

- As part of the campaign, cultural programmes like music festivals, fairs, and carnivals were held with a theme and message of civic hygiene and responsibilities of citizens toward maintaining cleanliness in the city.
- Involvement of schools and colleges in the campaigns were promoted.
- Waste management was introduced to children from primary school onward, and children learned the different colour codes for segregation in school.

Financial Strategy:

- User charges were introduced by the CCP and collected by the supervisors. Maintaining the ward-wise accounts, the supervisors were responsible for payment of cash incentives to the collection and transportation workers and for depositing the surplus amount.
- Other revenue sources were
  - sale of compost;
  - sale of segregated waste for recycling like plastic bottles, cardboard boxes, etc.; and
- EPR initiatives, e.g., with Tetra Pak.
- Costs were incurred by the CCP for bailing and transporting waste for co-processing to cement plants. This acted as an incentive for increasing recycling tie-ups with other players in the market.

Outcome:

- Collection of segregated waste from the households was 100%, and waste was further sorted into eight waste streams at the recycling stations.
- Ragpickers, women volunteers, and self-help groups (SHGs) were actively involved in streamlining the waste management system.
- Segregated waste was transported to the recycling units and compost units for further processing.
- Recycling efficiency improved through market creation and tie-ups for PET bottles, plastic bags, etc.
- Waste to landfill was minimised through effective management by co-processing waste fractions and sending hazardous waste to TSDF.

Success Factors:

- The vision for the city was clear, and there was a strong and stable leadership.
- Institutional and managerial models were established within the CCP.
- Technical innovations were designed for segregation, minimal manual handling of waste, co-processing, EPR, and tie-ups.
- Intensive campaigning and meetings with RWAs on the overall concept of source segregation were promoted. Youth, local celebrities, corporation staff, and communities were actively involved in awareness generation activities. The waste segregation system was integrated in the curricula from primary level onward.

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Overall Sustainability:

The expenditure on the solid waste programme has been managed entirely from the CCP's own sources. Collection of user charges and the various recycling initiatives have resulted in the financial sustainability of the project. The cash incentive scheme for the workers has ensured the programme is running on the ground. And surplus fund is deposited into the CCP's account for later use or innovation.

Source: CCP

Source Segregation of Municipal Solid Waste and its Institutionalisation at Kochi

Year of Start: 2007

Main Players: Corporation of Cochin (CoC), resident welfare associations (RWAs), ward committees, Kudumbashree, Confederation of Real Estate Developers' Associations of India (CREDAI), Rotary Club of Cochin, and other community-based organisations (CBOs) and non-government organisations (NGOs)

Approach: In 2002, the CoC, based on an earlier pilot initiative, decided to scale up source waste segregation and door-to-door collection initiatives as part of an integral solid waste management (SWM) strategy. The CoC initiated a citywide process of source segregation at the ground level as a joint initiative with community representatives, Kudumbashree, RWAs, NGOs, and CREDAI. To achieve source segregation, the following integrated approaches were adopted—institutional; managerial; legal; financial; and information, education, and communication (IEC) initiatives or improvements.

Institutional:

- Ward-level sanitation committees were formed with the respective Ward Councilor as Chairman; Junior Health Inspector; and the representatives of RWAs, Kudumbashree, CREDAI, NGOs, etc. as members for each ward.
- Health and safety measures were provided partially to the sanitation workers.
- CoC provided two different color bins free to all households—green (wet waste) bin of 15 liter (l) capacity and white (dry waste) bin of 10 l capacity.
- CoC provided three wheeler cycles or pushcarts and auto rickshaws to the wards for door-to-door collection.
- CoC provided trucks and regular workers for onward transporting of MSW at the ward level collection.

Managerial:

- Out of 74 wards, 15 wards were served by Kudumbashree (self-help groups [SHGs] of women) and the remaining 59 wards by contracted workers of the RWAs, NGOs, and CREDAI (serving in high-rise apartments registered under CREDAI).
- CoC's regular sanitary workers were also involved.

Legal:

- CoC passed bye-laws in 2008 to make segregation mandatory and a stringent penal

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provision in case households did not provide segregated waste to the waste collectors.

- Initially, a patrolling system was designed to monitor illegal dumping, collection, and transportation of waste. The monitoring was done in shifts, and a spot fine of Rs250–Rs10,000 was charged, depending on the quantity and quality of waste found during illegal dumping.
- CoC also levied fines on transportation contractors for not transporting segregated waste from households(HHs).

Financial:

- CoC introduced user charges of Rs30–Rs80 per household and Rs100–Rs200 per commercial establishment.

Information, Education, and Communication:

- Members of the ward-level sanitation committees organised the meetings with residents and interacted with communities regarding the concept and importance of segregation.
- Simultaneously, under IEC and awareness generation activities among citizens, CoC published various brochures and pamphlets and involved print and electronic media for disseminating information on segregation at household level.

Outcome:

- Collection of segregated waste (wet and dry) from households was 80%.
- The collection system as developed by RWAs, ward-level committees, Kudumbashree, and CREDAI integrated ragpickers on contractual basis as waste collectors.
- Door-to-door collection and source segregation ultimately led to a bin-free city and reduced the amount of waste to landfill.
- Segregated waste was transported to the processing plant.

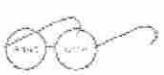
Success Factors:

- Institutional and managerial models were established.
- Intensive interactive meetings on the overall concept of segregation with residents and citizens of wards were held by the ward council, corporation officials, councilors, and the representatives of NGOs and sanitation committees.
- Effective community participation to adapt to the new system was ensured.
- Communication tools were developed and disseminated regularly to the communities.
- Educational institutions, NGOs, and local celebrities were actively involved in awareness generation activities.

Overall Sustainability:

It is a self-sustainable working model with no direct financial involvement in the municipal budget except for provision of physical infrastructure like handcarts and operation and maintenance (O&M) of transportation system. The collection system is completely managed by the RWAs, CREDAI, and Kudumbashree. User charges are collected directly by the door-to-door waste collectors and are used for funding the salary of the workers. The collection and segregation system in Kochi has been self-sustaining since its inception in 2007.

Source: CoC



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2.2.1.2 STORAGE OF MUNICIPAL SOLID WASTE AT SOURCE

2.2.1.2.1 Household-level Storage of Segregated Waste

3 differently coloured bins, each per household are recommended to promote and ensure segregation:

- Covered Green Bin: Wet waste
- Covered White Bin: Dry waste
- Covered Black Bin: Domestic Hazardous Waste

At the household level, dry waste, wet waste, and domestic hazardous waste should be stored in separate garbage bins, of appropriate capacity and colour (Figure 2.3). The colour of the garbage bins should be in accordance with the SWM Rules, 2016; wet waste is to be placed in a covered green bin and dry waste in a covered white bin. Because the rule does not specify the colour of the bins for storage of domestic hazardous waste, urban local bodies (ULBs) should decide on an appropriately coloured bin. For example, Coimbatore City Municipal Corporation uses red bins for collection of domestic hazardous waste. Capacity of bins depends on frequency of collection (daily, alternate day, or on demand) and quantity of waste generated.

A container of 12–15l (0.015 m^3) capacity for a family of five members should be adequate for each dry and wet waste, if collection takes place daily. However, a household may keep larger containers or more than one container for waste produced in 24 hours, having a spare capacity of 100% to meet unforeseen delays in clearance or unforeseen extra loads. If dry waste is not collected daily, container capacity has to be enlarged accordingly. Wet waste collection bins should be washed by the household each time they are emptied. It is not desirable to use plastic bags in waste bins.

In large apartment complexes and multistoried buildings, gated communities large waste collection bins for wet waste and dry waste should be placed at a convenient location. Residents should deposit segregated waste in the respective bins either themselves or through organised door-to-door collection system of the resident welfare association (RWA) or community-based organisation (CBO). Specification of bins and containers shall be compatible with primary collection vehicles, if applicable.

Number and capacity of bins required depends on the quantity of waste to be stored before collection, plus an additional 100% storage to avoid spillage in case of collection delays

Typical specifications for garbage bins used in apartment complexes and large buildings are the following: 60l (25kg) bins suitable for 12 households, 120l (50kg) bins for 24 households, 240l (96 kg) bins for 48 households, etc. that are of standard quality, high-density polyethylene (HDPE), injection or roto molded, ultraviolet (UV) tested, durable and could withstand rough handling, and compatible with lifting mechanism on primary collection vehicle, if applicable. The specific size of the containers depends on the number of connected households and the frequency of collection.



Figure 2.3: Bins for Collection of Dry, Wet and Domestic Hazardous Waste at Household[8]



2.2.1.2.2 On-site Storage of Bulk Wastes

"Bulk Waste Generator" means and includes buildings occupied by the Central government departments or undertakings, State government departments or undertakings, local bodies, public sector undertakings or private companies, hospitals, nursing homes, schools, colleges, universities, other educational institutions, hostels, hotels, commercial establishments, markets, places of worship, stadia and sports complexes having an average waste generation rate exceeding 100kg per day; the ULB may define the per day quantum of waste per generator that would classify as bulk waste. Shops, commercial establishments, and businesses should store segregated waste on-site. Whereas vegetable and flower market waste generators should deposit their waste in conveniently located large green bins for preferable utilization of waste on site or as directed by ULB. Number and capacity of bins required may be computed by considering quantity of waste to be stored before collection plus an additional 100% storage. Storage bins should be compatible with the primary collection system to avoid multiple handling of waste.

Typically, four-wheeled, HDPE, injection or roto molded, international standard, UV tested bins or metal bins of different capacities—e.g., for 240 l (96 kg), 600 l (270–280 kg), 770 l (315–350 kg), 1,100 l (449–495 kg)—may be used for bulk waste. These bins should be compatible with auto lifting by standard universal bin lifting devices on mobile compactors and other vehicles.

Bins should be compatible with the collection system to avoid multiple handling

8 "Panjim's Initiatives in Solid Waste Management", Rodrigues, S. (2013). Available at:http://iipnetwork.org/Rodriguez_Towards-Green-Trash)

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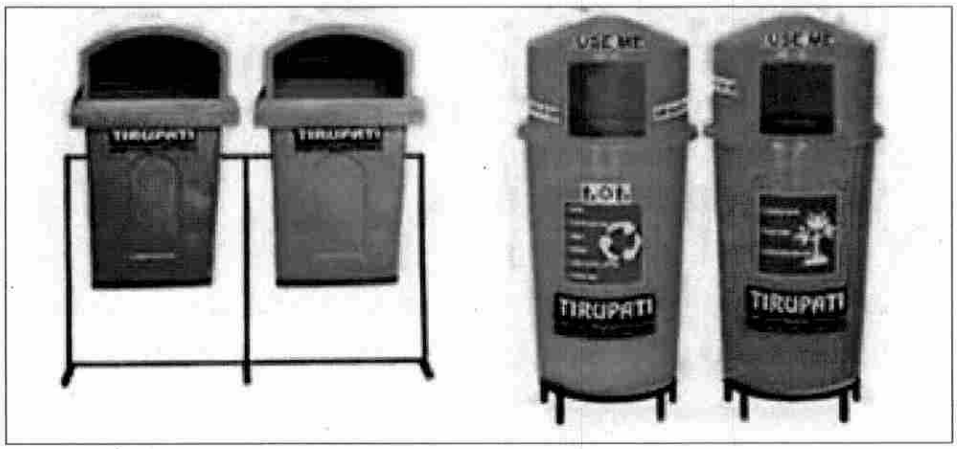
For specific storage requirements for construction and demolition (C&D) waste, please refer to Section 3.7 of of Part II. Small quantities of C&D waste are to be stored separately at household level, and this waste is to be transferred to the community C&D waste collection bins.

2.2.1.2.3 Storage of Municipal Solid Waste in Public Places or Parks

With a view to ensure that streets and public places are not littered with waste, litter bins (Figure 2.4) may be provided at important streets, markets, public places, tourist spots, bus and railway stations, large commercial complexes, etc. at a distance ranging from 25m to 250m depending on the local conditions. The collection from these bins should be segregated into wet and dry waste.

quate number of bins at optimum distance (25–250 m) should be placed at public places to avoid littering

Figure 2.4: Typical Waste Collection Bins in Parks and along Walk-Ways[9]



2.2.1.3 STORAGE OF YARD WASTE OR GARDEN WASTE

The SWM Rules, 2016 suggests that horticulture waste from parks and gardens should be collected separately and treated on-site to make optimum use of such wastes and also to minimise the cost of its collection and transportation. In large cities, the municipal authority may provide large containers for storage of waste or facilitate provision of large containers through private sector participation. In small cities, such waste may be stored on-site and the municipal authority may facilitate its periodic collection, either through the SWM department or by involving the private sector. The skip bins or containers shall be of a standard design and amenable to automatic hydraulic lifting and unloading by a transport vehicle. This waste should not be mixed with domestic waste.

On site composting of yard waste/ green waste should be promoted

9 Indiamart. Road Side Twin Litter Bins Available at: http://trade.indiamart.com/details.mp?offer=1761050930

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2.2.1.4 STORAGE AND PROCESSING OF SPECIAL WASTES INCLUDING DOMESTIC HAZARDOUS WASTE

Special wastes including domestic hazardous wastes are generated by residential, commercial, or institutional facilities which are regulated by rules other than the SWM Rules, 2016 and consist of the fractions mentioned in Table 2.1.

Special wastes including domestic hazardous wastes can pose a substantial or potential threat to health and environment because of their constituents which may be hazardous. A municipal waste component is hazardous if it contains one of the following characteristics: (i) ignitability, (ii) corrosivity, (iii) reactivity, and (iv) toxicity.

Special Wastes including Domestic Hazardous Wastes Categories from Households

- Printer cartridges, electronic parts and equipment
- Batteries from flashlights and button cells
- Bleaches and household kitchen & drain cleaning agents
- Car batteries, oil filters and car care products, consumables
- Chemicals and solvents and their empty containers
- Insecticides, pesticides and herbicides and their empty containers
- Light bulbs, tube-lights and compact fluorescent lamps (CFL)
- Paints, oils, lubricants, glues, thinners, and their empty containers
- Photographic chemicals
- Thermometers and other mercury containing products
- Discarded medicines, injection needles and syringes, after destroying them

Clause 15(j) of SWM Rules, 2016 ensure safe storage and transportation of the domestic hazardous waste to the hazardous waste disposal facility or as may be directed by the State Pollution Control Board or the Pollution Control Committee.

All waste generators should be directed by the municipal authority to not mix special waste including domestic hazardous waste with either the wet waste or dry waste, but to store such wastes separately and hand-over to the special waste collection centres, which should be established by the urban local bodies or to collection schemes through retail trade. The Rules have further directed ULBs to establish one domestic hazardous deposition/delivery centre per 20 sq. km.

Clause 15(i) of SWM Rules, 2016 establish waste deposition centres for domestic hazardous waste and give direction for waste generators to deposit domestic hazardous wastes at this centre for its safe disposal. Such facility shall be established in a city or town in a manner that one

ULBs should establish a minimum of one domestic hazardous deposition center per ward or per zone, for ease of deposition of the users

centre is set up for the area of twenty square kilometers or part thereof and notify the timings of receiving domestic hazardous waste at such centres;

However, given that ULBs are of varying sizes, larger ULBs may decide to establish one domestic hazardous deposition site per ward; smaller ULBs may choose to place the deposition centre(s) at appropriate locations, such as market places and commercial areas. The timings for receiving domestic hazardous waste at such centre should be notified to public, while ULBs should ensure safe handling of such waste as may be directed by the SPCB or PCC from time to time. ULBs should establish a minimum of one domestic hazardous deposition centre per ward or per zone, for ease of deposition of the users.

Manufacturers and suppliers of products resulting in special wastes should be encouraged to develop systems for "take back", treat or recycle such wastes, or send wastes to registered recyclers, as appropriate.

Having hazardous components, MSW has to be distinguished from hazardous wastes generated by commercial and industrial units, as defined by the Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016. Hazardous wastes should be disposed by the generating unit at the nearest treatment, storage, and disposal facility (TSDF). ULBs can also hold other hazardous waste manufacturers accountable, under aforesaid rules. E-waste shall be segregated at source and shall not be mixed with MSW. Special wastes are covered in detail in Section 7 of Part II.

2.2.1.5 MANAGING INDUSTRIAL WASTES GENERATED WITHIN MUNICIPAL JURISDICTIONS (EXCLUDING INDUSTRIAL ESTATES WITHIN MUNICIPAL AREAS)

SWM Rules, 2016 are also applicable to industrial townships, areas under the control of Indian Railways, airports, airbases, Ports and harbours, defence establishments, special economic zones, State and Central government organisations, places of pilgrims, religious and historical importance as may be notified by respective State government from time to time and to every domestic, institutional, commercial and any other non residential solid waste generator situated in the areas except industrial waste, hazardous waste, hazardous chemicals, bio medical wastes, e-waste, lead acid batteries and radio-active waste, that are covered under separate rules framed under the Environment (Protection) Act, 1986.

Industrial solid waste refers to waste generated by processing activities of different industries, e.g., thermal power plants producing coal ash; integrated iron and steel mills producing blast furnace slag and steel melting slag; nonferrous industries like aluminium, zinc, and copper producing red mud and tailings; etc. Industrial waste can be solid, liquid, or gas, and can be hazardous or non-hazardous. Hazardous industrial waste may cause

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danger to public health and environment and hence should not be mixed with MSW. Large industries have to manage their waste by themselves and are required to seek authorisations from respective SPCBs.

Small-scale service industries (both registered and unregistered) within city limits—e.g., automobile garages, electroplating industry, dyeing industry, lathe machines, etc.—which generate hazardous waste, should be identified by the ULB through a primary survey. A clear-cut plan for management of wastes from these industries should be chalked out for its separate collection, transportation, and appropriate disposal in consultation with the SPCB or PCC.

Although ULBs are not responsible for the management of industrial solid waste, ULBs should ensure that MSW generated by the industrial units should be handled appropriately by the industry. In places where the industrial unit or area has no appropriate municipal solid waste management (MSWM) system, a tie up with the regular MSWM system of the ULB should be organised. Collection of MSW from such units should be closely monitored to ensure that there is no cross contamination of waste with industrial waste illegally dumped in the municipal bins.

2.2.2 PUBLIC PARTICIPATION AND AWARENESS

The SWM Rules, 2016 direct ULBs to create public awareness through information, education, and communication (IEC) campaigns and educate the waste generators to minimise waste and prohibit littering. Municipal authorities should organise awareness generation programmes promoting segregation of waste and recycling or reuse of segregated waste. The communities should be educated, informed, and trained on waste segregation. ULBs should sensitise citizens to associated environment and health hazards of improper waste management. Further, the citizens should be made aware of the need to pay user fees or charges for ensuring sustainability of the MSWM services.

Post the introduction campaigns, regular reinforcements of segregation concepts will ensure full adoption by community

This process is most effective when led by the Mayor or Chairperson and the Chief Executive of the ULB, and prominent people are involved in the campaign to motivate the society at large. To ensure segregation at household level, along with the proper system of door-to-door collection and transportation, there must be sustained efforts by the authorities and strong leadership to motivate the citizens over a period of 15 days to one month along with the proper system (e.g., case study on Warangal).

Involvement of RWAs, CBOs, NGOs, self-help groups (SHGs), and market associations is imperative to ensure the success of segregation at source. Regular meetings among the ULB staff and representatives

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Building community awareness and consensus is essential for ensuring community participation in storage of segregated waste

of RWAs, market associations, NGOs, SHGs, and other stakeholders should be held until the community fully adopts this practice.

The ULB through the NGOs, Rotary clubs, CBOs, and other such organisations should conduct school-level awareness and education programmes focusing on source segregation; waste minimisation through reduce, reuse, and recycle; and the importance of proper management of waste. Students should be made aware of the menace posed by increasing waste quantities and environmental impacts of unscientific disposal. School authorities should educate and encourage students to practise segregation of waste in schools as per specifications given above in Table 2.1.

The Clean Cities Championship: A Participatory Approach for Improved Municipal Solid Waste Management in Warangal

Location: Warangal

Population: 3,512,576 (Census, 2011)

Year of Start: 2012

Main Players: Directorate of Municipal Administration, Government of Andhra Pradesh, Warangal Municipal Corporation (WMC), Clean Cities Foundation, Andhra Pradesh Industrial & Technical Consultancy Organisation, Andhra Pradesh Pollution Control Board, communities, and school students.

Approach: In order to make waste management a competitive sport, the Clean Cities Foundation in partnership with the Directorate of Municipal Administration started the initiative of source segregation and door-to-door collection service in collaboration with Andhra Pradesh Pollution Control Board and Andhra Pradesh Industrial & Technical Consultancy Organisation. This was a low-cost participatory approach for integrated municipal solid waste management. The process included a hands-on approach to planning a sound waste management system and then implementing cost-effective solutions on the ground. Strong leadership from the administrators and politicians ensured participation and revenue generation for sustaining the process.

The following approach was adopted:

- Financial grants for the championship were first secured from different departments at state level.
- Intensive pre-championship activities were carried out, namely:
  - Planning inputs: Assessment of resource and capacity enhancement needs for WMC
  - Administrative planning: Creation of solid waste management (SWM) and resource management wing within WMC with clear roles and responsibility
  - Technical planning: Micro route mapping and collection and transportation efficiency route synchronisation

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- Procurement of infrastructure like
  - Pushcarts with tools for segregation, bins, weighing scales, dry resource bags, and personal protective equipment
  - Tractors, sirens, and audio systems
  - Vermicompost sheds and windrow compost pads and dump site
  - Dry resource centers with bailing units
  - Biogas plant
- Transportation plan and rationalisation of vehicles, including servicing and deployment of compacters for secondary transportation
- Route and loading plans (373 pushcart-wise maps for 53 wards) prepared by field-level functionaries for the entire city on geographic information system maps provided by WMC, thus ensuring ownership of WMC
- Tie-ups with:
  - Private weighbridge close to dump site for continuous measurement of waste quantities
  - Recycling units to sustain the activity through revenue generation and creation of market for the material
  - Cement plants for dry combustibles that could not be recycled
- Stakeholder involvement:
  - Women SHGs were involved in door-to-door collection of waste in 60,000 households, which they already served. This was to demonstrate waste collection to other households in the area.
  - Mass awareness campaigns regarding segregation of waste were organised through different means like media, cycle rallies, etc. Focus group discussions among religious groups, resident welfare associations (RWAs), schools, colleges, self-help groups (SHGs), etc. were also conducted.
  - The WMC staff and municipal staff from other cities were divided into teams and received hands-on training during the championship. There were 240 teams from WMC and 130 teams from other cities.
- Training and Capacity Building:
  - Teams for carrying out the segregation and collection of waste were organised.
  - Training on the segregation and collection of waste was provided to the municipal staff and workers

The Championship :

- Championship was spread over 7 days.
- Different coloured contest cards were introduced for the municipal staff, SHGs, and households during the championship. Signatures on the cards by the route monitors (National Cadet Corps) earned eligibility to be part of the target group draw for prizes.
- Intensive micro and macro level management and continuous dynamic SMS updates were made on the official website of WMC for verification.

– Each participating team (WMC and other cities) was assessed for performance, and the winning team was awarded.

Outcome:

- SWM wing was established to oversee the task carried out on a timely basis and to address the problems as and when generated.
- Segregated waste was collected and weighed daily per route, and the data bank was updated through internet on real-time basis. Accurate measurements were documented for the total waste generated in Warangal City and of recycled, combustible, and compostable waste.
- Segregated waste was further transported to sorting centers, recycling units, and cement plants.
- WMC was able to reduce 30% to 40% of waste going to the dump site.
- Improved collection efficiency through constant training, monitoring, and efforts from the team to build the capacities of the workers.

Success Factors:

- A strong political and administrative will was required, and the Commissioner led the championship.
- Strategic planning and correct pre-assessment of the existing situation were initiated.
- Minimal financial inputs were needed to improve or adopt the locally appropriate technologies for the required capacity of MSW in the city.
- Training of municipal staff and SHGs was implemented and so was the ownership of the ground level workers in the system.
- Training and capacity building of the urban local body (ULB) staff was promoted as well as awareness and involvement of the citizen to ensure continued practice of the system.
- Intensive campaigning and interaction of officials with citizens was initiated regarding the proposed door-to-door collection and segregation of waste.
- Intensive monitoring of activities by the ULB was carried out with support of different group like citizen groups, National Cadet Corps, online systems, etc.

Sustainability:

There has been a reduction in operation and maintenance (O&M) costs by 30%. This initiative can be sustained through the regular municipal budget of the ULB as well as the revenue generated from the sale of recyclables and compost. However, for centralised infrastructure and rehabilitation of the dump site, financial aid would be required. This model of championship has been replicated in Guntur and Visakhapatnam in Andhra Pradesh, and many other municipalities have showed interest in doing the same to set up an efficient system of awareness raising and of segregation, recycling, and transportation of waste.

Source: WMC

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2.3 COLLECTION AND TRANSPORTATION

2.3.1 SOLID WASTE MANAGEMENT RULES, 2016 - REQUIREMENTS ON PRIMARY / SECONDARY COLLECTION AND TRANSPORTATION

As per SWM Rules, 2016:

Clause 15: Duties and responsibilities of local authorities:-

(b) arrange for door to door collection of segregated solid waste from all households including slums and informal settlements, commercial, institutional and other non-residential premises. From multi-storage buildings, large commercial complexes, malls, housing complexes, etc., this may be collected from the entry gate or any other designated location;

(f) prescribe from time to time user fee as deemed appropriate and collect the fee from the waste generators on its own or through authorised agency;

(h) 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; Bins for storage of bio-degradable wastes shall be painted green, those for storage of recyclable wastes shall be printed white and those for storage of other wastes shall be printed black;

(i) establish waste deposition centres for domestic hazardous waste and give direction for waste generators to deposit domestic hazardous wastes at this centre for its safe disposal. Such facility shall be established in a city or town in a manner that one centre is set up for the area of twenty square kilometers or part thereof and notify the timings of receiving domestic hazardous waste at such centres;

(j) ensure safe storage and transportation of the domestic hazardous waste to the hazardous waste disposal facility or as may be directed by the State Pollution Control Board or the Pollution Control Committee;

(k) direct street sweepers not to burn tree leaves collected from street sweeping and store them separately and handover to the waste collectors or agency authorised by local body;

(m)collect waste from vegetable, fruit, flower, meat, poultry and fish market on day to day basis and promote setting up of decentralised

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compost plant or biomethanation plant at suitable locations in the markets or in the vicinity of markets ensuring hygienic conditions;

(n) collect separately waste from sweeping of streets, lanes and by-lanes daily, or on alternate days or twice a week depending on the density of population, commercial activity and local situation;

(o) set up covered secondary storage facility for temporary storage of street sweepings and silt removed from surface drains in cases where direct collection of such waste into transport vehicles is not convenient. Waste so collected shall be collected and disposed of at regular intervals as decided by the local body;

(p) collect horticulture, parks and garden waste separately and process in the parks and gardens, as far as possible;

(q) transport segregated bio-degradable waste to the processing facilities like compost plant, biomethanation plant or any such facility. Preference shall be given for on site processing of such waste;

(r) transport non-bio-degradable waste to the respective processing facility or material recovery facilities or secondary storage facility;

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

2.3.2 GENERAL PRINCIPLES

Primary collection refers to the collection of waste from source of generation

Collection of segregated municipal waste is an essential step in MSWM. Inefficient waste collection services have an impact on public health and aesthetics of towns and cities. Collection of wet, dry and domestic hazardous waste separately ensures maximum recovery of recyclables. It also enhances the potential of cost-effective treatment of such wastes which can then easily meet the minimum quality criteria defined for different products, eg. production of compost from pure organic waste.

Secondary collection is the collection of waste from community bins, storage depots, or transfer stations for transportation to processing or disposal site

Waste collection services are divided into primary and secondary collection. Primary collection refers to the process of collecting, lifting and removal of segregated solid waste from source of its generation including households, shops, offices, markets, hotels, institutions and other residential or non-residential premises and taking the waste to a storage depot or transfer station or directly to the disposal site, depending on the size of the city and the waste management system prevalent in the city. Primary collection must ensure separate collection of certain waste streams or fractions depending on the separation and reuse system applied by the respective town or city (Section 2.2).

Secondary collection includes picking up waste from community bins, waste storage depots, or transfer stations and transporting it to waste processing sites or to the final disposal site. At the secondary collection

points, segregated waste must be stored on-site in separate covered bins or containers for further collection and should be kept separate during all steps of waste collection, transportation, and processing. Further, ULBs should ensure that at the secondary storage points the waste is should be attended daily or before container starts overflowing.

A well synchronized primary and secondary collection and transportation system, with regular and well communicated intervals of operation (with respect to primary collection), is essential to avoid containers' overflow and waste littering. Further, the transport vehicles should be compatible with the equipment design at the waste storage depot and should be able to transport segregated waste. They should also be easy to maintain. It should be ensured that waste collected from the doorstep in motorized vehicles should be either directly transported to the processing facility or through material recovery facility or transfer station, or waste storage depots for facilitating, sorting, and bulk transfer of waste. The vehicles used for transportation should be covered and not visible to public. It should have a facility to prevent spillage of waste and leachate en-route to the processing or disposal facility.

Figure 2.3, Figure 2.4, and Figure 2.5 as well as Figure 1.7 (of Part I) indicate suggested movement of household waste, market waste, street sweeping, and drain silt through the MSWM system.

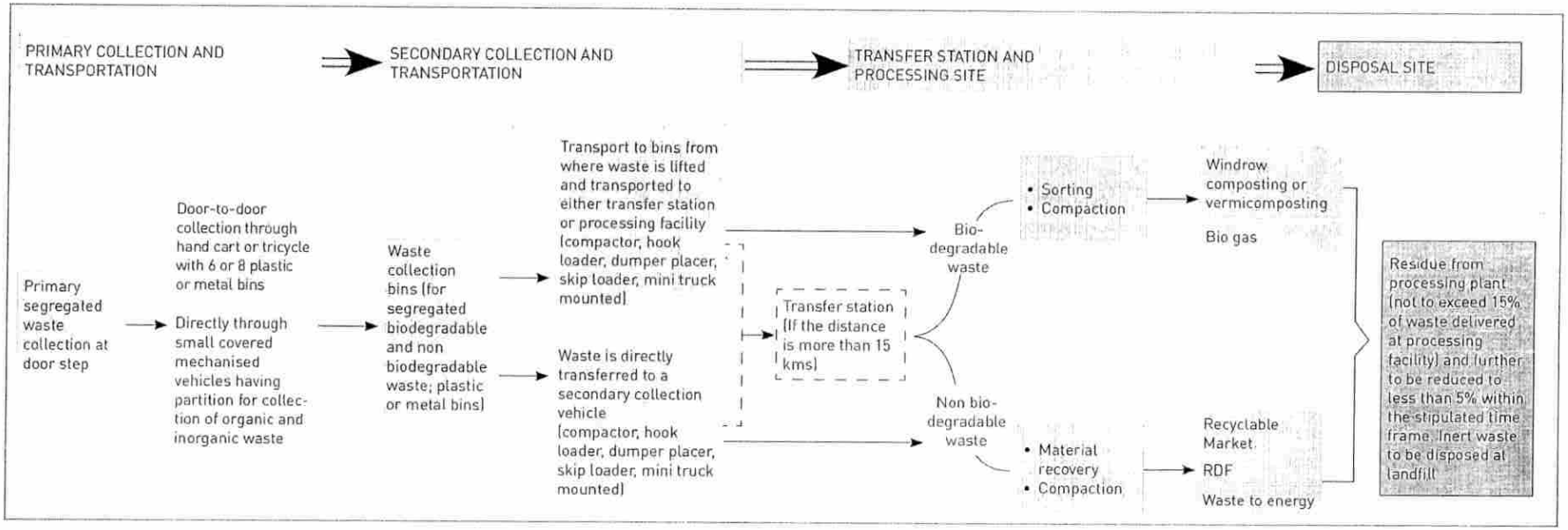
It is essential to separate street sweeping waste and silt cleaned from drains completely from household waste streams through all stages of collection, transport, and treatment, since street sweeping and drain silt can be infiltrated with significant amounts of toxic substances (e.g., heavy metals) and are often responsible for contamination of waste streams envisaged for composting and recycling. Accordingly, street sweeping and drain silt are covered in different flowcharts. For household waste, a tertiary collection system is necessary only in large cities where transfer stations are located at a great distance (more than 15 km) from disposal and treatment facilities.

Synchronisation between primary and secondary collection is very essential in order to avoid spillage of containers, littering or manual handling

Street sweeping and drain cleaning waste are to be collected in separate bins and transported directly to the sanitary landfill facility

Secondary waste storage containers should be covered and designed to facilitate mechanical lifting to avoid multiple handling

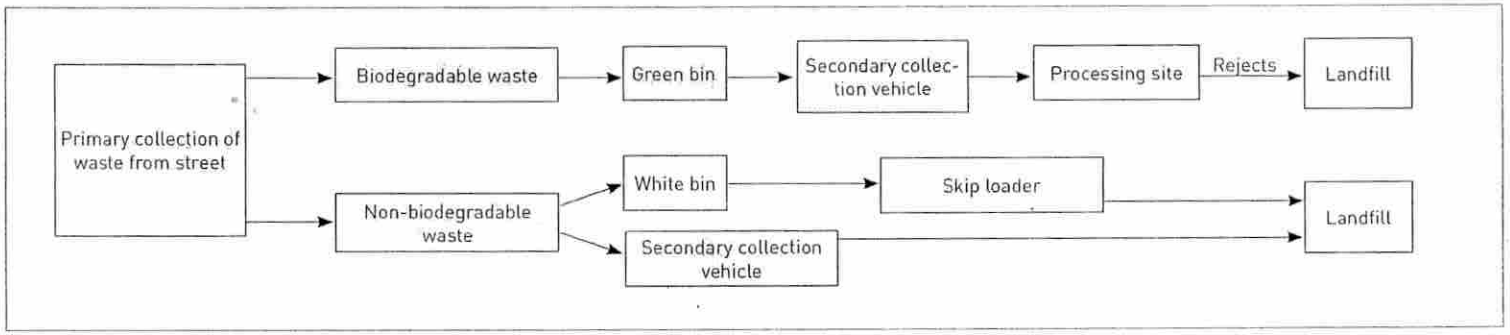
Figure 2.5: Flow Chart for Household Waste Collection, Transportation and Disposal[10]



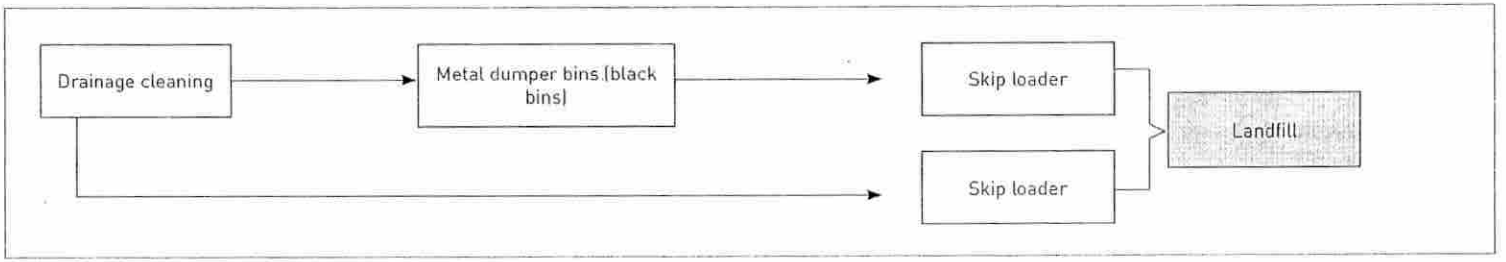
- The compactor is an appropriate vehicle for collecting biodegradable and recyclable component of MSW
- Skip loaders/ Hook loaders are preferred for collecting inert waste or Construction and Demolition waste
- Waste may be transferred to the transfer station if the processing site is located at least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

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

Figure 2.6: Flow Charts for Collection, Transportation and Disposal of Street Sweeping and Drain Silt[11]



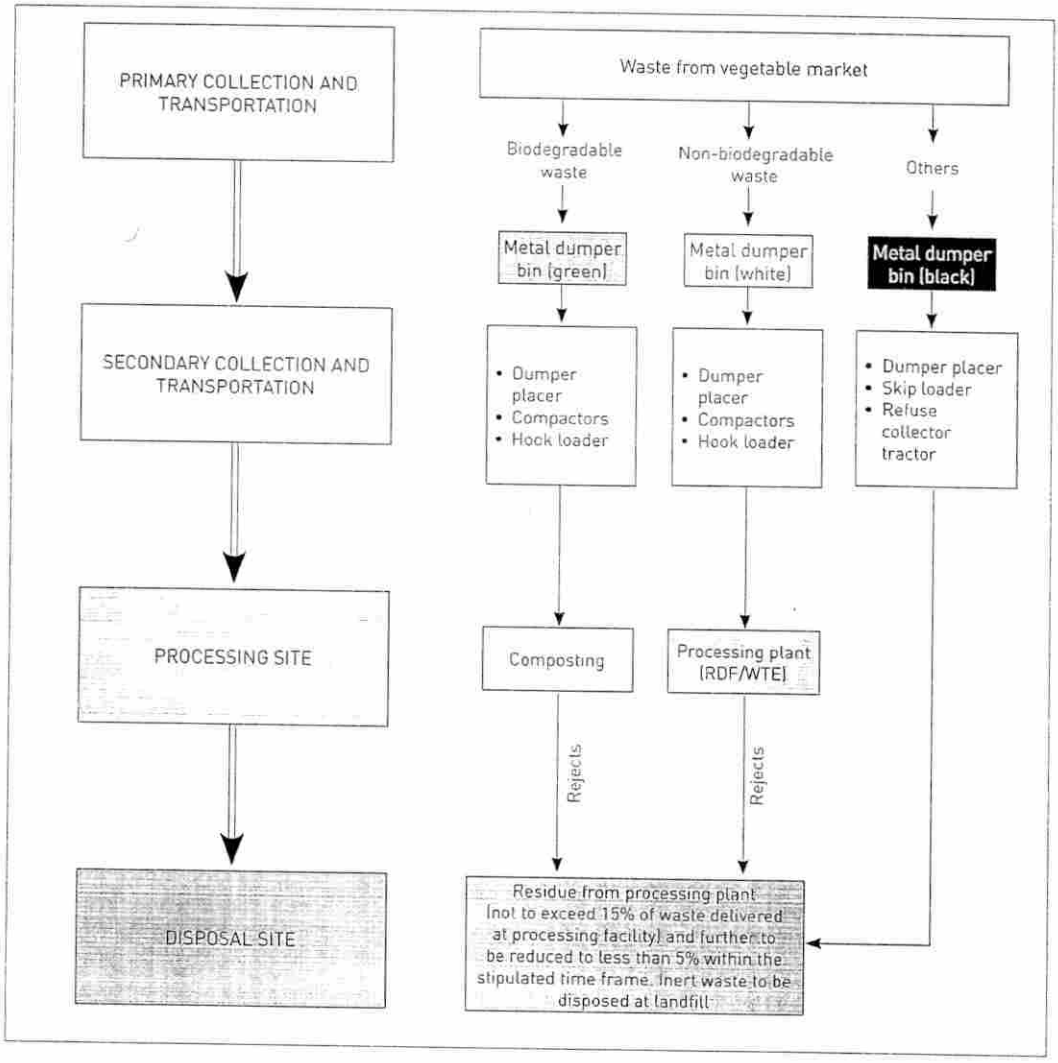
Street sweepings are predominantly inert wastes. A skip loader/ hook loader is preferred for transportation of street sweepings.



11 Developed by the Expert Committee for revision of MSWM Manual (2013-15).

Only in cases where the processing or disposal facilities are more than 15 km from the collection area that transfer stations should be provided

Figure 2.7: Flow Chart for Collection, Transportation and Disposal of Vegetable Market Waste[12]



2.3.3 PRIMARY COLLECTION

2.3.3.1 LOCATION AND ORGANISATION OF PRIMARY COLLECTION

Primary collection of segregated MSW from individual households and establishments (door-to-door collection) is accomplished through the use of containerised pushcarts, tricycles or small mechanised vehicles, compactors, or tipping vehicles depending on the terrain of the locality, width of streets, and building density.

Spacious and well-lit safe neighbourhoods allow collection systems with compactor vehicles and tipping equipment which are more efficient. Narrow streets do not allow for the use of conventional primary collection vehicles. In cramped neighbourhoods, handcarts or pushcarts,

12 Developed by the Expert Committee for revision of MSWM Manual (2013-15).

or tricycles or small mechanised vehicles may be used for door-to-door collection of waste, which may then be transferred to a larger vehicle in the vicinity. Where access to individual houses or establishments is difficult, handcarts or rickshaws could be made to stand at designated spots.

In hilly areas, many of the houses are accessible only by footpaths or steps, thus restricting the use of handcarts and tricycles. Segregated waste from households in hilly areas should be collected using backpacks having small leakproof containers up to 50l capacity or using local traditional load-bearing methods like pack animals, shoulder poles, headbands, wheeler bags, etc. The waste collectors should ideally collect wet waste from each household with a bag or basket on their back and with another bag for dry waste. The waste collectors should be well equipped with personal protective equipment (PPE) and should also be provided with a whistle to announce their arrival for waste collection.

Waste collection route planning is critical to ensure an efficient door-to-door collection and transportation system. In hilly areas, waste collection should ideally start at the highest point and proceed to lower levels. This would ensure that waste collectors or waste collection vehicles need not carry increasing amounts of waste up steep slopes.

The frequency of door-to-door collection should be determined by the density of population, collection system, and climatic conditions. In hot and humid regions, at least wet waste is to be collected on a daily basis. Isolated houses, shops, and establishments may be served on a less than daily basis, depending on the quantities of waste generated. Motorised collection vehicles are able to handle relatively larger quantities of waste and are preferred for periodic waste collection.

Frequency of collection is determined by the density of area, collection system, and climatic conditions. For instance, wet waste should be collected daily in hot and humid areas

Domestic waste should be collected in the morning. Waste from the commercial areas should be collected between 10a.m. and 2p.m. Vegetable market waste should be collected in nonpeak hours (early morning, late afternoon, or at night). The collection of market waste might also need to be done more than once a day.

The municipal authority may engage with RWAs, CBOs, NGOs, SHGs, or the private sector in providing door-to-door collection services. Penal provisions may be introduced after assessment or review of overall management system for failure of service where contracts are awarded.

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Door-to-Door Garbage Collection - An initiative of Shimla Municipal Corporation and Shimla Environment, Heritage Conservation and Beautification Society

Location: Shimla

Main Players: Shimla Municipal Corporation (SMC), Shimla Environment, Heritage Conservation and Beautification (SEHB) Society

Year of Start: 2010

Approach: Shimla, the capital city of Himachal Pradesh, with its strong cultural heritage and panoramic scenic beauty, is among the most famous tourist destinations in India. Due to a rapidly growing population and poor infrastructure toward the end of 20th century, hygiene, sanitation, and public health became a cause of concern for the city. The initiatives taken by SMC to deal with the solid waste menace and overall situation remained largely unsatisfactory, wherein SMC undertook three door-to-door collection initiatives involving various NGOs and voluntary organisations during 1999–2008. However, concerns raised by the local people, which was followed by a writ petition, resulted in the High Court of Himachal Pradesh issuing directions to improve the solid waste management (SWM) system. Subsequent to the directions of the High Court, the Urban Development Department notified door-to-door collection initiative for Shimla in 2006. This led to the establishment of SEHB Society registered under the Himachal Pradesh Societies Registration Act, in 2009.

Under this initiative, the following approaches were adopted to bring about significant improvements in SWM system.

Institutional and Managerial:

- The Municipal Commissioner headed the SEHB Society's waste collection initiative and was responsible for overall supervision, along with the Corporation Health Officer as member secretary of the society. The SEHB staff, which was supervised by the Chief Sanitary Inspector, looked after collection and transportation services.
- A dedicated team was allocated for smooth functioning of the system. There were two coordinators for SEHB. All 25 wards had a dedicated supervisor and assistant supervisor reporting to the coordinators, who in turn report to the sanitary inspectors.
- A mechanism for collection was defined through physical verification of households and communities.
- Optimisation of routing of each vehicle and provision of a substitution plan for any breakdown in vehicles was established.
- Centralised complaint redressal system within SMC and dedicated telephone lines at SEHB office were established to resolve the complaints of users. Feedback registers were updated daily.
- Regular monitoring was done by the health officer and sanitary inspectors, as well as pre-arrangement or substitution of the workers to maintain efficiency in case of absences from work or during holidays.
- Effective and timely remittance of salaries of the field staff was maintained.

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- SMC provided identity cards to SEHB Society's workers and also employee provident fund benefits and employees' state insurance benefits.
- Regular health checkup of garbage collectors was performed.
- Woman participation was encouraged through different modalities like providing easy terrain to work, working close to their homes, and husband and wife working in same wards.

Legal:

- Door-to-door collection bye-laws were introduced with special mandate for citizens to hand over the MSW to SEHB Society, the agency authorised by SMC.
- SMC introduced user charges and its provision within the bye-laws for compliance.
- Penal provisions were introduced for non-compliance of citizens, e.g., littering and non-participation in the door-to-door collection system.

Information, Education and Communication:

- For increasing community participation in this initiative, SMC organised community meetings to disseminate the details of the collection system and its functioning.
- Mass media (jingles for radio channels, local advertisements) and print media were used to further promote the initiative and sensitise people.
- Ward-level lucky draw was carried out for registered users.
- SEHB Society distributed its annual calendar, with all necessary information and messages, to the households.
- SEHB's case study and brochure were disseminated for further outreach and to sensitise people to the initiatives taken.

Outcome:

- More than 90% of coverage (25 wards) and collection of waste from the households was achieved.
- Redressal of complaints by the ward supervisors for nondelivery of service was effective and timely.
- The initiative was compliant with laws pertaining to the municipal solid waste management (MSWM).
- Overall environmental improvement and aesthetic value of the city was achieved.
- There were less incident of monkey nuisance and conflict.

Success Factor:

- A strong political and administrative will to improve the MSW system in the city.
- Strategic planning and revisiting or assessing the existing situation.
- Intensive campaigning of officials and interaction with citizens regarding the door-to-door collection system.
- Effective monitoring and follow-up by officials.
- Penalty provisions for littering and noncompliance in the door-to-door collection system through bye-laws.

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Overall Sustainability:

Collection of user charges has resulted in the financial sustainability of the project. There has been a steady rise in the user charges collection during the last financial year. A dedicated team has been appointed for maintaining the regular cash flow which is essential to payment of salaries and operational liabilities of the self-financing scheme. Strict monitoring is carried out to ensure the collection revenues as well as the overhead expenditures.

Source: SMC

2.3.4 VEHICLES AND EQUIPMENT FOR PRIMARY COLLECTION

Primary collection vehicles should meet local requirements. Before selecting a vehicle for primary collection, it is advisable to assess the amount of waste generated, local climatic conditions, topography of the area, and available facilities for repair and maintenance of vehicles.

Vehicles Typically Used for Primary Collection

- Handcarts or tricycles with containers or bins
- Tricycles with hydraulic tipping containers
- Light commercial vehicles (mini trucks) with hydraulic tipping containers
- Four-wheeled mini trucks with international standard garbage collection bins

2.3.4.1 HANDCARTS OR TRICYCLES WITH CONTAINERS OR BINS

Handcarts should have a capacity to carry 4 to 6 containers of 40 to 60l capacity. The containers should be green for wet waste and blue for dry waste (Figure 2.8). Bins should be made of HDPE, injection or roto molded, UV tested, and universally used as standard garbage handling bins.

Containerised handcarts are suitable for door-to-door collection of MSW from households, shops, and establishments from narrow lanes and hilly areas and also for collection of street sweepings where women sanitation workers are involved. Bins or containers can be easily unloaded into secondary collection bins or secondary transport vehicles based on the prevalent collection and transportation system in the ULB. This can be done without depositing the waste on the ground, avoiding multiple handling of waste.

Tricycles with 6 to 8 containers of 40 to 60 l capacity can also be used for door-to-door collection of waste from narrow lanes. Male workforce is engaged to facilitate the picking up of larger quantity of waste in one trip and taking the waste to a secondary waste storage depot placed at a longer distance. Refer to Section 2.4.3 of Part II for the more details about the types of equipment for street sweeping.

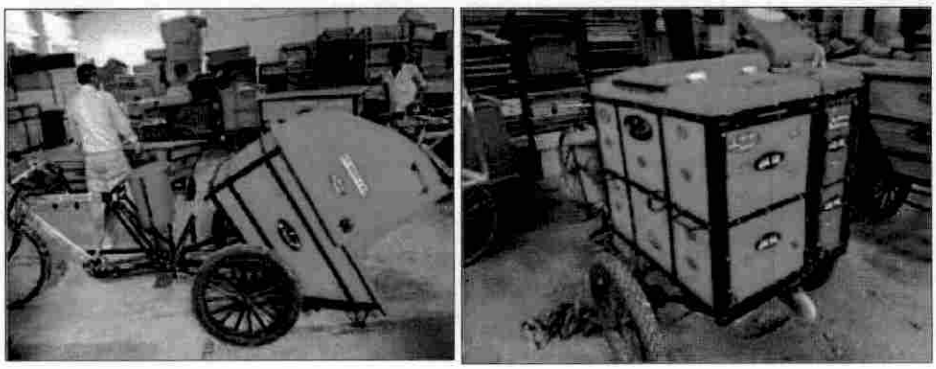
Figure 2.8: Hand Carts with Bins[13]



2.3.4.2 TRICYCLE WITH HYDRAULIC TIPPING CONTAINERS

MSW tricycles should have mild steel epoxy painted and tipping containers of 350l (140 kg per trip). The tipping containers should be mounted on a standard tricycle (Figure 2.9). These tricycles are suitable for door-to-door collection from small lanes and small waste generators.

Figure 2.9: Tricycle with Hydraulic Tipping Container[14]



2.3.4.3 LIGHT COMMERCIAL VEHICLES (MINI TRUCKS) WITH HYDRAULIC TIPPING CONTAINERS

These vehicles are suitable for door-to-door collection of segregated waste for lanes with less than 5m width. They have a total payload capacity of nearly 600–900 kg per trip. The load height is approximately 1,500 mm from the ground level. They should have a leakproof MS

13 Source taken from Manufacturer
14 Ibid.

load body with drainage tube and plug. The small tipper should be built on a suitable chassis. These vehicles should have four openings, two on each side to facilitate direct transfer of waste from a domestic bin to the vehicle. They can also have a central removable partition to facilitate storage of segregated waste. It is desirable to use up to $3m^3$ capacity vehicle for door-to-door collection to cater to a large number of houses in a single trip (Figure 2.10).

Adequate repair and maintenance system should be established for mechanical and manual vehicles and other heavy equipment to lower potential downtime

Figure 2.10: Mini Truck with Hydraulic Container



2.3.4.4 FOUR-WHEELED MINI TRUCKS WITH INTERNATIONAL STANDARD BINS

Normally the practice is to unload the small containers manually into the bin or the hydraulic container. The main advantage of the four wheeled mini truck using bins instead of a hydraulic container is that the loading height can be decreased from 1,500mm to 1,200mm or less from bins placed on the ground. For the same logic, this type of system cannot be fitted on the larger chassis because then the loading height would be even higher. Avoidance of hydraulic tipping will make these trucks suitable in remote places, where provisions for maintenance of the hydraulic component of a large number of vehicles may not be available. Further, maintenance is costly and time-consuming.

A typical setup is that the vehicle can carry 8 bins of minimum 240 l. Bins should be made of injection or roto molded HDPE. Each mini truck should carry 4 green containers for wet waste and 4 blue containers for dry waste.

ULBs should have adequate workshop facilities for the maintenance not only of their fleet of vehicles, but also of containers, handcarts, etc. The workshop, public or private sector, or public–private partnership (PPP) should have adequate technical staff (trained men and women), spares, and preventive maintenance schedules to ensure that at least 80% of the vehicles run on the road each day and the downtime is minimised to the extent possible. For more information on preventive maintenance, refer to Section 6.3 of Part II.

2.3.5 STAFFING AND EQUIPMENT REQUIREMENTS FOR PRIMARY COLLECTION

Clause 15: Duties and responsibilities of local authorities:-

(zd) ensure that the operator of a facility provides personal protection equipment including uniform, fluorescent jacket, hand gloves, raincoats, appropriate foot wear and masks to all workers handling solid waste and the same are used by the workforce;

Efficient primary collection requires adequate equipment, facilities, and trained staff. Table 2.2 below gives specifications of the requisite primary waste collection service systems to be deployed in different types of localities. Table 2.3 gives service norms for deployment of vehicles and staffing for primary collection of waste. The specific requirement for equipment or vehicles should be calculated based on waste generation projections of the city (at least for the coming 5 years).

Table 2.2: Elements of Primary Waste Collection System

SOURCE	PRIMARY COLLECTION SERVICES	TRANSPORTATION	PPE FOR WASTE HANDLER
Societies/ Apartment Complexes	• Door-to-door collection services with a minimum of 2 bins for collection of wet waste and dry waste (10–15 l) • A pair of community bins of - 60 litres (20 to 30 kg) or - 120 litres capacity (40 to 60 kg) or - 240 litres capacity (80 to 120 kg) or - 1.1 cu. m capacity (300 to 450kg) depending on number of houses to be served (i.e. 12, 24, 48, 200 units). The specifications should be as per Central Institute of Plastics Engineering and Technology (CIPET) specification • Contract for door-to-door collection with private sector, CBOs, NGOs, RWAs, or SHGs	Containerised light weight handcarts Tricycles for both men and women Pickup vans Motorised waste collection vehicle Any suitable combination of the above	Gloves Shoes Clothes that cover whole body

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Table 2.2: Elements of Primary Waste Collection System [contd.]

SOURCE	PRIMARY COLLECTION SERVICES	TRANSPORTATION	PPE FOR WASTE HANDLER
Inaccessible Residential Areas	• 2 community bins or containers of 60–120 l capacity for 20–40 dwelling units • 2 domestic bins for storage of waste at source—5, 10, 15, 20 l (for 2–8 kg waste) capacity, as per CIPET specification	• Containerised light weight hand carts • Tricycle for both men and women • Waste collected from the area should be transferred to a light commercial vehicle (LCV) outside the slum area.	Gloves Shoes Clothes that cover whole body
Residential areas	• Door-to-door collection services for segregated waste • 12–15 l capacity domestic bins, one of them with lid, made as per CIPET specification • Contract for door-to-door collection with private sector, NGOs, RWAs, or SHGs	• Containerised handcarts • Tricycles for both men and women • Pickup vans • Motorised waste collection vehicle	Gloves Shoes Clothes that cover whole body
Markets/ Bulk Waste Generators	• Doorstep collection services for recyclable material or dedicated waste streams on full cost recovery basis • Markets: 1.1–4.0m^3 covered bins for storage of waste as per the quantity of waste generated in the market • Large commercial complexes: 3.0–7.0m^3 containers	• Motorised waste collection vehicle with container lifting device • Compactors compatible with containers • Non-compactor trucks	Heavy duty gloves Shoes Clothes that cover whole body Face mask
Hilly areas	• Door-to-door collection service for segregated waste—manual collection or with small motorised vehicles • Door-to-door collection service for segregated waste—5, 10, 15, 20 l (for 2–8 kg waste) capacity, HDPE, injection molded, tested bins • 2 domestic bins of 12–15 l or a pair of community bins of 60, 120, 240 l depending on the number of houses to be served (20, 40, or 80 houses)	• Lightweight containerised handcarts • Tricycles for both men and women • Pickup vans • Motorised waste collection vehicle • Combination of vehicles specified above	Heavy duty gloves Shoes Clothes that cover whole body Face mask

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Table 2.3: Estimates for Deployment of Vehicles and Manpower for Primary Collection[15]

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

(Note: Compactor may not be used for primary collection purposes)

2.3.6 COMMUNITY INVOLVEMENT IN PRIMARY COLLECTION

Community participation in waste management activities is critical for ensuring a well-functioning collection system. Involvement of the community in the primary collection system, specifically in determining the timings for waste collection, is important for the effective planning and implementation of the primary waste collection system. Community initiatives need to be inclusive. Active engagement of men, women, youth, and children should be given equal importance. Separate group discussions, involvement of community leaders, community associations, SHGs, and local members who represent the interest of the community at large (especially with a focus on bringing in the voices of women) must be adopted.

ULBs should make concerted efforts to integrate the informal sector of waste pickers into regular waste collection operations through the private sector, NGOs, RWAs etc.

15 Reference Material on Municipal Waste Management for Urban Local Bodies (2012). All India Institute of Local Self-Government (AIILGS).

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2.3.7 ROLE OF THE INFORMAL SECTOR IN PRIMARY WASTE COLLECTION

As per SWM Rules, 2016 ULBs are directed to:

Clause 15: Duties and responsibilities of local authorities:-

(c) 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 of waste;

(d) Facilitate formation of Self Help Groups, provide identity cards and thereafter encourage integration in solid waste management including door to door collection of waste;

h) 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; Bins for storage of bio-degradable wastes shall be painted green, those for storage of recyclable wastes shall be printed white and those for storage of other wastes shall be printed black

The informal sector in any city includes the kabadiwalas or scrap dealers (the kabadi system) and the waste pickers. The involvement of the informal sector should be examined and integrated into the waste management system of the city.

Recycling carried out by informal sector (individual or group of waste pickers) plays a critical role in reducing waste quantities and depletion of raw materials as well as minimising the financial and environmental burden of cities

The kabadi system network forms an important link in the overall waste recycling system prevalent in the country. The kabadi system or scrap dealers can be compared to micro-entrepreneurs who buy reusable and recyclable material like newspapers, metal, glass, cardboards, plastics, etc. The kabadi system is involved in the purchase of about 70%–75% of recyclables in the country from households and commercial establishments. In this informal sector, there are individuals, families, groups, and small enterprises that carry out unregistered and unregulated activities. People who are part of the local kabadi system purchase recyclable waste from households, shops, and establishments. They segregate this waste in plastic, paper, metal, cardboard, glass, e-waste, etc. and then sell the segregated waste to the large wholesalers. The large wholesaler is the final link between the recycling factory and the kabadi, and can extend credit, bargain, etc.

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There is another set of informal sector known as waste pickers who also play an important role in the informal recycling system. They are instrumental in recovering discarded recyclable waste from the streets, bins, dump sites, etc. They pick up 5%–10% of the recyclables from the municipal waste to earn their living (Figure 2.11). This informal sector helps to reduce the depletion of raw material, natural resources, and energy that otherwise would be used in the production of virgin or new products. Sorting of discarded waste by the informal sector or waste pickers also occurs on the street corners, at municipal bin level, and at the dump sites where the waste pickers sort the recyclable material from the mixed waste.

This form of mixed waste is fraught with danger and makes the waste pickers susceptible to injuries and infections. Moreover, a lot of waste pickers or ragpickers are usually harassed by the police, property owners, and shop keepers. Many of them have to justify their work to various people and are condemned by society. Many of these waste pickers are women who have to live with constant insecurity, harassment, and threat to their livelihood.

In order to avoid child labour and unhealthy practice of segregation of recyclable material from soiled and infected waste without use of personal protective equipment (PPE), as well as to reduce exploitation and discrimination of this low-income group, municipal authorities should make concerted efforts to integrate the informal sector of waste pickers into regular waste collection operations through the private sector, NGOs, CBOs, SHGs, and RWAs.

The aim should be to raise the status from waste pickers to waste collectors and provide them with working tools and PPE like gloves, shoes, full sleeves coat, etc. The following are important prerequisites for defining any initiative to integrate informal sector into the formal system: (i) assessing the size of the existing informal system, (ii) assessing the quantity of material being handled, (iii) identifying the number of waste pickers and persons that are part of the kabadi system, and (iv) identifying their linkages to the wholesale market.



Informal recycling activities reduce environmental costs and also provide employment opportunities. However, ensuring hygienic conditions and environmentally sound recycling practices is a challenge

With the help of local NGOs, the informal sector can be organized to form viable business groups, cooperatives or societies and would be an ideal approach for achieving their integration. Such initiatives should be supported by appropriate local policies and bye-laws. This would result in institutionalizing and ensuring rights of workers (both men and women) in the entire process.

Waste pickers should be encouraged to form cooperatives through the involvement of local NGOs or self-help groups (SHGs), and should be allowed to collect recyclables from households. Cooperatives tend to

Waste pickers are instrumental in recovering recyclables that have not been bought by the kabadiwalas

protect their rights, thereby retaining their dignity of labor and right to livelihood, i.e., right to access recyclables Such initiatives will not only ensure a higher level of income for waste pickers, but will also ensure hygienic conditions for waste pickers and environmentally safe waste recycling practices.

Provision of social security and welfare benefits to waste pickers should also be considered. As a general rule, any form of health problems related to occupational health hazards should be addressed appropriately. Social benefits of workers should include health checkups, medical health care, and treatment facilities. Care must be taken to ensure that workers (be they contractual or otherwise) have access to proper facilities such as separate toilets for men and women, storage space for their belongings, etc. For further information, please refer to Section 1.4.5.9 of Part II.

Figure 2.11: Waste picker with recyclable material



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Organizing the Unorganised: Toward Formalisation and Social Inclusion of Informal Waste Pickers and Recyclers

Location: Pune, Pimpri Chinchwad, Maharashtra

Main Players: Kagad Kach Patra Kashtakari Panchayat (KKPKP), Solid Waste Collection and Handling (SWaCH), Pune Municipal Corporation (PMC), and Pimpri Chinchwad Municipal Corporation

Year of Start: KKPKP 1993, SWaCH-2007

Approach: KKPKP is a registered trade union of waste pickers, scrap collectors, and itinerant buyers working in the cities of Pune and Pimpri Chinchwad (Maharashtra). It was founded in 1993 with 800 members to secure their livelihood and restore their dignity and rights as workers and as citizens. It was formed on the basic premise that scrap collection is "work" and scrap collectors are "workers." In 2013, KKPKP has around 9,000 members, most of whom are Dalit women. In 1998, KKPKP promoted Kagad Kach Patra Nagari Sahakari Pat Sanstha (KKPNSPS), a savings-linked credit cooperative of waste pickers.

In 2007, KKPKP promoted SWaCH, a waste pickers cooperative. SWaCH is the institutionalised outcome of a pilot project jointly undertaken by KKPKP, SNDT Women's University, and the PMC. The autonomous social enterprise provides front-end waste management services that include door-to-door waste collection, composting, and biogas plant operation and maintenance through an agreement with the PMC. For the Pimpri Chinchwad Municipal Corporation, 350 members of KKPKP also work as contract workers in door-to-door collection.

In PMC, 2,300 SWaCH members service 400,000 households, offices, shops, and small commercial enterprises. The workers of SWaCH are not municipal employees but have been authorised to recover user fees for the services that they provide. Each worker provides door-to-door waste collection services to about 100–150 households and is paid Rs20–Rs30 per household per month by the service user. The worker also has rights over the recyclable materials. Together, the workers earn minimum or higher than minimum wages with flexible hours of work. Collection is carried out using pushcarts and motorised waste collection vehicles. Collection and safety equipment and space for material recovery are provided by the PMC. Between 2012 and 2013, SWaCH has cost the PMC a total of Rs. 3.63 crore, which amounts to Rs. 2 per household per month, the lowest spent by any municipality in the country. A proposal for provision of social security and welfare benefits to waste pickers is under consideration.

Institutional Structure:

KKPKP is a democratic membership organisation. Its office bearers include the President, General Secretary, Joint Secretary, and Treasurer. The main decision-making body is the Representatives Council of 80 members, largely women. The Council meets once a month for deliberating and resolving issues. The education level of the members varies from illiterate to class 12 who take care of the functions of the union. The union also has a few hired staff, quite a few of whom are members' children. All members pay an annual membership fee.



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Approaches for Economic, Social and Political Inclusion:

Waste pickers are an economically marginalised, socially excluded, and politically disempowered occupational community. The KKPKP therefore relies on the twin strategies of struggle and agitation for rights and social justice as well as reconstruction through institutional alternatives. Institutionally, SWaCH and KKPNSPS deal more with economic and financial inclusion, while the KKPKP focuses more on social and political inclusion and addressing injustice and inequality.

The following are the approaches for economic, social, and political inclusion:

- Seeking state recognition of scrap collectors as "workers" and scrap collection as "work"
- Organizing and mobilizing scrap collectors into a trade union so that they are recognised as workers
- Visibility and voice for waste pickers as workers, dalits, women, and citizens
- Seeking municipal recognition and legitimacy through issue of photo identity cards for contribution to waste management and recycling
- Rights to access recyclables
- Claims on government resources such as space for material recovery centers, collection and safety equipment, children's scholarships, medical and life insurance, and welfare benefits
- Market interventions for fair trade and labour practices in the scrap trade
- Revision and restructuring of solid waste management to include labour, governance and environmental concerns
- Engagement in citizenship rights and governance

Outcome:

- Waste pickers recognition as workers and scrap collection as work in Maharashtra and some other states through provision of identity cards in various government documents, such as the Bajaj Commission Report, Second National Labour Commission Report, and Plastic Waste (Management and Handling) Rules.
- Entitlements to collection equipment, medical and life insurance, educational benefits for children
- Inclusion as an occupational category under the Socio-economic Caste Census and Antyodaya beneficiaries under the Food Security Act, 2013
- PMC provided identity cards to KKPKP workers in 1995–1996 and later provided medical insurance and educational scheme benefits to all registered waste pickers.
- Pimpri Chinchwad provided dedicated space for sorting and segregation of waste in 1998.
- Organised door-to-door collection and transportation services for the citizens through SWaCH and KKPKP since 2006
- SWaCH and KKPKP have organised drop-off points for collection of municipal waste, e-waste and old clothes, environmental awareness campaigns, and other outreach programmes for the citizens.

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Contribution to Outcomes:

- Strong political influence through intensive mass campaigning and rallies
- Participatory institutional structures and processes in the union and cooperatives
- Use of research to inform advocacy
- Participatory and inclusive approaches
- Support of academic and other institutions

Overall Sustainability:

KKPKP is supported through membership fees and its member-based economic activities. KKPNSPS is a financial institution that sustains through savings and lending operations. SWaCH sustains through member contributions from the services that they provide through the cooperative. SWaCH also receives some infrastructure and equipment assistance from the PMC.

Source: KKPKP

2.3.8 SECONDARY COLLECTION AND TRANSPORTATION

As specified under General Principles (Section 2.3.2 of Part II), secondary storage or collection and transportation is necessary for waste collected from households by smaller vehicles such as carts, tricycles, auto rickshaws, etc.

2.3.8.1 CONCEPT OF BIN-LESS AREA OR CITY

Wherever possible, it is advisable to synchronise primary collection and secondary collection, thereby avoiding the need for secondary storage bins or depots.

Segregated waste at the household level is collected by primary collection vehicles, which directly transports this waste to secondary collection vehicles. Secondary collection vehicles are parked daily at specific locations for the entire time during primary collection. Separate



It is advisable to synchronise primary collection and secondary collection, thereby avoiding the need for secondary storage bins or depots

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.

vehicles or chambers within a vehicle should be provided to ensure segregated transportation of waste.

2.3.8.2 SECONDARY STORAGE

Storage depots are required for secondary collection of waste in cities where the bin-less system is not adopted. In most cities, the following types of waste storage depots exist:

1. Cement-concrete bins
2. Masonry bins
3. Dhalaos
4. Metal bins or containers

Being unhygienic, cement concrete bins, masonry bins, and dhalaos are being replaced by metal containers. In general, waste storage containers should be covered and designed to facilitate mechanical lifting to avoid multiple handling and environmental harm. It is necessary to wash community bins at regular intervals to ensure a healthy and hygienic environment for users and workers. The design of waste storage containers or depots (secondary collection points) should be synchronous with the design of vehicles deployed for both primary and secondary waste collection (Figure 2.12).

Figure 2.12: Synchronised Primary Collection and Secondary Storage[16]



Indicative Secondary Storage Systems

- Bins for community places, on public roads and for bulk generators
- 1100 litre capacity four wheeled bins/containers, designed for lifting by compactor
- 3000 to 7000 litre capacity metal containers, designed for lifting by dumper placer system
- Hook lift containers 8 cu.m. or larger (multi-purpose bulk waste containers)

16 Toolkit for Solid Waste Management, 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

2.3.8.3 VEHICLES AND EQUIPMENT FOR SECONDARY STORAGE COLLECTION

2.3.8.3.1 Bins for Community Places on Public Roads and for Bulk Generators

- Galvanised iron mobile garbage bins ranging from 0.5m^3 to 7m^3 capacity are available. The bins are designed to be lifted or emptied by mechanised container lifting devices such as compactors, dumper placers, etc. They can be used for storage and handling of biodegradable and recyclable waste. They can also be used for secondary storage of street sweeping and silt collected from drains.
- The bins are suitable for bulk waste generators and for placement as community bins at waste storage depots.

2.3.8.3.2 Four-wheeled Compactor Containers

- The mobile compactors are designed for transfer points on public roads and places and are especially suitable for biodegradable and recyclable waste.
- The containers are available at 7m^3 to 10m^3, or larger. They are designed for lifting by universal hook lift system mounted on heavy duty trucks and made for the following purposes:
  - carrying all types of waste in bulk; and
  - depositing debris and biodegradable waste components of MSW (using top loading containers).



Use of Stationary Compactors for Improved Secondary Collection and Transportation in Kolkata

Location: Kolkata

Year of Start: 2012

Main Players: Kolkata Municipal Corporation (KMC) and Kolkata Environmental Improvement Project of Asian Development Bank (ADB).

Approach: To improve the collection efficiency and transportation system for high volumes of waste generated in densely populated areas in Kolkata City, KMC has piloted the use of stationary compactors for secondary waste collection under the Kolkata Environment Improvement Project of ADB. The stationary compactors, when coupled with hook loaders, provide high transport efficiency for waste. The approaches that were adopted for installation and operationalisation of stationary compactors are detailed below:

- KMC identified 78 sites for installation of stationary compactors.
- KMC procured portable compactors and prime movers (hook loaders) with financial

assistance from Jawaharlal Nehru National Urban Renewal Mission.

- The waste compactors were specifically designed for each site based on the space availability and volume of waste generated in the service area.
- In order to synchronise the system with the existing primary collection system, the portable compactors were installed with a tip cart mechanism. The tip cart mechanism proved to be flexible for manual feeding, wheel barrow feeding, and feeding by small 1–2 m^3 auto tippers.



Stationary Compactor

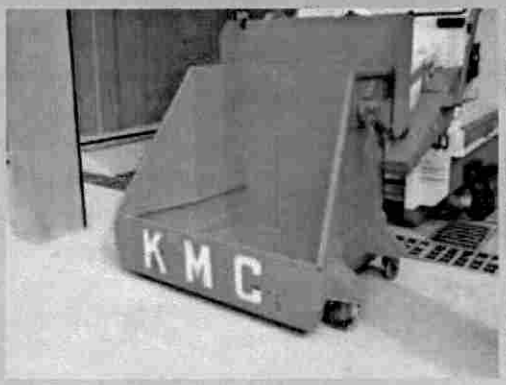
- KMC provided training and capacity building of the municipal workers for the operation and maintenance of the compactor, as well as orientation for the primary collection workers.

Outcomes:

- Collection and transportation efficiency of the municipal solid waste system has been improved after the introduction of the stationary compactors.
- Municipal waste is now transported in closed containers that minimise odor and spilling of garbage.
- Open dumping and burning of waste at the secondary collection points have been stopped.
- Portable compactors and prime movers facilitate night transportation of municipal waste.

Success Factors:

- There was a strong political will to eradicate open dumping sites in the city.
- Disturbance to the established primary collection system in the areas was minimal.
- Use of static compactors led to increased efficiency of collection and transportation.
- Small space available was optimally used for installation of the compactors with minimal construction at the sites.
- KMC provided adequate training and capacity building for the municipal and primary collection staff.





Overall Sustainability:

As of 2015, only five stationary compactors have been installed. Funding is required for establishing the entire system. With only 1 year of operation, the overall sustainability of the system is still to be assessed.

Source: KMC

2.3.9 CRITERIA FOR SIZING WASTE STORAGE CAPACITIES

Secondary waste storage capacities should be designed to accommodate at least double the expected daily in-flow of waste, that is the storage capacity should be 200% more than the expected daily in-flow of waste.

2.3.10 MAINTENANCE OF WASTE STORAGE DEPOTS OR CONTAINERS

ULBs should ensure that secondary storage bins are cleaned at least once in a month and should be painted at least once in a year. Periodic inspection of waste storage depots should be carried out once in three months and any damage caused to the flooring, screen walls, etc. should be repaired.

Periodic inspection of waste storage depots or containers should be carried out once in 3 months

The metal sheet of the containers might corrode if not well maintained. At a minimum, annual painting of the container from inside and outside must be carried out for increasing the life of containers. Potentially necessary replacements should be provided from stand-by equipment.

2.3.10.1 SECONDARY SEGREGATION AND SEGREGATION AT TRANSFER STATIONS

Unsegregated waste, which has not been sorted at primary level, should be segregated either at an intermediate stage (e.g., transfer station) or at the processing plant, prior to treatment, in cases where waste is brought directly to the plant from the waste collection areas. Segregation may be accomplished through manual or mechanised segregation. Multiple handling of waste should be avoided.

2.3.11 SECONDARY TRANSPORTATION

2.3.11.1 TYPES OF VEHICLES AND EQUIPMENT FOR TRANSPORTATION

Larger capacity vehicles should transport waste from the secondary or tertiary collection point (depot or transfer station) to the processing and treatment facility or landfill. The types of vehicles should synchronise well with containers placed at depots or transfer stations to prevent multiple handling of waste. The selection of the type of vehicles should

Vehicles Typically Used for Secondary Transportation of Wastes

- Skip truck (dumper placer)
- Refuse collector without compactor
- Rear loading compactor truck (refuse compactor)
- Light commercial vehicle with tipping floor
- Hook loader or hook lifter

reflect the quantity of waste to be transported, travel distance, road widths, road conditions, work shop facilities, etc.

2.3.11.1.1 Skip Truck (Dumper Placer)

Skip trucks are used for transportation of skips (dumper bins) of different sizes to treatment or disposal sites (Figure 2.13). The usual skip sizes are 2.5m^3, 3m^3, 4.5m^3, and 7m^3. When a full skip (container) is lifted, an empty skip should be replaced to prevent littering. These are also appropriate vehicles for transportation of inert or construction and demolition (C&D) waste.

Skip Trucks are recommended for transportation of large quantities of C&D and inert waste

- The system should be used to lift waste containers with wastes having densities up to 1,000 kg per m^3.
- The skip truck should be able to make at least 5–6 trips in an 8-hour shift within a radius of 15 km. Twin dumper placers can also be used to lift twice the number of containers in the given time

Figure 2.13: Skip Truck (Dumper Placer Machines)[17]



17 Ready Reckoner on Municipal Solid Waste Management for Urban Local Bodies, Chennai. Commissionerate of Municipal Administration, 2008. http://cma.tn.gov.in/cma/en-in/Downloads/Ready%20Reckoner%20on%20Municipal%20Solid%20Waste%20Management%20for%20ULBs.pdf

2.3.11.1.2 Refuse Collector without Compactor

At places with small size containers of 0.5 to 1.1m^3, the refuse collector vehicle without compactor of 6 to 15m^3 capacity was used in some cities which lifted and unloaded the contents of the small container into the body of the vehicle through a hydraulic system and put the empty container back in place. These are now being replaced by refuse compactors.

2.3.11.1.3 Rear Loading Compactor Trucks Used for Transportation

Compactor trucks are used for transportation from smaller transfer points either to larger transfer stations or directly to treatment or disposal sites (Figure 2.14). Compactors can be of different sizes. Some features of the compactor trucks are as follows:

- The loading hopper should be suitable for unloading tipper vehicles and hand held bins, as appropriate for the primary collection.
- Compaction capability to compress garbage or solid waste should be between 800 and 900kg/m^3.

The three sizes of compactor trucks used in India are:

- small compactors of 5–6m^3 for 4.5–5.5 tonnes of waste per trip;
- medium compactors of 8–10m^3 with a payload capacity of 7–7.5 tonnes of waste per trip; and
- large compactors of 12–16m^3 with a payload capacity of 10–12 tonnes of waste per trip.

Figure 2.14: Medium Size Compactor Truck [18]



18 Source from Manufacturer

Figure 2.15: Transfer of Waste from Secondary Collection Bins to Refuse Compactor[19]





2.3.11.1.4 Light Commercial Vehicle with Tipping Floor

Wherever possible, municipal authorities should plan for direct transfer of waste collected from households to secondary collection vehicles (Figure 2.15). In such instances, mini trucks with a tipping floor are appropriate for secondary waste transportation. Door-to-door collectors and sweepers may be directed to transfer waste from primary collection vehicles or handcarts directly to these vehicles.

In small cities with poor repair and maintenance facilities, where high-tech vehicles may not work efficiently, tractor–trolley combination for lifting of containers or towing of containers may be used. Simple hydraulic tipping trailers are recommended to avoid manual unloading at processing plants or disposal sites.

Routing of secondary collection vehicles should be planned to ensure synchronisation of primary collection, maximise operational efficiency and minimise environmental impacts of transportation. Transportation through environmentally sensitive areas should be avoided

2.3.12 WASTE TRANSPORTATION PLANNING AND DEPLOYMENT OF EQUIPMENT AND VEHICLES

Secondary collection and transportation contribute significantly to the cost of MSWM services. Vehicle productivity is the primary indicator of the efficiency of secondary waste collection and transport system. Efficiency may be improved by optimising the collection and transfer operations. Collection routes should be effectively planned to minimise transport distances and ensure an equitable distribution of workload among staff. All the vehicles may be utilised in at least two shifts, depending on waste generation, to lift all containers, ensure full utilisation of the fleet of vehicles, and limit the size of the total fleet. Transportation of waste at night may be done in areas prone to traffic congestion.

To facilitate efficient and cost-effective collection and transportation, ULBs should develop a proper strategy for deployments of collection and transportation vehicles. Table 2.4 and Table 2.5 below show some indicative models of deployment for collection and transportation vehicles for various quantities of MSW. Therefore, during MSWM plan preparation, most suitable solutions need to be tailored according to the local condition. As mentioned, it is important to design the system only on the basis of real data on waste quantities and waste composition.

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

Table 2.4: Municipal Solid Waste Management Plan for Municipal Councils and A, B, C Class Cities[20, 21]

APPROXIMATE POPULATION	ULB GENERATING TONNES/DAY	PRIMARY DOORSTEP SEGREGATED COLLECTION EQUIPMENT AND VEHICLES	SECONDARY COLLECTION OF STREET WASTE EQUIPMENT AND VEHICLES	DECENTRALISED OR CENTRALISED PROCESSING, RECOVERING AND RECYCLING	WASTE DISPOSAL AT COMMON/REGIONAL LANDFILL
Up to 50000	2.0–2.5 TPD per 10,000 population	Door-to-door collection services through containerised handcarts or tricycles 2 bins for storage of wet waste and dry waste 10-15 l capacity domestic bins, one of them with lid (as per CIPET specifications) 2 community bins of 60 l capacity (20–30 kg) or 120 l capacity (40–60 kg) or 240 l capacity (80–120 kg) or 1.1 m^3 capacity (300–450 kg) Bulk generators at source requires 120 l (49 kg), 240 l (96 kg) bins Contract with private firm, RWA, and NGO, if possible	3–4 m^3 containers to be placed at the rate of 4 per km^2 area or 1 per 5,000 population Transportation of containers by tractor having container lifting device	Decentralised processing through composting or biogas technology for both biodegradable and recyclable waste collected from households, shops, etc. If no land is available for decentralised processing , town level processing must be done and direct transfer of waste collected from streets and drains to disposal site through tractors at the rate of 1 tractor per 10,000 population.	Inert only to be transported to common or regional landfill facility
50,000 to 100,000	10-30 TPD @ 250 gm/capita/day	80% households to be served by covered tractor or covered LCV for door-to-door collection at 1 vehicle per 1,500 households, shops, etc. 20% households to be served by tricycles with container for door-to-door collection or handcarts for narrow lanes at 1 tricycle per 200 units Direct transfer of waste from tricycle to tractor or LCV to processing facility	100% street sweeping waste to be collected in containerised handcarts and deposited in 3-4 m^3 containers Containers to be placed at 4 per km^2 area or 1 per 5,000 population. Containers to be lifted by tractors or twin bin dumper placers	50% decentralised processing of waste if suitable space is available If no space, domestic and trade waste to be processed at centralised facility with resource recovery	Inert only from the processing facility Street sweepings and silt from the drains may be landfilled

20 Reference Material on Municipal Waste Management for Urban Local bodies, All India Institute of Local Self Government, 2012 & Manual on Municipal Solid Waste Management, CPHEEEO, MoUD, GOI, 2000
21 Central Institute of Plastics Engineering & Technology

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Table 2.5: Municipal Solid Waste Management Plan for Municipal Corporations[22]

APPROXIMATE POPULATION	ULB GENERATING TONNES/ DAY	PRIMARY DOORSTEPS SEGREGATED COLLECTION EQUIPMENT AND VEHICLES	SECONDARY COLLECTION PLACE, EQUIPMENT AND VEHICLES	DECENTRALISED/ CENTRALISED PROCESSING, RECOVERY & RECYCLING	BULK TRANSPORTATION, LANDFILL DISPOSAL
1,00,000 to 5,00,000	25-150 TPD	75% door-to-door collection through covered LCV 25% door-to-door collection through containerised tricycles or handcarts from narrow lanes Direct transportation of waste to processing facility if distance is under 5 km, or transportation through compactors if distance of processing facility is longer Compactors to be deployed based on capacity of vehicle and volume or weight of waste	Street sweeping and silt from the drains may be collected in containerised handcarts and taken to secondary storage depot having 1.1–4.0 m^3 metal containers. Containers to be placed at 4 per km^2 area or 1 per 5,000 population. Containers to be lifted by twin bin dumper placers or refuge collector or compactor machines. Dumper placers and compactors based on capacity of vehicle and volume or weight of waste	100% door-to-door collected waste to be processed at decentralised sites if available, or processed at one facility Composting, biogas, or RDF facilities may be created.	Inert street sweeping, silt from the drains, and residual waste from processing plants to be landfilled
Population between 5- 10 lakhs	150-400 TPD	75% door-to-door collection through covered LCV 25% door-to-door collection through containerised tricycles or handcarts from narrow lanes Direct transportation of waste to processing facility if distance is under 5 km, or transportation through compactors if distance of processing facility is longer Compactors to be deployed based on capacity of vehicle and volume or weight of waste	Street sweeping and silt from the drains may be collected in containerised handcarts and taken to secondary storage depot having 1.1–4.0 m^3 metal containers. Containers to be placed at 4 per km^2 area or 1 per 5,000 population. Containers to be lifted by twin bin dumper placers or refuse collector or compactor machines. Dumper placers and compactors to be deployed based on capacity of vehicle and volume or weight of waste	100% door-to-door collected waste to be processed at decentralised sites if available, or processed at one facility Composting, biogas, or RDF facilities may be created.	Inert street sweepings, silt from the drains, and residual waste from processing plants to be landfilled

22 Reference Material on Municipal Waste Management for Urban Local bodies, All India Institute of Local Self Government (2012).

Table 2.5: Municipal Solid Waste Management Plan for Municipal Corporations [contd.]

APPROXIMATE POPULATION	ULB GENERATING TONNES/ DAY	PRIMARY DOORSTEPS SEGREGATED COLLECTION EQUIPMENT AND VEHICLES	SECONDARY COLLECTION PLACE, EQUIPMENT AND VEHICLES	DECENTRALISED/ CENTRALISED PROCESSING, RECOVERY & RECYCLING	BULK TRANSPORTATION, LANDFILL DISPOSAL
Above 10 lakhs	400 TPD & above	75% door-to-door collection through covered LCV 25% door-to-door collection through containerised tricycles or handcarts from narrow lanes Direct transportation of waste to processing facility if distance is under 5 km, or transportation through compactors or transfer stations if distance of processing facility is longer Compactors to be deployed based on capacity of vehicle and volume or weight of waste Large containers of more than 10 t capacity with hook loaders may be deployed at transfer stations for bulk transfer of waste through processing or disposal facility.	Street sweeping and silt from the drains may be collected in containerised handcarts and taken to secondary storage depot having 1.1–4.0 m^3 metal containers Containers to be placed at 4 per km^2 area or 1 per 5,000 population. Containers to be lifted by twin bin dumper placers or refuse collector or compactor machines. Dumper placers and compactors to be deployed based on capacity of vehicle and volume or weight of waste	100% door-to-door collected waste to be processed at decentralised sites if available, or processed at one facility. Composting, biogas, or RDF facilities or waste-to-energy power plants may be installed, as power plants will not be viable if the waste is less than 500 TPD.	Inert street sweepings, silt from the drains, and residual waste from processing plants to be landfilled

2.3.12.1 MANAGEMENT INFORMATION SYSTEM FOR WASTE TRANSPORTATION

Advanced information management, mapping, and communication technologies may be used for efficient MSWM, such as:

- Management Information System (MIS)
- Geographic Information System (GIS)
- Global Positioning System (GPS)
- Radio Frequency Identification (RFID)
- General Packet Radio System (GPRS)

Simple as well as advanced management information systems (MIS)—e.g., geographic information system (GIS), Global Positioning System (GPS), radio frequency identification (RFID), and general packet radio services (GPRS)—are important tools for ULBs to manage MSW in large and mega cities (refer to Section 6.1.3 of Part II). It is essential for the head of the SWM department as well as the head of the ULB to be informed of the day-to-day performance of the SWM service, the service being very vital for maintaining the health and well-being of the people.

As part of the larger MIS, daily reports on some aspects of the MSW transportation system need to be complied in order to take stock of existing performance and take corrective measures as and when required, such as:

- the number of sanitary workers with their proper roles and responsibilities laid out, daily reporting of supervisors and drivers that are on contractual basis as well as prior substitute arrangements for those absent to avoid backlog of work;
- vehicles and equipment reporting on duty and performing the expected function, number of vehicles off the road on account of breakdown;
- quantity of waste transported, treated, and disposed at the treatment or processing facilities and at landfill; and
- arrangements made or proposed for clearing breakdowns.

Information on the following is required for a basic MIS: (i) waste generation and composition; (ii) staff position and staff requirements; (iii) specific engagement with NGOs, SHGs, community authorities, and other organisations; (iv) recovery of user fees; (v) location of waste storage depots; (vi) number of vehicles, their capacities and types; (vii) number of bins; and (viii) location and capacity of waste processing and disposal sites.

These data coupled with spatial data may be used in GIS software to maintain and manage the waste transportation and processing system. A GPS can be synchronised with the GIS to monitor and track waste transportation vehicles and identify any irregularities in waste movement (refer to Section 6.1.1 and 6.1.2 of Part II).

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Effective Collection and Transportation System to Manage Municipal Solid Waste in Surat

Year of Start: 1995 and scaled up in 2007

Main players: Surat Municipal Corporation (SMC), PPP contractor, Resident welfare associations.

Approach: Surat, the industrial hub and trade capital of Gujarat is one of the fastest growing cities in the state. Owing to its economic importance, the population of Surat continued to grow over the years and increased eight fold in the last four decades. However, the city infrastructure could not keep pace with its population increase leading to inadequate service provision, poor sanitation conditions, unhygienic surroundings thereby impacting public health. This sporadic development and lack of basic services and infrastructure led to an outbreak of plague in the year 1994 claiming many lives. The major cause of the plague was considered to be ineffective management of waste, which led to the blockage of storm water drains resulting in flooding of the fringe areas of the city.

As plague was considered to be a manifestation of the service inabilities related to solid waste and drainage management, the Surat Municipal Corporation assessed the issues and challenges of city administration and carried out major administrative as well as technical reforms for improving the overall system. The following approach was adopted for bringing about significant improvements in the solid waste management system:

- Administrative and financial reforms were carried out along with the rearrangement of the six zones of waste management into 52 sanitary wards for better control of waste collection
- Introduction of centralised complaint redressal system in order to create a responsive waste management system.
- Slum improvement operations were undertaken with the assistance of NGOs.
- Introduction of daily monitoring system for enhancing waste collection and its efficiency.
- Ensuring cleanliness and street sweeping round the clock at nuisance spots.
- Engaging private contractors for collection and transportation of waste to the disposal site, as well as sweeping and scrapping all major streets during the night time.
- Identification and selection of vehicle based on the width of the road and route provided.
- Introduction of Time Place Movement for the collection and transportation system wherein collection vehicles have to move in accordance with the provided time schedule, areas of coverage and number of units.
- Establishment of bulk garbage collection systems for hotels, commercial establishments, slaughterhouses that will collect waste in separate shifts suiting their requirement and timings.
- Massive community meetings were organised by SMC to disseminate the details of the collection system and its functioning.

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Outcome:

- More than 90% of coverage of SWM services in Surat and collection of waste from the households.
- Timely collection of waste from every household/ shops on daily basis.
- Effective and timely redressal of complaints by the ward supervisors for non-delivery of service.
- Installation of GPS systems on all the vehicles in order to track and improve the collection and transportation efficiency of the vehicles.
- Overall environmental improvement and aesthetic value of the city.
- Skill development and capacity building of the ground staff and contractors engaged in collection of solid waste was undertaken when the system was introduced.

Success factor:

- Strategic planning and revisiting/ assessing the existing situation.
- Proactive role of SMC to streamline and monitor the collection and transportation system.
- Capacity building of SMC staff, contractors, vehicle drivers and workers prior to the installation of the system.
- Collection of waste at a stipulated time by the contractors.
- The real time tracking of the vehicles through time place movement chart and GPS systems.
- Intensive campaigning and interaction of officials with citizens regarding the proposed door to door collection system.

Overall sustainability:

Collection of user charges has resulted in the financial sustainability of the project. Surat Municipal Corporation has started collecting user charges towards various services like water, sewerage, solid waste and street lighting. It is being collected once in a year along with the property tax bill. The user charges collected through these services meet the O&M cost of the services. The efficiency of tax collection is also more than 90%. Apart from this, there is a well-defined system of collection of administration charges towards various offences like littering garbage, absence of garbage collection bins, open burning etc.

Source: SMC

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2.3.12.2 MANAGEMENT OF CONTRACTS FOR WASTE COLLECTION AND TRANSPORTATION

Municipal authorities might involve private sector to ensure efficient service delivery and to bring in expertise and finances that may not be available with the ULB. Collection and transportation of waste can be entrusted to a private contractor partly or fully. It is essential to identify the exact services to be rendered through private sector participation. This can be done by determining the (i) number of households, shops, and establishments to be served; (ii) frequency of service; (iii) time of service delivery; (iv) type and level of service; (v) type and capacity of vehicles to be used; and (vi) distance from service area to transfer station or processing and disposal site. It is also essential to set up a mechanism for measuring the performance of the contractors and decide the mode of payment.

The contractor should keep all vehicles and equipment deployed for performing the services in good working conditions. The contractor must also ensure efficient, inclusive, and fair treatment of its workers, keeping in view the health and safety aspects in conformity with national and international guidelines and standards. Specific requirements for women workers, such as provision of crèches (day care centres) and linkages to anganwadis (courtyard shelter) in the nearby community, should be encouraged.

It is necessary to develop a proper contract management and monitoring system before contracting private firms (for details, refer to Section 5.3 of Part II.

2.4 STREET CLEANING

Street cleaning is a fundamental service ensuring clean and hygienic urban conditions. Generally, households, commercial entities, and transport operators should be made responsible for garbage minimisation on the streets. Street wastes include paper, plastics, dirt, leaves, and other vegetative matters. Manual sweeping is commonly practiced in India, as many streets are congested and narrow. Inefficient waste collection systems coupled with public littering significantly contribute to waste piles on the streets.

A wide variety of tools, equipment, and methods (both manual and mechanical) are available for street sweeping. Through the introduction of efficient methods of combining manual and mechanical sweeping, municipal authorities can achieve significant savings.

2.4.1 SOLID WASTE MANAGEMENT RULES, 2016 - REQUIREMENTS ON STREET CLEANING

As per SWM Rules, 2016:

Clause 15: Duties and responsibilities of local authorities:-

(k) direct street sweepers not to burn tree leaves collected from street sweeping and store them separately and handover to the waste collectors or agency authorised by local body;

(n) collect separately waste from sweeping of streets, lanes and by-lanes daily, or on alternate days or twice a week depending on the density of population, commercial activity and local situation;

(o) set up covered secondary storage facility for temporary storage of street sweepings and silt removed from surface drains in cases where direct collection of such waste into transport vehicles is not convenient. Waste so collected shall be collected and disposed of at regular intervals as decided by the local body;

Manual handling of wastes is prohibited. However, if unavoidable due to constraints, manual handling should be carried out under proper precautions with due care for health and safety of workers. Workers should be provided with protective gear such as uniforms, shoes, gloves and other implements etc., for their safe and easy working. They should be subjected to periodic health checks and should be provided with social security benefits including health insurance.

2.4.2 PLANNING FOR STREET CLEANING

Both manual and mechanical street cleaning are possible. However, manual street cleaning is preferred in narrow, congested streets and in streets where the road carpeting is damaged

It is necessary to have a well-planned, time-bound daily system for street sweeping including adequate staffing and equipment. Street sweepers should be instructed to report daily for duty at a designated location, which could be the nearest municipal ward office or an office space identified by the commissioned contractor. However, it should be ensured that such location will have a provision for storing street sweeping equipment. The location may also serve as an office for the supervisor. Table 2.6 below shows some important aspects for the planning of street cleaning and Table 2.7 gives the different areas in a city and their required cleaning frequencies and scheduling.

Table 2.6: Street Sweeping Norms for Small towns or Small Cities or Mega Cities[23]

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

2.4.2.1 STREET CLASSIFICATION AND STREET CLEANING FREQUENCY

Streets are classified based on their location, traffic intensity, type of street surface, character of area (e.g., commercial or residential), etc. Based on street classification, the frequency of service for street sweeping may be determined (Table 2.7).

23 Manual on Municipal Solid Waste Management (First Edition), Central Public Health and Environmental Engineering Organisation (CPHEEO), 2000, Ministry of Urban Development.

Table 2.7: Typical Classification of Streets and Frequency of Sweeping[24]

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

Planning an effective street sweeping system requires classification of streets, according to the required frequency of sweeping. The classification may be based on location, traffic intensity, type of street surface, character of area (e.g. commercial or residential), etc.

In cities and towns where doorstep collection of waste is ensured, the frequency of road sweeping can be reduced, especially in low-density and low-traffic areas

ULBs should adjust the frequency of street cleaning based on local conditions. Also, the time of street cleaning should be carefully defined to avoid conflicts with traffic, parked vehicles, and pedestrians. The service should be carried out preferably during hours of less activities in the streets, e.g., early morning and at night. Night time service is only advisable on well-lit main or commercial roads, mainly because street cleaning activities can disturb residents and could be potentially dangerous, especially for women workers. ULBs should ensure the safety of all workers at night by providing them with appropriate personal protective equipment (PPE). Should women be engaged, sufficient protection is to be provided to ensure that they are not harassed by strangers, police or law enforcers, or other members of the community. Workers should also be provided with proper uniforms with definite colour code, which have reflectors (for the night work), along with ID cards. This would ensure that workers are recognised and have proper access to protection officers or police if required. Constant checking and regulatory mechanisms should be put in place to ensure that all workers are safe from all forms of harassments, dangers, and accidents. Adequate protection should be afforded to women working at night through deployment of constables or patrol teams who should be informed of how many women at any given time would be engaged in work on particular streets.

Street sweeping in residential areas may be carried out in two spells—5 hours in the morning and 3–4 hours in the afternoon. Staff involved in street sweeping should also be responsible for cleaning drains (up to 18 inches depth), along the same "beat." Multiple handling of wastes should be avoided. The local sanitary inspector should be responsible for inspecting and maintaining records on the extent of service provision.

24 Manual on Municipal Solid Waste Management (First Edition), Central Public Health and Environmental Engineering Organisation (CPHEEO), 2000, Ministry of Urban Development.

ULBs can adopt different strategies for tourist places, where many people are present almost at all hours. In such places, regular cleaning throughout the day (2–3 times) and during weekends and national holidays may be necessary.

2.4.3 MANUAL STREET CLEANING

Manual cleaning involves sweeping and collection of waste by sanitation workers from streets, roads, lanes, by-lanes, and public places. Street sweeping normally includes cleaning the road surface and footpaths on both sides of the road. All waste from street sweeping should be transported separately without mixing with domestic or any other commercial establishment waste. This is to ensure efficient waste processing and to avoid mixing of inert with other waste, thereby minimising the burden of segregation and facilitating efficient waste processing.

Ideally, street sweepings and silt collected from drains should be transferred from the wheel barrows to a designated black storage bin or container placed at the waste storage depot. Depending on the type of road and activity on the road, the size of the bins may be decided. These bins should be regularly lifted by municipal authorities before bins start overflowing and taken to waste processing facility for further processing (sand recovery facility, if available) and reuse or for disposal at the landfill site.

2.4.3.1 TYPE OF STREET CLEANING EQUIPMENTS

Use of appropriate tools plays an important role in improving work efficiency. Equipment for manual sweeping should be relatively light and easy to handle for both men and women to ensure that workers do not expend disproportionate energy in wielding such equipment. Local authorities should apply modern technology where appropriate and should also organise training and capacity building programmes for their staff.

Commonly used equipment for street cleaning are the following.

Long handled brooms: They cause less strain and support correct posture. An adequate type uses bunches of filaments inserted into a wooden stick. The length of the broom should be such that the male and female workforce can use it comfortably, without bending. The handle should not be heavy. The filaments should be tightly spaced to facilitate easy collection of fine silt and dust, leading to efficient cleaning of streets. There are two types of long handled filamentous broom used by municipal staff in India (Figure 2.16).

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Brooms with sufficiently long handles allow for easy removal of street sweepings and dust

- **Fan-shaped filament broom:** The filaments of the broom fan out, removing litter from the streets but leaving behind sand and silt.
- **Bunched filament broom:** The filaments are bunched together to facilitate removal of litter, sand and silt from the streets.

Figure 2.16: Fan-shaped and Bunched Filament Brooms (Delhi Model)



A typical long handled filament broom may consist of the following specification (as per Delhi model):

- Length of the broom: 80–85 cm
- Weight of the broom: 1kg
- Binding material: 20 gauge MS sheet ring having width of 1.5–2.0 cm
- Handle of the broom: bamboo of 135 cm length, 3–4 cm diameter
- Weight of the bamboo handle: 900g (approximately)

Shovels: Heaps of street wastes gathered by brooms have to be picked up and placed in a container. The conventional tool for this purpose is a large straight-blade shovel or metal plate and metal tray. However, when the waste comprise large quantities of light materials such as leaves, a shovel is ineffective because dried leaves fall of or are blown away during transfer. A solution is a pair of flat boards, usually plywood, between which the waste is retained by hand-pressure.

Handcarts: Handcarts facilitate transportation of street waste. Handcarts should have four to six detachable plastic containers with a capacity of 25–40 l each to allow easy transferring of waste into community waste storage bins. It must have sealed ball bearings and handles having a crossbar up to navel height, and its wheels should have rubber strips or tyres for ease of handling and minimising fatigue.

2.4.4 MECHANISED STREET CLEANING

Generally, mechanised street cleaning equipment have a driving unit attached with brushes for dislodging sticking material. They may also be equipped with a water tank and sprayers to loosen particles and reduce dust. A vacuum system or conveyor system transfers waste from the street to the storage receptacle. There is a wide range of mechanised street cleaners available in the market. Equipment should be chosen carefully, taking into account the street conditions and needs of the city, reliability, ease of procurement of spare parts, investment cost, and operation and maintenance costs.

2.4.4.1 MECHANICAL BROOM SWEEPER

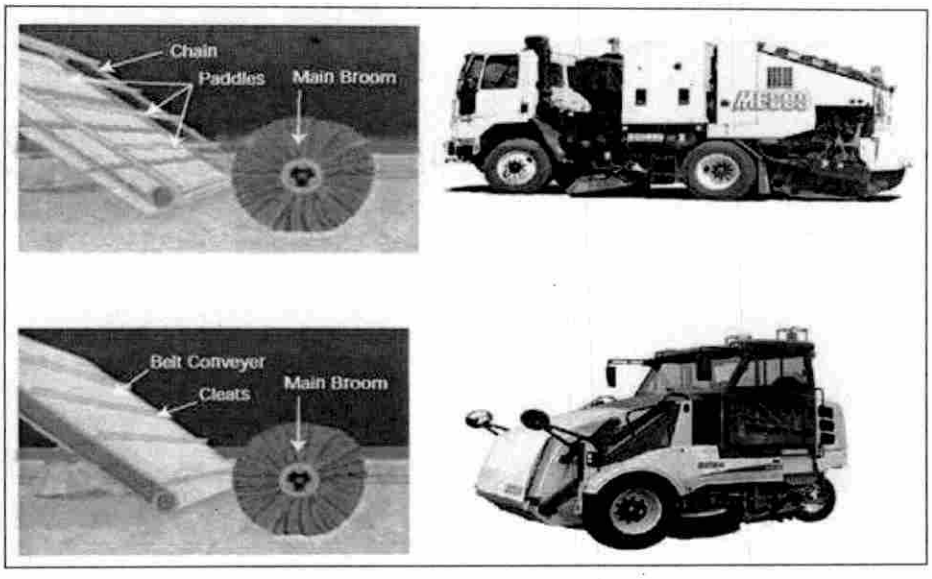
A mechanical broom sweeper (Figure 2.17) is designed to remove standard road waste, using various kinds of circulating brushes that sweep material onto a conveyer belt and then into bins. Mechanical broom sweepers use a gutter broom which displaces debris from the curb into the path of the main broom, which is attached to a conveyer belt. Mechanical broom sweepers have an ability to pick up large debris such as plastic bottles, cans, wet vegetation, gravel, and coarse sand. They are also effective in removing packed dirt from roadways. However, they are ineffective in picking up fine material.

ULBs should make well-informed decisions while choosing mechanical sweepers and should consider local conditions, investment cost, and operation and maintenance costs

Mechanical broom sweepers have lower energy demand than regenerative sweepers and vacuum sweepers. Gender stereotyping associated with driving should be avoided; women should also be encouraged to drive and provided with training.

The lower powered mechanical broom sweepers are more suitable for large, flat, paved surfaces like shop floors, industrial floors, etc.

Figure 2.17: Mechanical Broom Sweeper[25]

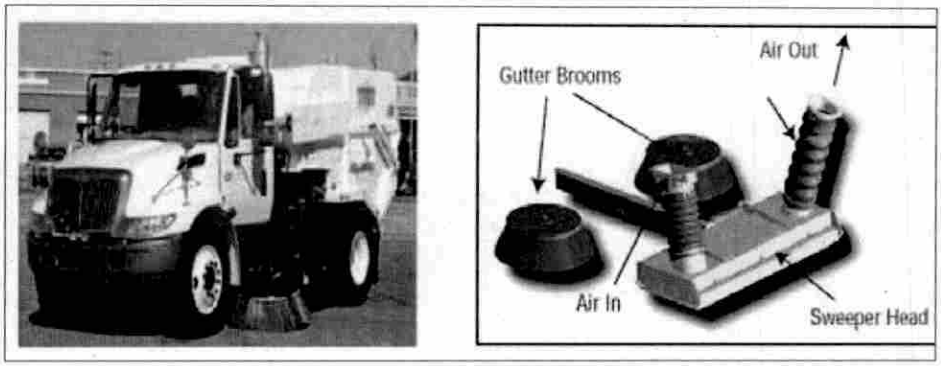


2.4.4.2 REGENERATIVE AIR SWEEPER

The regenerative air sweeper (Figure 2.18) uses a broom to collect large debris or waste. It also uses forced air and high power vacuum for the collection of fine material. It blows high pressure air onto the road to loosen very fine sediment. A vacuum suction lifts all particles and captures them in a hopper. Regenerative air sweepers can remove fine sand and dust, provided the surface is dry. They contribute to preventing air pollution by capturing fine sand particles. They have relatively higher energy consumption compared with the mechanical broom sweeper, and are quite expensive. However, they can clean a wider path and limit the amount of dust-laden air that is exhausted back into the atmosphere. They are also able to pick up large debris, since the blast of air is able to dislodge material and get them into the airflow stream that is created by the suction. But regenerative air sweepers are more productive on flat roads, and their performance may not be satisfactory for most of the Indian roads. Such machines need the requisite power to create an effective vacuum environment which is also facilitated when the surface it operates upon is relatively flat and there are no unpaved shoulders along the road. Also, potholes need to be repaired promptly to enable smooth working.

25 Resource for Implementing a Street Sweeping Best Practice, Local Road Research Board, Department of Transportation, Minnesota, 2008.

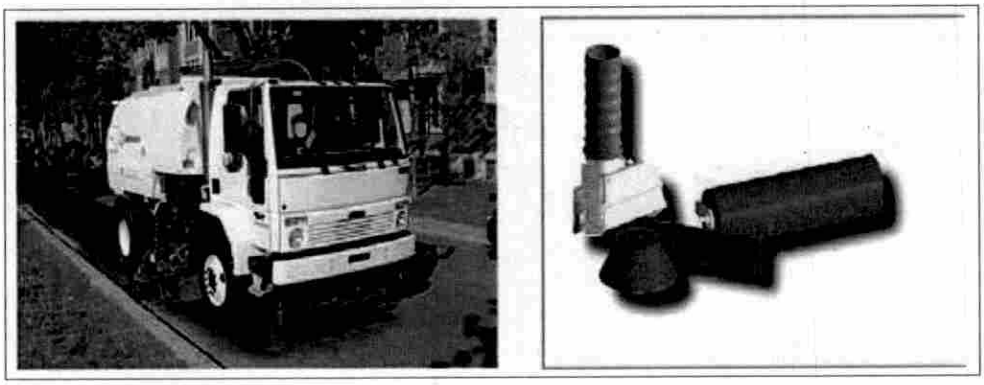
Figure 2.18: Regenerative Air Sweeper[26]



2.4.4.3 VACUUM SWEEPER

A vacuum sweeper (power sweeper machine) uses a broom to move debris towards the vacuum nozzle. Typically, there is a suction inlet on one side of the sweeping head, and the "used" air is constantly exhausted during the sweeping process (Figure 2.19). There are various types of vacuum sweepers based on the location of the vacuum nozzle. Vacuum sweepers utilise a fan that exhausts air directly to the atmosphere and uses water for dust suppression. They can vacuum material from channels and gutters and collect fine particles from within cracks, but cannot pick up large debris like tree trimmings and disposed packaging. However, since there is no vacuum suction beneath the broom, the area of the road under the broom may still retain fine material. Even though vacuum sweepers use water-based dust suppression systems, they exhaust a high level of particulates into the atmosphere on a continuous basis.

Figure 2.19: Vacuum Sweeper and Vacuum Nozzle[27]



There are two types of vacuum sweepers available in the Indian market:

- **Chassis mounted:** The power sweeping unit with container is mounted on a vehicular chassis with hydraulic motors and power controls for driving brushes, suction unit, and jet washing, with auxiliary engine

26 Ibid.
27 Ibid.

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carrying out these functions, whereas the automobile chassis engine drives the vehicle. The payload capacity of power sweeping machines is approximately 4,000–5,000 kg with a 4–6 m^3 stainless steel or higher grade container for storage of sweeping wastes.

- **Self-propelled:** The self-driven power sweeping machine (Figure 2.20) is a composite vehicle with a container, hydraulic motor, and power controls for driving brushes, suction unit, and jet washing. The payload capacity ranges from 2,000–3,000 kg in a container of 1.75–2.50 m^3. This is relatively a small machine which can be deployed on both narrow and wide roads. Two side brushes throw dust towards a main or inner broom which finally transports dust into a central hopper.

Mechanised sweepers with a capacity of 1.85 m^3 and three front brushes are capable of working at two levels and can be used to clean footpaths as well. An attached vacuum wander hose can collect heavy material. An attached sprinkling bar can be used for washing streets.

Figure 2.20: Self-propelled road sweeping machine[28]



Using one self-propelled vacuum sweeper and one chassis mounted vacuum sweeper in conjunction will yield the best results and can cover a total of 50 km in two 8-hour stretches

The following operational conditions should be considered for mechanised street sweeping:

- It is essential to work mechanised sweepers in two shifts minimum to ensure economic viability.
- One skilled operator and one semi-skilled cooperator are required to operate a mechanised sweeper.

28 Source taken from Manufacturer

- Given that the machine will not be able to clean all odd and uneven places, an additional group of four manual sweepers may also need to be deployed with every power sweeper.
- Typical fuel efficiency of a mechanised sweeper is 1.5–2.0 km per l and lower, if road conditions are not conducive or in places of heavy littering.
- All brushes are to be replaced or refurbished after nearly every 1,000 km of sweeping operations (7–10 days actual operations in two shifts).

Collected sweeping is to be unloaded into containers and transported to the disposal place in a separate vehicle other than the mechanical sweeper.

2.4.4.4 FINANCIAL IMPLICATIONS OF MECHANISED STREET CLEANING

The total cost of mechanised street cleaning or sweeping includes the purchase cost of the machine, annual cost of operation and maintenance, cost of disposing the debris, and wages of the driver and helper. It is also necessary to consider efficiency, average life, and availability of spare parts and the presence of authorised garages for maintenance of the machine before buying the product, so that improvement in street cleaning services would not result in unexpected costs.

For Assisting the ULBs in Selection of an Appropriate Power Sweeper

The selection of the type of sweeper will depend on specific conditions of roads targeted for sweeping. In general, mechanical sweepers are more effective at picking up large debris and cleaning wet streets and have lower capital and operating costs. However, mechanical sweepers can create large amounts of airborne dust. Vacuum-assisted and regenerative air sweepers are more effective in removing fine particles and associated heavy metals but tend to be ineffective for cleaning wet streets. They are effective in areas where respirable particulate matter is a cause of concern. They may also be noisier than mechanical sweepers.

Compared to mechanical broom sweepers and air regenerative sweepers, vacuum sweepers are more effective but also more expensive. However, given their high performance rate in comparison with the other two options, vacuum sweepers yield substantially better cost efficiency in most cases.

2.4.5 CLEANING OF SURFACE DRAINS

In many cities there are open surface drains along the roadside, which needs to be cleaned regularly to permit free flow of storm water or grey water. MSWM authorities should ensure through campaigning, statutory regulations, and monetary fines that citizens and sweepers

In order to ensure that sweepers do not dispose waste into drains, same staff that is responsible for cleaning street should be made responsible for cleaning adjacent drains as well

do not dispose waste into drains. A further approach to prevent this is to make the same staff responsible for cleaning streets as well as adjacent drains up to a depth of 45–60 cm. The solid waste dumped in storm drains should be collected by drain cleaners and disposed off, along with drain cleaning and street sweeping material, in a municipal sanitary landfill because of a high possibility of contamination.

The staff requirement for drain cleaning depends on the length of drain. As a general rule, one person can clean up to 500 m of a shallow surface drain (not more than 45–60 cm) per day. This could be adjusted based on local conditions. Tools which meet proper safety standards for waste transfer, such as safety equipment and vehicles, should be given to the drain cleaners. Generally, light shovels and handcarts are required for drain cleaning. The equipment for surface drain cleaning does not differ much from the street cleaning equipment.

The removal of silt from surface drains or storm water drains deeper than 60 cm and manholes should be done by the engineering division of the local authority. It is advisable to explore new technologies like suction pumps loaded onto trucks (Figure 2.21) for removal of silt from manholes to avoid manual scavenging.

Figure 2.21: Truck Mounted with Pressure Water Jetting and Suction Machine[29]



2.4.5.1 SILT MANAGEMENT

Clause 15: Duties and responsibilities of local authorities:-

(n) collect separately waste from sweeping of streets, lanes and by-lanes daily, or on alternate days or twice a week depending on the density

29 Bhopal Municipal Corporation

of population, commercial activity and local situation;

(o) set up covered secondary storage facility for temporary storage of street sweepings and silt removed from surface drains in cases where direct collection of such waste into transport vehicles is not convenient. Waste so collected shall be collected and disposed of at regular intervals as decided by the local body;

If the street sweepings contain biodegradable or recyclable waste, such waste shall be segregated and sent to respective processing facility". The silt collected from surface drains should not be allowed to stay on open roads or footpaths beyond 4 hours. Wet silt should be removed from the main roads in less than 4 hours and, in other areas, within 24 hours and should be directly transported to the landfill or be disposed at the waste storage depots in the black container to prevent nuisance and health hazards. This waste is not amenable for composting given the possibility of high contaminants and inert content in the silt.

Silt removed from surface drains and stored on the side of the drain should be collected as soon as possible and transported directly to the landfill

2.4.6 TRANSFER STATIONS

In large cities where disposal sites are more than 15 km away from the collection area, it is economical to set up transfer stations as tertiary storage depots to save transportation time and fuel. The transfer station or tertiary storage depot can also be equipped with a material recovery facility, where recyclables are sorted and sent for further processing or to recyclable markets. Transfer stations usually consist of large containers of about 15–25 m^3. A ramp facility can be provided to facilitate unloading of vehicles or dumper placer containers directly into large vehicles or containers kept at a lower level just below the ramp. The transfer station can also have the facility of a hopper, into which waste can be transferred, and then with the help of a static compactor, waste can be pushed into the large hauling vehicle or container.

Transfer stations should be set up in large cities where disposal sites are more than 15 km away to save on transportation time and fuel

Transfer stations are usually part of the waste management system in large cities like Delhi, Mumbai, Bengaluru, Kolkata, Ahmedabad, Coimbatore, Chennai, etc. The smaller municipal authorities should consider setting up simple transfer stations having a ramp facility for transfer of waste from a small vehicle or container to a large hauling vehicle. Only large cities should consider setting up large transfer stations to handle over 300 tonnes per day (TPD) of waste using static compactor facilities.

Consideration for setting up of transfer station:
- Small ULBs- simple transfer stations with a ramp facility
- Large ULBs- transfer stations to handle at least 300 TPD using static compacter facilities

General Rule of Thumb

- If the one-way travel distance to disposal is over 15 km or over 30 minutes, the need for transfer stations should be assessed.
- Transfer stations should be made only when the cost of direct haul in collection vehicles would outweigh the cost of supplemental haul in large bulk-haul transfer vehicles plus the cost of the supporting transfer system infrastructure at the transfer station and disposal site.

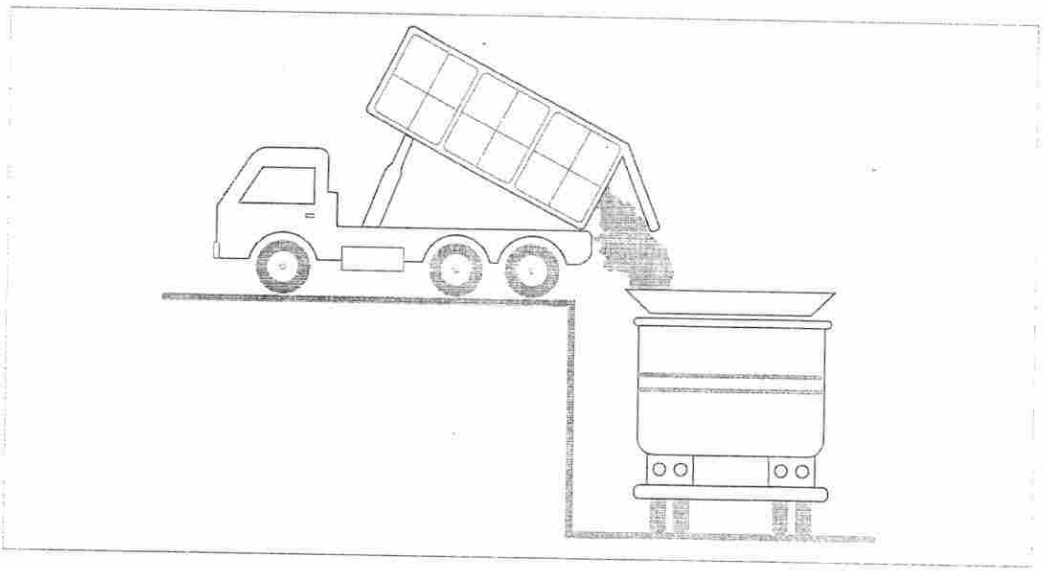
2.4.6.1 TYPES OF TRANSFER STATIONS

Waste is unloaded at a transfer station either directly into tertiary transport vehicles (direct unloading) or into a storage area. [30]

Direct Unloading: A direct unloading system involves a two-level arrangement, wherein the collection vehicles drive up a ramp to the upper level to discharge the waste into a transfer vehicle parked onsite or loading system as depicted in Figure 2.22.

Direct unloading systems require limited civil works and stationary equipment facilities, and are thus low-cost solutions for implementation and operation. However, the direct unloading system requires the availability of transfer vehicles at the transfer station to keep pace with the arrival of collection vehicles, so that no delays are caused in the collection operations. The direct unloading system is usually implemented only as a small-scale system, i.e., typically where the quantity of waste handled is less than 300 TPD. In most cities, collection vehicles arrive at the transfer station within 1 or 2 peak hours per shift. The size of the transfer fleet in a direct unloading system would have to meet these peak hour demands.

Figure 2.22: Direct Transfer Station[31]



In case of large-scale transfer station, discharge hoppers and transfer vehicles should be provided to make sure that collection trucks are never kept waiting

Unloading-to-Storage: An unloading-to-storage system involves collection vehicles discharging into a storage area. From the storage area, wastes are subsequently loaded into transfer vehicles. The storage area may be a platform on the same level as the unloading level, in which case only a two-level arrangement is required. The storage area may be

30 Transfer Station Design Concepts for Developing Countries [online]. Cointreau, S., [n.d]. Available at: http://siteresources.worldbank.org/INTUSWM/Resources/463617-1202332338898/transferdesignoptions.pdf

31 Toolkit for Solid Waste Management, 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

a pit, below the level of the unloading level or above the level on which the transfer vehicle is parked, in which case a three-level arrangement is required. The storage area is commonly designed to hold the peak quantity of waste generated in 1 day.

In the unloading-to-storage system, waste unloaded to a storage platform is pushed by a bulldozer (or wheeled loader) into a hopper or onto a conveyor. Waste unloaded to a storage pit is picked up by an overhead crane or pushed by a bulldozer to the receiving hopper. The crane or bulldozer operator visually inspects the waste during operation to set aside any waste which is potentially hazardous or could damage the transfer vehicle during loading (Figure 2.23 and Figure 2.24).

Figure 2.23: Stationary Compactor Transfer Station Design

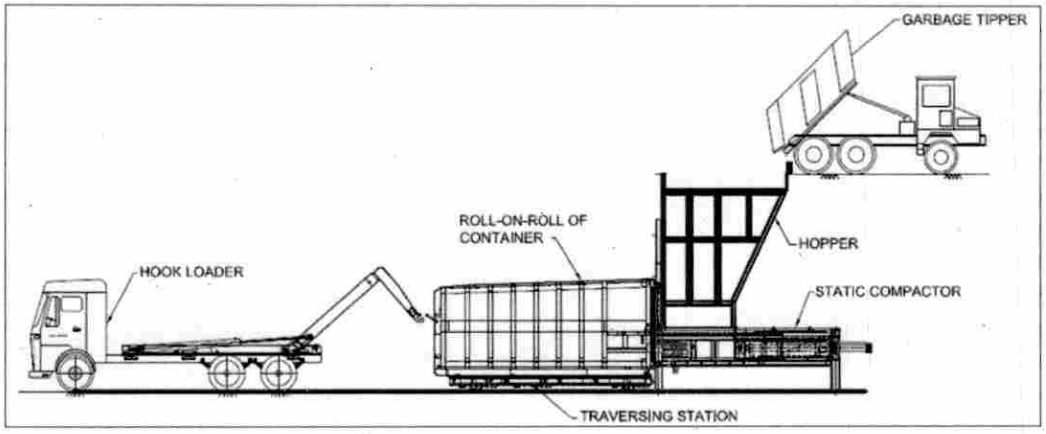
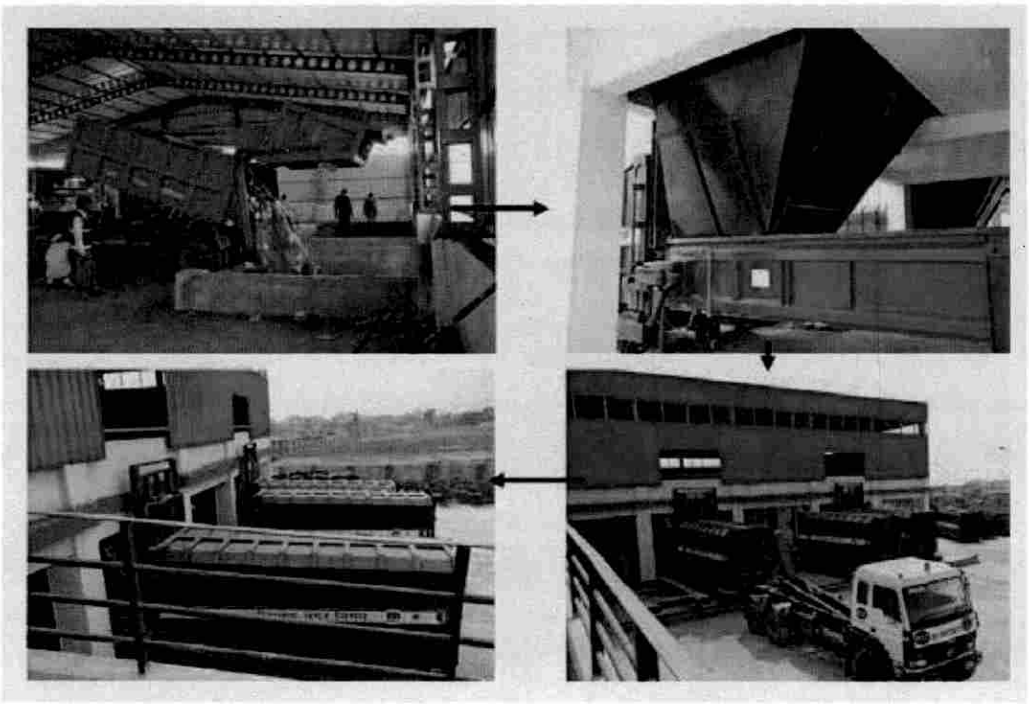


Figure 2.24: Typical activities at the Transfer Station[32]



32 Taken from Municipal Corporation of Faridabad

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Modern Waste Transfer Stations in Coimbatore

Modern municipal solid waste transfer stations are located in cities like Coimbatore and Surat. Coimbatore City has three modern transfer stations at Peelamedu, Sathy Road, and Ukkadam. All transfer stations have facilities to quickly unload the waste, compact it, and transfer it to the waste processing facilities. The transfer station has a split level building with a high roof suitable for monsoon operations. Waste is brought to the transfer station for loading into larger containers. These transfer stations are designed based on local conditions, with an aim to achieve maximum utilisation of space and, most importantly, to ensure a quick turnover of unloading and loading of waste.

The transfer station includes several equipment, such as heavy-duty high compaction compactor, hopper, charge box, load on loaders, and a trailer-type hook loader with a container of 20 cubic meters (m^3). The system is designed to process 200 tons (t) of compacted waste per day.

Transfer Station Capacity and Waste Loading Bay Arrangement

These transfer stations are initially designed for 200 tons per day (TPD) waste handling capacity. For these transfer stations, one stationary compactor with 35 tons per hour (TPH) throughput is provided initially. An additional bay to house a similar compactor for future augmentation will be provided. In addition, an additional bay without stationary compactor for loading the waste into open-at-top containers by direct deposition is provided. Each transfer station is able to handle more than 200 TPD of waste. The working shift coincides with the arrival of waste from 7 a.m. to 3 p.m. (varies as per the required condition).

As the waste quantity increases in peak hours, waste is directly loaded into open containers to match the increased waste quantity. The transfer station is at all times able to load the open containers without compaction. The advantage of this arrangement is that during downtime of the stationary compactor, the transfer station operations are able to continue without any disruption.

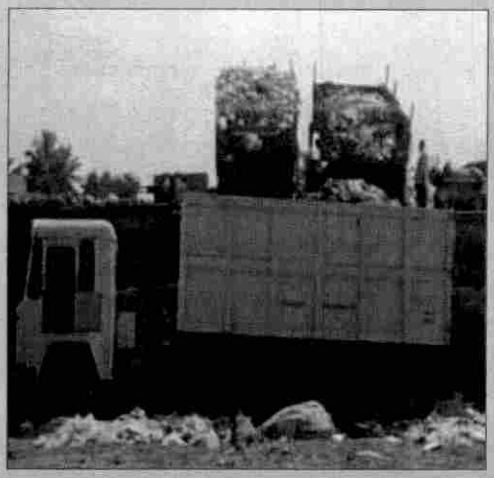
To facilitate unloading operations on the floor, a separate area with enough space for 1 hour storage, with a waste height of 0.5 m for peak hour waste arrivals (30 TPH), is provided on the upper deck portion of the transfer station. This facility, however, is used only under exceptional conditions.

Salient Features of a Transfer Station (Sathy Road)

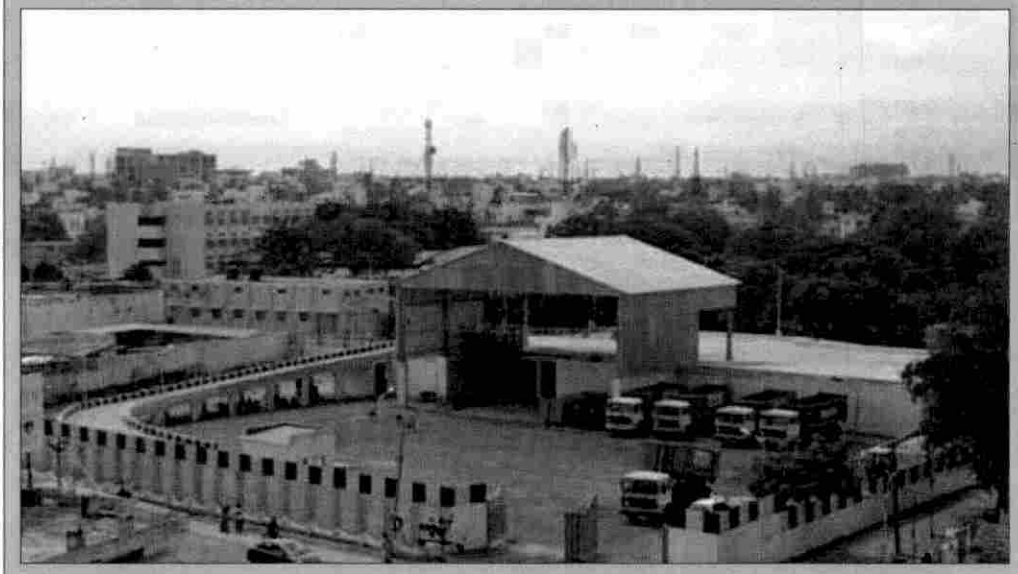
- Area of the site: 1.55 acres
- Designed capacity: 200 TPD
- Number of stationary compactor: 1
- Capacity of charge box or hopper: 3.34 m^3
- Round distance from transfer station to disposal site: 34 km
- Waste handled during peak hour (6:30 a.m. to 9:30 a.m.): 70 t
- System capacity: 35 TPH
- Capacity of computerised weigh bridge: 40 t

Site before commencement of work





Site after commencement of work



Source: Coimbatore City Municipal Corporation

2.5 ACTION POINTS FOR AWARENESS GENERATION THROUGH INFORMATION, EDUCATION, AND COMMUNICATION ACTIVITIES FOR 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.

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3

Technical Aspects of Processing and Treatment of Municipal Solid Waste

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3. TECHNICAL ASPECTS OF PROCESSING AND TREATMENT OF MUNICIPAL SOLID WASTE

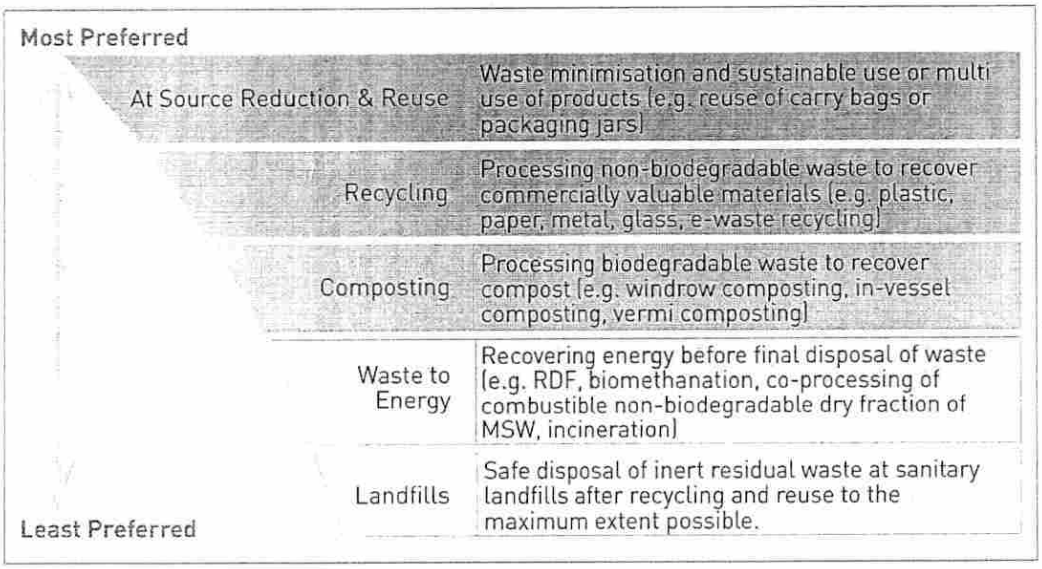
Municipal solid waste management (MSWM) and adoption of processing technologies depend largely on the quantity and characteristics of the total waste generated in an urban local body (ULB). A prerequisite for overall project implementation is the availability of the financial resources and in-house capacity of local authorities.

Integrated solid waste management (ISWM), as discussed Section 1.2 of Part II, is a strategic approach to manage municipal solid waste (MSW) in a sustainable manner by considering all aspects of MSWM, namely generation, segregation, transfer, sorting, treatment, recovery, and disposal in an integrated manner, with an emphasis on maximising resource use efficiency.

The least preferred option of ISWM is disposal of waste in landfills, where no landfill gas capture is planned. Normally, landfills that integrate the capture and use of methane are preferred over landfills that flare landfill gas.

However, Indian laws and rules do not permit disposal of organic matter into sanitary landfills and mandate that only inert rejects (residual waste) from processing facilities, inert street sweepings, etc. can be landfilled. In cases where old dumps are to be closed, there is a possibility of capturing methane gas for further use; which may be explored. However, repeated burning of the waste significantly decreases the potential of capturing methane.

Figure 3.1: Integrated Solid Waste Management Hierarchy[1]



The ISWM hierarchy ranks waste management strategies according to their environmental benefits

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

The sections below elaborate on MSWM processing technologies and disposal options in the order as specified by the ISWM hierarchy. And as mentioned, waste minimisation should be the prime objective of any waste management system in ULBs.

3.1 RECYCLING AND RECOVERY

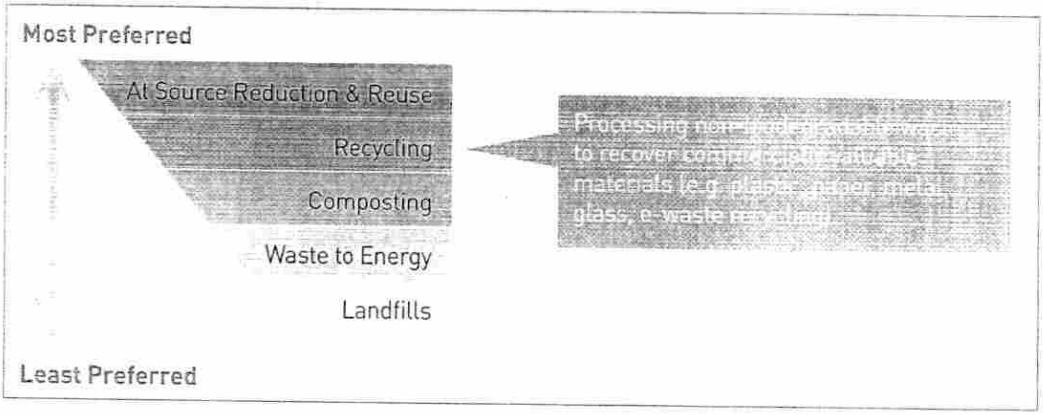
Preferential order of waste management options as per the ISWM hierarchy:

- At Source Reduction and Reuse
- Recycling
- Composting
- Waste to Energy
- Landfills

Solid Waste Management (SWM) Rules, 2016 defines recycling as "the process of transforming segregated solid waste into a new product or a raw material for producing new products." Further, it also states that "arrangement shall be made to provide segregated recyclable material to the recycling industry through waste pickers or any other agency engaged or authorised by the urban local body for the purpose."

According to the ISWM hierarchy, recycling is a preferred waste management strategy after source reduction and reuse. Recycling systems should be adopted before planning for any waste processing or treatment facilities. Figure 3.2 indicates the importance of recycling in the ISWM hierarchy.

Figure 3.2: Recycling in Integrated Solid Waste Management Hierarchy[2]



3.1.1 ADVANTAGES OF RECYCLING

Recycling diverts a significant fraction of municipal, institutional and bulk waste from being dumped or disposed in landfills. This results in saving of scarce resources as well as reducing environmental impacts and the burden of waste management on public authorities. If appropriate market mechanisms are established, recycling can generate revenues, contributing to the overall cost recovery for municipal solid waste service provision

- For the ULB:
  - Reduces waste volume.
  - Cost savings in collection, transportation and disposal.

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

- Longer life span for landfills.
- Reduced environmental management efforts.

- For the economy:
  - Reduction of imports of raw materials, fertilisers etc. and hence foreign currency required.
  - Livelihood opportunities for recyclers in the recycling industry.
- For the environment:
  - Sustainable use of resources
  - Reduced amount of waste going to storage sites and reduced requirement of land.
  - Reduced environmental impacts including impacts of climate change.



Recycling plays a vital role in reducing the quantity of waste, increasing resource recovery and minimising the financial and environmental burden of MSWM

3.1.2 ASSESSMENT OF RECYCLABLES - CHARACTERISATION AND QUANTIFICATION

As per data received from CPCB, it is estimated that urban India generated 1,43,449 metric tonnes of municipal solid waste per day in 2014-15. Of this waste 40-60% is organic and 10-20% is recyclables. This indicates there is a clear waste minimisation potential of 14,344 – 28,689 metric tonnes per day through recycling and recovery. Figure 3.3 is indicative of the typical waste fractions in municipal solid waste generated in India.

According to the Central Pollution Control Board (CPCB), urban India generates about 51 million metric tonnes of solid waste per year with a per capita waste generation rate of 0.2–0.6 kilogram per day (2014–2015).

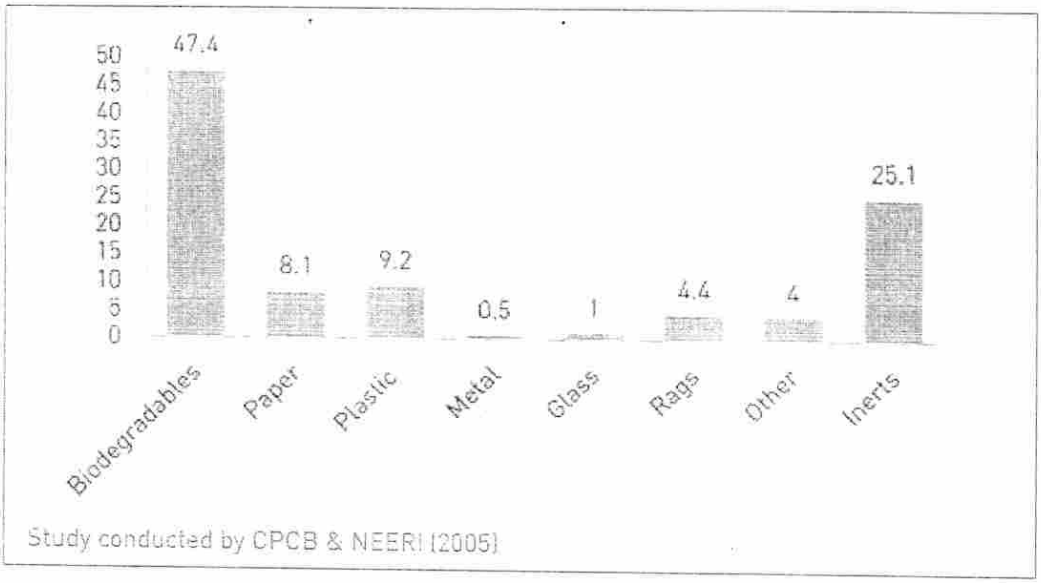
This India-wide assessment underlines the importance of recycling. However, this information is not adequate when designing material recycling strategies for a specific municipality

Recyclables mainly paper, plastic, metal, and glass can be retrieved from the waste stream for further recycling. Table 3.1 gives an overview of typical recycling material and their recycling potential.

Every strategy for recycling (as also for other steps of municipal solid waste management) should be based on a thorough waste analysis or characterisation in the respective city. Only based on this composition and quantification of municipal solid waste, a detailed estimation of the potential for recycling of different materials is possible. Methods for waste characterisation are described in Chapter 1 of Part II.

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Figure 3.3: Municipal Solid Waste Characterisation in India[3]



The composition of MSW depends on a large number of factors like food habit, culture, tradition, lifestyle, climate, and income. As depicted above, biodegradables make up 47.4% of the MSW stream. Metals and glass make up only about 1% each of the MSW stream because of their high potential for recycling. The inerts—street sweepings, drain silt, and construction and demolition (C&D) debris—make up 25% of the MSW stream as the street sweepings, drain silt, and construction and demolition debris eventually find their way into municipal solid waste.

Table 3.1: Important Recycling Material: Recycling Potential and Special Conditions

MATERIAL	RECYCLING POTENTIAL	SPECIAL CONDITIONS
Aluminium	• It has a high market value. • It can be recycled easily by shredding and melting. • It can be recycled indefinitely because it does not deteriorate through reprocessing. • It requires significantly less energy than producing aluminium ore.	• Separate collection is important
Batteries	• It recovers valuable metals. • It protects environment from heavy metals such as lead, cadmium, and mercury.	• There is a large variety in types and sizes of batteries. • Only some types allow adequate material recovery.

3 'Improving Solid Waste Management in India,' D. Zhu, et al., (2008). Available at: https://openknowledge.worldbank.org/bitstream/handle/10986/6916/425660PUB0Wast12732601OFFICIAL0USE1.pdf?sequence=1)

Table 3.1: Important Recycling Material: Recycling Potential and Special Conditions [contd.]

MATERIAL	RECYCLING POTENTIAL	SPECIAL CONDITIONS
Construction and demolition waste*	• Demolition waste can be sorted, crushed and reused for production of pavement material, flooring tiles, road construction, landscaping and other purposes. • Due to the amounts of demolition waste, its recycling allows significant reduction of otherwise required disposal capacities.	• Standards for recycled products are yet to be stipulated.
Glass	• It has a moderate market value. • It can be melted and sorted into colours. • Recycling glass saves energy compared with processing raw material. • It can be recycled indefinitely because it does not deteriorate through reprocessing.	• Broken glass can contaminate and eliminate opportunities for recycling of other material such as paper.
Paper and cardboard	• It is easily recycled. • Paper or cardboard from recycled paper requires less energy during production and helps protect the forests.	• Recycling potential is reduced with each recycling cycle through deterioration of fibres.
Polyethylene terephthalate (PET)**	• It can be recycled if segregated from other waste.	• Quality of recycled product decreases with every processing cycle. • Recycled products have specific designated uses and cannot be used for other purposes.
Other plastics	• Other plastics, such as polyethylene or polyvinyl chloride, can be recycled but have less value in the market than PET. The value depends on recycling and manufacturing options in the vicinity.	• Clean segregated plastics, are subjected to mechanical recycling into the same plastic type. • Where recycling is not possible due to mixed plastics, they are then co-processed for energy recovery or used as aggregates in road material.
Electronic waste	• It contains high value metals. • Electronic items can be dismantled and its components reused or recycled.	• If recycling is not carried out under controlled conditions, metal is often covered with polyvinyl chloride or resins, which are often smelted or burned, causing toxic emissions. • Disaggregation of electronic waste for recycling can be costly.
Metal (steel, copper, nickel, zinc, silver, etc.)	• Scrap metal has a high market value, especially steel, copper, and silver. • It can be recycled indefinitely because it does not deteriorate through reprocessing.	• High value metals, such as copper and silver, are incorporated in electronic devices, but extraction can cause severe environmental impacts, if uncontrolled.

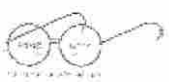


Table 3.1: Important Recycling Material: Recycling Potential and Special Conditions [contd.]

MATERIAL	RECYCLING POTENTIAL	SPECIAL CONDITIONS
Thermocol or Styrofoam	• It can be processed to recover fuel and other by-products • It can be re-ground with new expanded polystyrene for further use. • It can be powdered and made into sheets, which can be used to make furniture.	• Fuel production is through pyrolysis, gasification, and hydrocracking. • Regulated facilities with appropriate environmental controls are required for handling thermocol recycling

* For further detailed information refer Section 3.7 of Part II
** For further detailed information refer Section 7.4 of Part II

3.1.3 STAGES OF MATERIAL RECOVERY

The SWM Rules, 2016 defines "Materials Recovery Facility" (MRF) means a facility where non-compostable solid waste can be temporarily stored by the local body or any other entity mentioned in rule 2 or any person or agency authorised by any of them to facilitate segregation, sorting and recovery of recyclables from various components of waste by authorised informal sector of waste pickers, informal recyclers or any other work force engaged by the local body or entity mentioned in rule 2 for the purpose before the waste is delivered or taken up for its processing or disposal; Material recovery starts at the primary level, by households who segregate recyclables like newspapers, cardboard, plastics, bottles, etc. from waste to sell such material to local recyclers, scrap dealers or haulers. The item that cannot be sold to the kabadi system is discarded and becomes part of the MSW. Waste pickers pick up parts of this waste to earn their living. Well-segregated recyclables can directly be transferred to a processing site or to the recyclable market depending on local conditions.

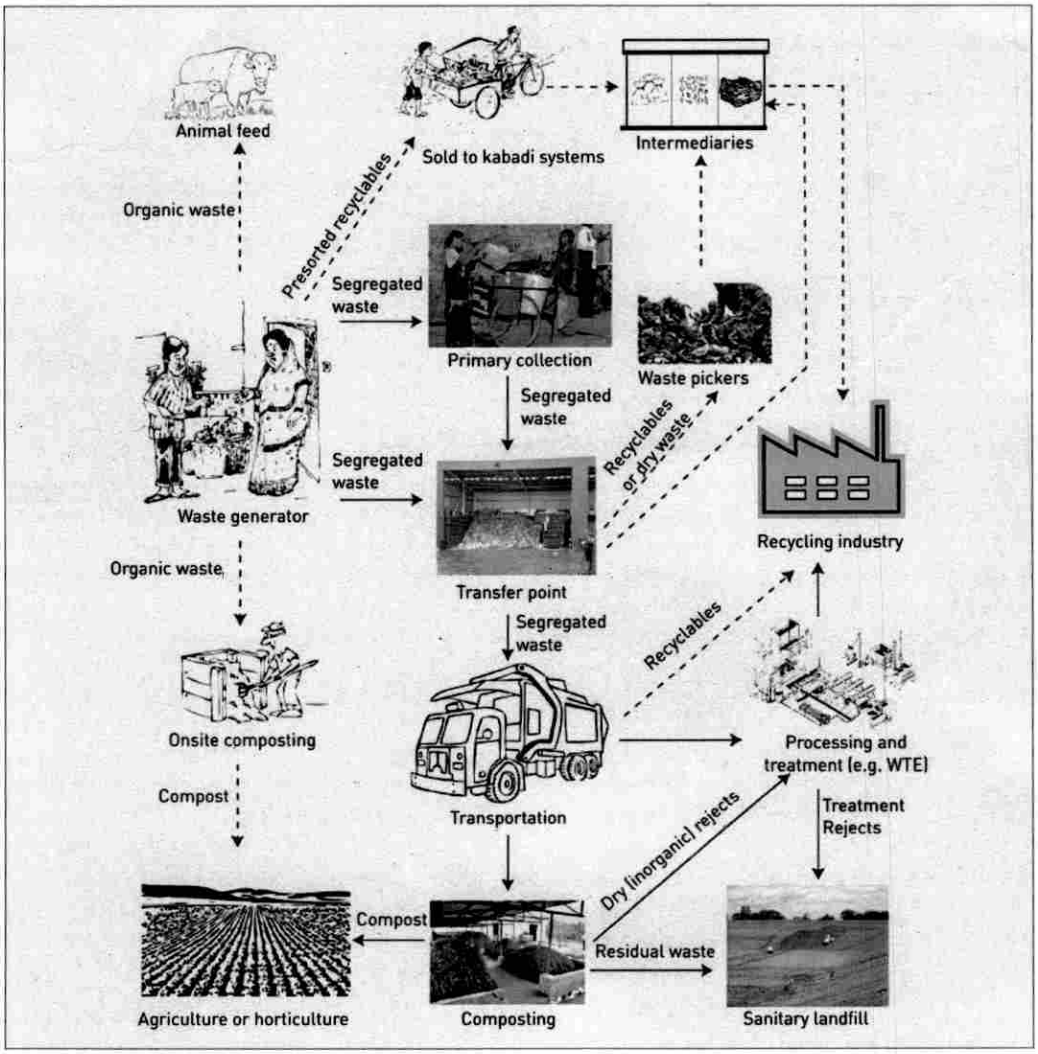
The dry fraction of the segregated waste may be further segregated locally, at the transfer station or at the processing plant:

- The dry waste fraction can be segregated at the ward level, where waste from one or more wards is collected and segregated. Different recyclables are either sent directly to locally available recycling facilities or sold to wholesale dealers. The residual waste, depending on the composition, is sent for processing or disposal—compost, refuse derived fuel (RDF), landfilling. Where decentralised compost facilities are available, the wet waste fraction is processed locally.
- The dry waste fraction may also be transported to the waste transfer station, where it is further segregated. Municipal corporations can also appoint informal waste pickers for manual sorting of waste at the transfer station. Segregation at the transfer station is through manual or mechanised segregation.

- Where the dry waste fraction reaches the processing site (compost or RDF) directly, manual or mechanical pre-sorting should be carried out to recover recyclable material. This also ensures good quality process output.
- In case regional processing or disposal facilities exist, transfer of recyclables to the regional facility should be avoided. The dry waste fraction should be sorted out either at the ward level or transfer station level. If this is not possible, appropriate sorting facilities should be available at the regional facility. Figure 3.4 illustrates the different stages of materials recovery along the SWM chain.

Special waste including domestic hazardous waste that is collected either along with the dry waste fraction or separately is also to be segregated at the material recovery facility (MRF) and disposed according to the nature of the waste. Recyclable waste should be sent to the recycling industry, and hazardous waste should be disposed at the nearest treatment, storage, and disposal facility (TSDF) or as specified by the SPCB or PCC.

Figure 3.4: Stages of Material Recovery in Municipal Solid Waste Management Chain[4]



4 Adapted from: 'Improving Solid Waste Management in India,' D. Zhu, et al., (2008). Available at: https://openknowledge.worldbank.org/bitstream/handle/10986/6916/425660PUB0Wast12732601OFFICIAL0USE1.pdf?sequence=1

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3.1.4 MATERIAL RECOVERY FACILITY

As per SWM Rules, 2016:

Clause 15: Duties and responsibilities of local authorities:-

(h) 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; Bins for storage of bio-degradable wastes shall be painted green, those for storage of recyclable wastes shall be printed white and those for storage of other wastes shall be printed black;

(r) transport non-bio-degradable waste to the respective processing facility or material recovery facilities or secondary storage facility;

Configuration of a MRF depends upon factors such as type and quantities of material to be processed, quality and quantity of incoming waste, processing rates and desired quality of end products

A material recovery facility (MRF) accepts mixtures of waste fractions—e.g., selected materials collected in the dry waste bin (see specifications in Section 2.3 of Part II)—separates and diverts recyclable materials, and transfers the remaining waste for disposal. ULBs should identify and earmark land for recycling facilities while preparing a master plan for the city to encourage recovery of valuable resources from waste in a systematic and formalized manner. Such sorting facilities should be so designed that the solid waste stored is not exposed to open atmosphere and should be user friendly[5].ULBs should also look into possibilities for establishing recycling centres at ward level to enhance maximum materials recovery.

The configuration of a MRF processing line is critical to the overall quality of the materials segregated by the line. It depends on numerous factors including the type and quantity of materials to be processed, quality and quantity of incoming waste, desired processing rates, and required specifications for the end products. While no two MRFs are identical, they generally employ common design principles and sequencing in the configuration of equipment and labour.

3.1.4.1 TYPES OF MATERIAL RECOVERY FACILITY

Depending on the scale of operations and the level of mechanisation in the facility, MRFs may be classified as manual or mechanised. Usually small-scale units, manual MRFs largely employ manual sorting practices and are typically owned, managed, and operated by the informal sector. Material is segregated based on the types of waste (paper, plastic, metal, glass etc.) and gradation of material within each waste type (e.g., paper segregated into news print, office paper, packaging paper, printed books, etc.). Segregated material is then sold to intermediaries, who supply material in bulk to the recycling industry. Mechanised MRFs are large facilities with sophisticated systems and

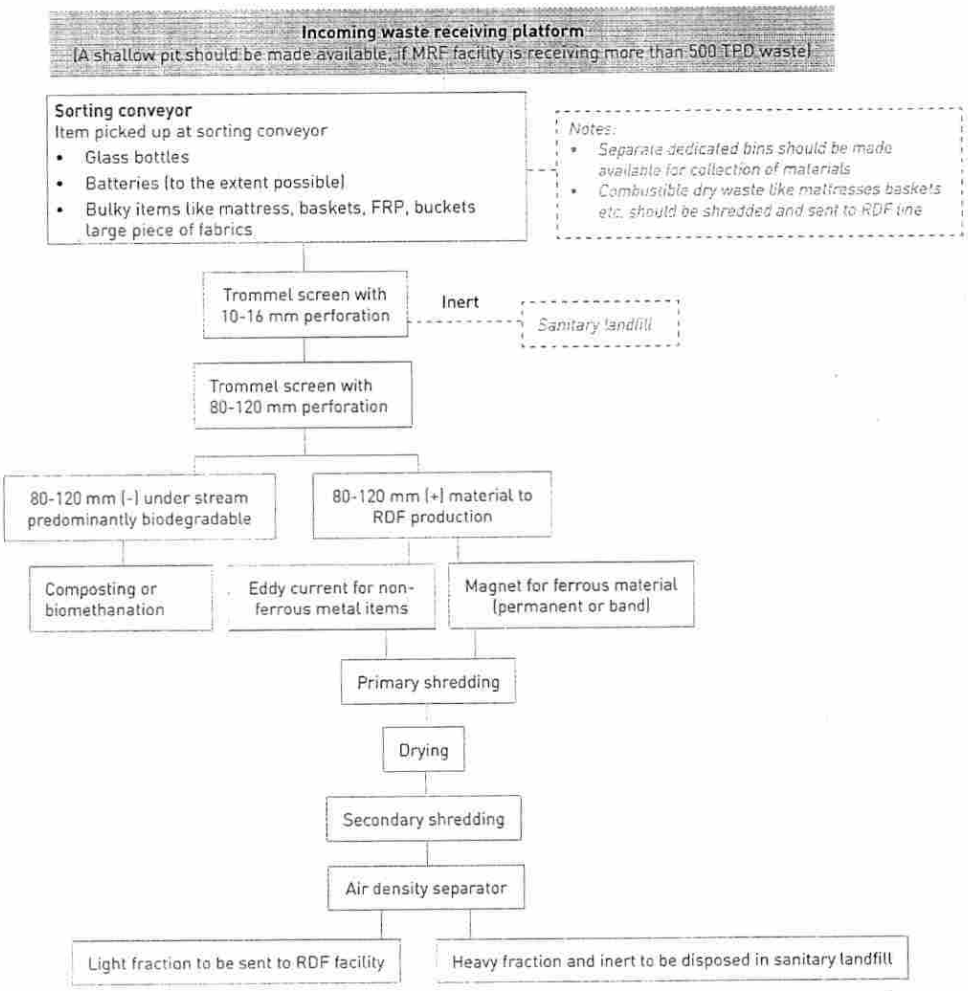
5 Materials Recovery Facility Technology Review, 2009. Available at: http://www.dep.state.fl.us/waste/quick_topics/publications/shw/recycling/InnovativeGrants/IGYear9/finalreport/Pinellas_IG8-06_Technology_Review.pdf

equipment that enable efficient separation of large quantity of material into different fractions. Mechanised MRFs are operating in some industrialised nations; such facilities do not exist yet in India.

Configuration of the MRF processing line will vary depending on how material is received:

- **Mixed stream:** Unsegregated waste mixed with biodegradable and non-biodegradable material is collected and sent to the processing facility. At the processing facility, the mixed waste stream may be segregated manually or mechanically to separate recyclable material from compostable and inert waste (Figure 3.5). Compostable matter and recyclable materials may then be processed separately, and residual inert wastes should be sent to the landfill.

Figure 3.5: Indicative Material Recovery Facility and Pre-sorting Facility for Mixed Waste[6]



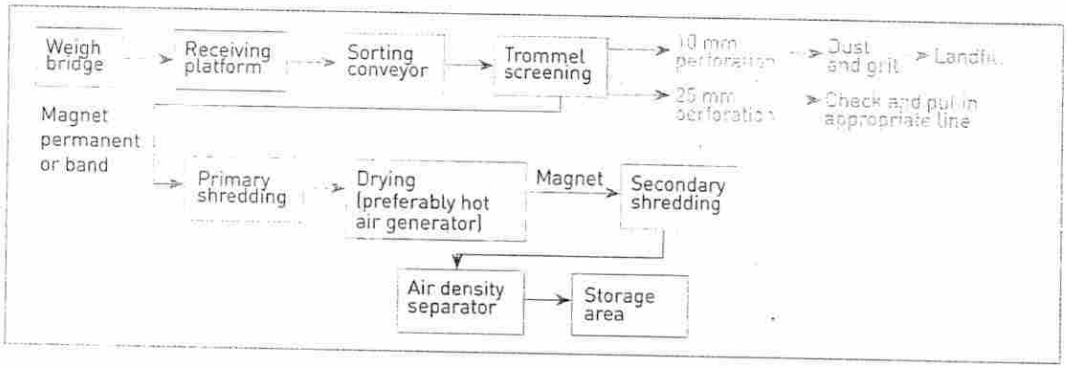
- **Source separated:** MSW is segregated into biodegradable and recyclables at the point of generation before it is collected. Further, incoming recyclables are sorted at the point of collection. Some processing might be needed for further sorting of material, such as steel cans from aluminium cans, glass by colour, paper by quality, etc.,

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

but the primary purpose of the facility is to remove contaminants and prepare the material for marketing, often by baling, flattening, or crushing.

- **Dry waste stream:** Dry segregated material is received in a mixed form consisting of a combination of fibres (paper, card board, mixed paper, magazines, etc.) and commingled containers (plastic, glass, metal, etc.), among other materials. The first stage of processing typically uses manual labour or equipment that separate material into various streams (fibre, paper, plastic, containers, etc.). These recyclables are also sorted by using automated machines when quantities to be handled are large. Below is a flowchart (Figure 3.6) depicting the indicative MRF and pre-sorting facility dedicated to dry waste.

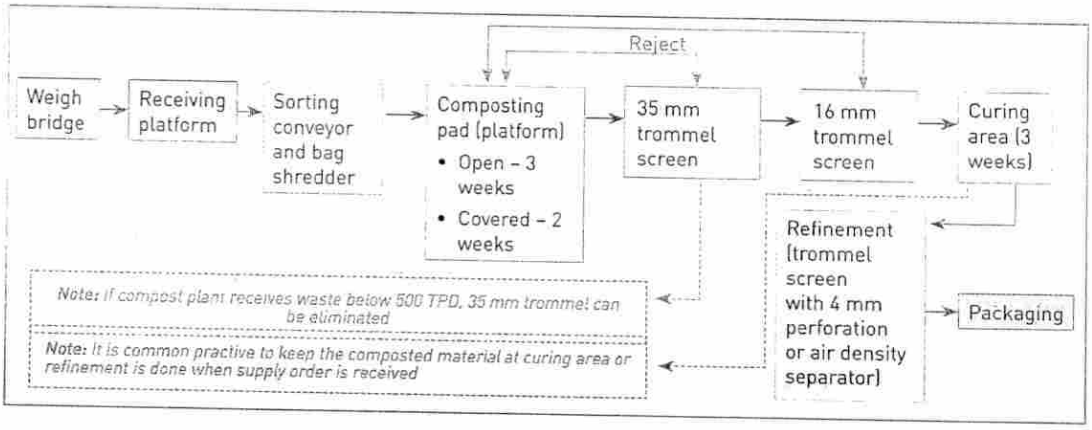
Figure 3.6: Indicative Material Recovery Facility and Pre-sorting Facility Dedicated to Dry Waste



Configuration of MRF also depends on the types of incoming waste; whether the incoming waste is source separated, dry waste stream or mixed waste stream

- **Wet waste stream:** If the ULB intends to compost biodegradable or wet waste, the wet waste that is segregated either at the source or at the mixed waste receiving MRF facility should be further pre-processed before being placed in windrows or sent for biomethanation. The pre-processing is carried out at the composting facility. Figure 3.7 outlines the pre-processing and processing at a windrow composting facility.

Figure 3.7: Indicative Material Recovery Facility and Pre-sorting Facility Dedicated to Wet Waste



3.1.4.1.1 UNIT PROCESSES IN MATERIAL RECOVERY FACILITY

MRF units employ varying combinations of manual and mechanical processes, based on the type of facility, availability of equipment, labour availability, and associated cost implications. MRF units employing manual labour for sorting operations have relatively lower costs, but may also operate at lower efficiencies compared with mechanical sorting facilities.

An MRF unit, depending on the level of complexity, will consist of a combination of units in varying degrees of mechanisation (as shown in above figures):

- **Pre-sorting:** Bulky and contaminated wastes hamper further sorting or processing in the facility; mechanical or manual pre-sorting is essential to separate out these wastes. Manual sorting results in higher labour costs and lower processing rates. Manual sorters remove bulky waste as the waste passes along a conveyor belt, which carries the pre-sorted waste to the mechanised sorting unit of the facility.
- **Mechanical sorting:** Mechanical processes based on principles of electromagnetics, fluid mechanics, pneumatics, etc. are used to segregate the different waste streams in the pre-sorted waste. Mechanical processes require specialised equipment for segregation of commingled municipal waste. Mechanical sorting typically employs the following processes:
  - **Screening:** Screening achieves an efficient separation of particles into two or more size distributions. Two types of screens are used in MRF centres disc screens and trommels.
  - **Ferrous metal separation:** In the second stage, electromagnets are used for separating heavy ferrous metals from mixed waste.
  - **Air classification:** The residual waste stream is passed through an air stream with sufficient velocity to separate light materials from heavy material, specifically for separating out lightweight plastics and paper from the mixed stream. Three types of air classifiers may be employed: (i) horizontal air classifier, (ii) vibrating incline air classifier, and (iii) incline air classifier. Heavy or bulky plastics are sorted out either in the pre-processing line (manually) or in the "detect and routing" systems, employed at later stages of material recovery.
  - **Non-ferrous metal separation:** The non-ferrous metal separator segregates zinc, aluminium, copper, lead, nickel, and other precious metal from commingled waste. An eddy current separator removes non-ferrous items from the commingled waste based on their electrical conductivity.
  - **Detect and route system:** This system separates various grades of paper, plastics, and glass, which are not sorted out in the air classifier. This system works in two stages. The first stage employs

programmed optical sensors to determine the nature of different materials. In the second stage, based on information received from the sensor, sorted material is routed to appropriate bins by directional air jets.

- **Size reduction:** Sorted materials after segregation are usually too large for further use or processing; they should be reduced to smaller sizes.
- **Baling:** Sorted and sized material is baled for further processing or use.

Table 3.2: Different Processes or Stages and Equipment Employed in a Material Recovery Facility

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

Recyclables separated from mixed waste usually have the lowest quality and might be contaminated by residual waste. In India, the segregation of recyclables from the mixed waste stream is often practiced, not through formal collection systems, but through informal workers (waste pickers).



Options for optimising this system through better inclusion of informal workers are explained in Section 2.3.7 of Part II.

3.1.5 NEED FOR ESTABLISHING MARKET LINKAGES AND EXTENDED PRODUCER RESPONSIBILITY

The type of materials in demand in the recycling market determines the level of segregation and segregated collection

Any recycling programme depends on two crucial factors: community awareness and willingness to cooperate, and access to markets for segregated materials with acceptable and reliable conditions.

Market development for recyclables involves an assessment of the supply as well as the demand. The supply of recyclable materials should meet the requirements of recycling industries, both in terms of quality and quantity.

Products made from recyclable materials should meet market requirements as well. Unless a community has an established market for materials it collects, it may end up temporarily storing some materials and later landfilling some or all of them.

It is necessary for decision makers to assess and establish market linkages prior to bringing recycling programmes into operation

Market establishment for recyclables might take place with or without intervention of the ULB, the latter in the framework of extended producer responsibility (EPR) discussed in Section 1.2.2 of Part II.

Various voluntary industrial initiatives have started recently where industries have set up their own collection and recycling systems. Mineral water suppliers voluntarily take back mineral water containers and refund the customer for the returned containers. Breweries buy back beer bottles from the kabadi system. There are also examples of different breweries using a bottle design to facilitate reuse of these bottles, which are collected by the informal system. "Go Green with Tetrapak" initiative launched by Tetrapak in 2010 along with a retail chain encourages customers to deposit their used, empty Tetrapak cartons (tetrapaks) at the store for recycling. More than 6,00,000 tetrapaks have been collected at 130 collection points in Mumbai since the initiative's inception. The recycling of 6,00,000 empty tetrapaks so far has saved over 75 trees.[7]

Local governments should encourage businesses to adopt and promote recycling initiatives, e.g., take-back of large mineral water containers

EPR initiatives also benefit industries through saved production costs. Manufacturers and suppliers are ideal partners for municipal public private partnerships (PPPs) for development of drop off sites and take back facilities. Companies manufacturing durables (e.g., Nokia, LG, and Samsung) are in the process of establishing drop-off points for used electronics and components at various points of sale in the larger Indian cities. Such initiatives may be strengthened through appropriate municipal guidelines and bye-laws.

7 Tetra Pak. 2014. *Go Green with Tetra Pack Recycling now reaches Mumbaikars through nearly 130 carton collections points.* 16 February. http://www.tetrapak.com/in/about-tetra-pak/press-room/news/go-green-mumbai

3.1.6 INFORMAL SECTOR INVOLVEMENT IN RECYCLING

Informal sector contributes significantly to improving resource efficiency, thereby enhancing environmental and climate protection

In India, recyclable material is either purchased by the kabadi system from the source of waste generation or picked up by waste pickers. Municipal authorities can promote recycling by educating the citizens and training them in segregating waste at source into dry, wet and domestic hazardous categories and handing over segregated wastes to waste collectors. Recyclable material is sold to the recycling industry though a chain of intermediaries. Waste collected by the kabadi system is sorted and sold to intermediaries who further clean, sort and store the waste. Waste pickers pick up discarded recyclable materials from primary and secondary collection points including dumpsites or landfills, and sell such material to the appropriate recycling industry. It has been estimated that the informal sector alone recovers as much as 56% of recyclable material.[8] All such activities should be compliant with environment, safety, health, and hygiene norms.

The informal recycling sector:

- supplements the formal system;
- manages all types of waste through the informal network;
- provides employment to a large number of people;
- operates competitively and with high levels of efficiency;
- establishes linkages with the formal economy at some point in the recycling chain; and
- offsets carbon emissions by making recycling possible and thus reducing the extraction and use of virgin raw materials.

Involvement of child labour, littering on street, exploitation by middle men are some of the issues that need immediate attention from local governments

However, there are some potential points of conflict between formal municipal solid waste management (MSWM) services and informal recycling activities that need to be recognized and addressed while attempting integration of the two systems. The current informal practice of materials recovery and recycling by individual waste pickers who leave behind unwanted waste leads to some litter remaining on the streets. Targeted as the sole cause of litter on the streets, the waste pickers are frequently banned from residential areas. These areas are the best places to retrieve recyclable waste, but harassment of waste pickers forces them to collect recyclables from landfill sites, a practice that leads to even higher health threats and environmental pollution. The presence of waste pickers or scavengers at transfer stations and landfill sites can interfere with vehicle movement, which is dangerous, increasing vehicle turnaround and thus reducing efficiency. The waste pickers work under unacceptable working conditions and many of them are exposed to health issues. In most cases, waste pickers are women and children from low-income groups, the most vulnerable groups in the Indian society. They are often exploited by middlemen or waste merchants because of their low social status. Child labour is also a matter of great concern.

8 Promoting Recycling in Municipal Solid Waste Management through Sustainable Business Models. Janya, S. 2014. RETA 7450 Project Preparation Support for Livable Cities.

As long as the door-to-door collection system is not operationalised and segregated waste is not collected from the doorstep, waste pickers would continue to earn their living from rag picking at the cost of their health and well-being. The solution lies in organizing and training waste pickers to enable access to upgraded livelihoods, e.g., waste pickers as source waste collectors through self-help groups (SHGs), resident welfare associations (RWAs), community-based organisations (CBOs), non-government organisations (NGOs), cooperatives, or the private sector, and thereby improving their quality of life.

These welfare activities can be undertaken through social development programmes in collaboration with local NGOs which provide schools, health care facilities, etc., to waste pickers. Children should be kept away from these activities. Provision of a valid identity card to waste pickers through local NGOs or CBOs, and creation of health schemes, access to medical facilities, and regular medical checks can help in improving the lives of waste pickers. The ULB should identify a specific agency to conduct this activity periodically, at least once every 2 years. This would help identify waste pickers and facilitate their easy integration into formal waste management systems.

Refer to Section 1.2.4 of Part II for further details on informal sector integration into conventional solid waste management services.

3.1.7 RECYCLING OF PLASTICS

Recycling of one plastic bottle would save enough energy to power a 60 watt bulb for 3 hours

It is estimated that approximately 4,000 to 5,000 TPD of plastic waste is generated in India; that is roughly 4%–5% by weight of MSW. The major problems in plastic waste management are collection, segregation and disposal. At present, plastic waste collection is done through the informal sectors such as the kabadi system and waste-pickers[9] (refer Section 7.4.4 of Part II.

3.1.8 THERMOCOL RECYCLING

Thermocol or Styrofoam, scientifically known as expanded polystyrene, is produced from a mixture of about 90%–95% polystyrene and 5%–10% gaseous blowing agent (pentane gas or carbon dioxide). Thermocol is an excellent material for packaging goods (especially electronic goods) and for the construction and decorating industry because it is light and has good insulating properties. Environmentally sound recycling of thermocol still remains to be commercially established in India, and thermocol recycling regulation is yet to be notified.

Different methodologies are available for recycling thermocol, e.g., grinding and mixing it with new beads, shredding it into fine powder, reducing

9 Available at: http://cpcbenvis.nic.in/newsletter/URBAN%20WASTE%20PROFILE_LV.pdf CPCB (2010).

its volume using solvents (Bhabha Atomic Research Centre [BARC] process), etc.

Pune's Science and Technology Park has set up a plant at Ranjangaon to recycle discarded thermocol into cheap furniture items. The furniture manufactured from recycled thermocol is relatively cheap, durable, and fireproof. A hub of electronic industries, Ranjangaon produces 10 TPD of thermocol waste.

A thermocol compactor may also be used to reduce the bulk of thermocol waste generated within a ULB. This compacted thermocol is then sold to the recycling market for further processing or recycling.

Initiative of Corporation of Panaji for Managing Thermocol Waste

Corporation of Panjim has installed a styropactor in the MRF for dealing with the large quantities of thermocol that are generated in the city. The thermocol compactor compresses the thermocol which is then auctioned to bulk recyclers on a regular basis.

3.1.9 RECYCLING PAPER AND BOARD

In India, the informal sector mainly performs the collection of waste paper through door-to-door collectors, kabadi system, and waste pickers. The informal sector carries out as much as 95% of the collection of waste paper in the country. The value chain comprises direct collection from various source points and small shops, where primary sorting of waste into different categories takes place; (ii) zonal segregation centres owned by wholesalers, where the waste material gets collected from small shops and baled; and (iii) finally dispatched to end users, which are usually paper mills.

Paper recyclers are developing new technologies for handling, identifying and separating paper grades for recycling. One such technology allows segregation of paper fibres during the recycling process according to fibre length, coarseness, and stiffness through a sequential centrifuging and screening process.

Relevance of paper and cardboard in the waste stream

The growth in the paper industry has mirrored the growth in gross domestic product (GDP) of the country; an annual average growth of 6%–7% has been observed over the last decade. Globally, India is the fastest growing market for paper. Economic projections even assume that growth in paper consumption would exceed GDP growth, with an annual growth close to 9%. Consequently, the import of pulp and paper products is likely to show a growing trend. These figures demonstrate the high relevance of paper and cardboard as a fraction of the MSW.[8]



'Wealth Out of Waste (WOW) in South India

ITC Paperboards and Specialty Papers Division launched the wastepaper collection programme called Wealth Out of Waste (WOW) in 2011 in select areas in Hyderabad, Bengaluru, and Coimbatore. WOW is expanding to more areas in South India. In Chennai, the division has tied up with 30–40 information technology (IT) companies, including Infosys, IBM, and Wipro, which would sell their wastepaper to ITC for recycling. ITC also plans to tie up with residential welfare associations (RWAs), non-government organisations (NGOs), and urban local bodies (ULBs) to expand WOW.[9]

Making of Handmade Paper

The Indian handmade paper industry produces a variety of paper and paper products mainly by using wastepaper collected from various sources (e.g., schools and colleges) and other materials such as cotton rags, tailor cuttings, hosiery cuttings, etc. Other agro-based fibres available in the North Eastern region like jute, sabai grass, ramie, banana, straw, angelie grass, elephant grass, etc. are also used to blend with the primary fibres for mottling effects and to manufacture special varieties of thin paper.

The basic steps of recycled handmade paper making process are the following:

A. CHOPPING AND DUSTING

The paper raw material and waste cotton rags are sorted manually to remove unwanted materials like plastics, iron and dust etc. that could contaminate pulp. Once the material is sorted, it is put through a rag chopper that cuts the rags into small uniform sized pieces. While the wastepaper is directly sent to the beater after being dipped in the water for 3 to 4 hours, 2 to 3 people could be engaged in this phase depending upon the amount of raw material.

B. BEATING

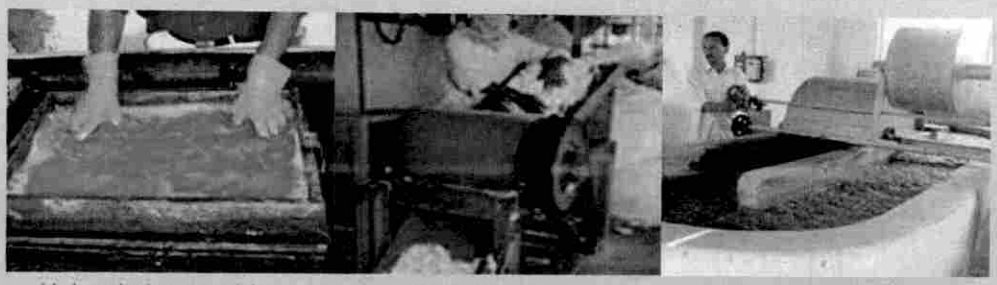
The chopped rags are converted into a fine pulp in a Hollander Beater. Pulping of the raw materials is done using non-polluting chemicals or agents such as lime, soda ash, caustic soda, oxalates, oxygen, and peroxides. It is not necessary to use harmful chemicals like alkali sulphide and sulphite, and chlorine and chlorine compounds for the delignification processes. Rosin soap and alum are added to give the paper the desired physical properties and the required consistency. When making coloured or textured paper, colour dyes, straw, hemp, grass etc. are added in this phase. The resulting pulp is now ready for sheet formation.

C. SHEET FORMATION

There are two methods of sheet formation which are being used in India:

i. **Lifting:** Lifting is a modern method done with the help of Univat. Lifting employs the use of a steel water tank fitted with an apparatus to lift the mould. The mould is clamped between two wooden frames in a water tank. A measured quantity of the pulp, depending on the thickness of the paper required, is poured evenly into the mould.

10 Effective Recycling of Waste Paper for Production of Good Quality Newsprint. Tyagi S., V. Mohan, Roy Choudhary, K et. al. (2013), Available: http://www.ipptaonline.org/July-Sept,%202013/2013_Issue_3_IPPTA_Article_02.pdf



Univat being used for sheet formation | Rag-chopper | Hollander beater

This mould is then shaken side to side horizontally and raised mechanically to drain excess water. A sheet of pulp is formed over the mould which is taken out after unclamping the frame.

ii. **Dipping:** Dipping is a traditional method where the pulp is transferred from the beater into a masonry trough or vat. Depending on the thickness of the paper required, the pulp is diluted by mixing it with water. The mould made of a wooden frame with a wire mesh or a bamboo stick mat is dipped by hand into the pulp. The frame is then shaken side to side and lifted out of the vat. A sheet of pulp is formed over the mould. Out of the two processes, lifting is favoured more as dipping requires constructing masonry trough or vat.

D. PRESSING AND DRYING

A manual or hydraulic press is used for squeezing out the excess water from the sheets. This compresses the pulp adding strength to the fibre and facilitating the drying process.

E. CALENDARING

The calendaring machine is fitted with two chilled cylinders rotating in opposite direction to give a smooth finish to the sheets of paper passed through them. Calendaring also tends to enhance the gloss of the paper.

F. SHEET CUTTING

At this phase, the calendered sheet still has a deckle edge. The sheets are cut to standard size of 22"x 30" or to desired sizes as required by the customers.

G. PAPER PRODUCTS

While it is possible to manufacture several handmade recycled paper products, there is a consistent market demand for select products such as papier-mâché, notebooks and diaries, stationeries, lampshades, invitation cards, and office paper.



Paper Products

The municipal authorities should promote recycling of paper to save trees and other natural resources. This will provide employment to skilled and unskilled labor and correspondingly reduce the municipal authority's waste management costs.

3.1.10 RECYCLING OF GARDEN WASTE OR YARD WASTE

Yard waste consists of grass, leaves, and tree and bush trimmings. The horticulture waste from parks and gardens should be composted at the site or at a decentralised facility, thereby reducing the amount of yard waste entering the solid waste stream. Additionally, grass clippings, leaves, and woody yard wastes can also be used as mulch in gardens and around shrubs to keep the soil moist, control weed growth, and add nutrients. Organic material, e.g., straw, dried stems, etc., containing higher percentage of lingocellulosic material takes much longer time for composting process to complete (for details refer Section 3.2 of Part II). These can be readily converted into mulch in shorter period of time.

3.1.11 CONSTRUCTION AND DEMOLITION WASTE

Construction and demolition (C&D) waste generally constitutes about 10%–20% of total urban solid waste.[11]

The report of the Supreme Court's expert committee in 1999 and the SWM Rules, 2016 recommend that ULBs shall facilitate the separate collection and transportation of C&D waste. Due to the challenges associated with processing and disposal of C&D waste, separate rules have been established namely Construction and Demolition Waste Management Rules, 2016 that describes the management of C&D waste and roles and responsibilities of various stakeholders.

C&D and other inert waste may be utilised for making bricks, pavement blocks, construction materials such as aggregates etc. Ward level debris deposit sites should be created. Containers could be provided at such locations, and a small collection charge could be levied for receiving such waste and transporting it for disposal. Rates may be prescribed for such collection by the ULB, and contracts could be given for managing such sites. Helplines should be created to ensure prompt clearance of C&D waste.

ULBs must make serious efforts to utilise C&D waste and should motivate the private sector to set up processing plants. There are several plants of various capacities in India to make bricks, paver blocks, aggregates, etc. out of such waste material. Profitable use of C&D waste will minimise the cost of managing such waste and requirement for valuable landfill space, besides giving employment opportunities to unemployed youth. It will also save natural resources and reduce the use of virgin soil.

11 "Rebuilding C&D Waste Recycling Efforts in India", Ghosh,G.,Ghosh, S. & Aich, A., (n.d.). Waste Management World. Available at: http://www.waste-management-world.com/articles/print/volume-12/issue-5/features/rebuilding-c-d-waste-recycling-efforts-in-india.html

Section 3.7 of Part II provides details on C&D waste collection and transportation. The potential and appropriate processes for recycling C&D waste are also discussed in detail.

3.1.12 E-WASTE

E-waste or waste electrical and electronic equipment (WEEE) includes surplus, obsolete, or broken electrical or electronic devices. Its quantum is increasing yearly, and disposal of e-waste is becoming a global environmental and public health issue.

According to a study,[12] India generates annually about 3,80,000 tonnes of e-waste, which is expected to increase manifold. The study also reveals that only about 6% of e-waste is recycled, of which 95% is operated through the informal sector. While mainly interested in precious metals (such as copper, silver, and platinum), recyclers are also interested in glass, plastic, and batteries within these devices. Currently applied processes for recycling WEEE are largely unscientific and environmentally unsound, hence posing serious health threats. It will be a challenge to reorganise the recycling of WEEE to establish recycling methods that protect both workers and the environment. One option would be the introduction of the extended producer responsibility (EPR) concept, where the producer of an electrical or electronic device guarantees product redemption after use through recycling or disposing it in an environmentally friendly way (for details refer to Section 7.7 of Part II).

3.1.13 GREENHOUSE GAS MITIGATION POTENTIAL FROM RECYCLING AND REUSE

Waste handling and disposal generates greenhouse gases (GHG) both directly and indirectly. The most efficient way to reduce direct and indirect GHG emissions in waste management is to reduce waste generation at source, followed by material recycling. Direct emissions are decreased when waste is not disposed at landfills nor treated in any other way (e.g. combustion). Indirect emissions can be cut down by decreasing the energy consumption both in acquiring and producing raw material and also in manufacturing the product itself. It is possible to substitute virgin material with recovered material. In most cases, the replacement of virgin material by recycled material decreases the use of net energy and thus the GHG emissions. For example, recycling 1 tonne of paper reduces 1 metric tonne of carbon dioxide (CO_2) equivalent emissions. Similarly, recycling 1 tonne of aluminium avoids approximately 9 tonnes of CO_2 equivalent emissions. As a result, use of recycled material in place of fresh material could lead to reduction in GHG emissions. On the other hand, recycling practise can also result

12 Carried out by MAIT and GIZ in 2007

in GHG emissions either from transportation of material or from the recycling process itself.

3.2 COMPOSTING

Municipal solid waste (MSW) primarily consists of organic, inorganic, and inert fractions. Under natural conditions, the organic fraction of waste continually decomposes, accompanied by a strong foul odour and production of gases, which are predominantly methane or CO_2 depending on the aerobic condition of the decomposing mass. Vector infestation during the natural decomposition is a common phenomenon.

Composting is a process of controlled decomposition of the organic waste, typically in aerobic conditions, resulting in the production of stable humus-like product, i.e., compost.

Composting is a biological process in which microorganisms convert organic matter into compost

Considering the typical composition of wastes and the climatic conditions, composting is highly relevant in India and should be considered in all municipal solid waste management (MSWM) concepts. Composting of the segregated wet fraction of waste (see Section 2.2 of Part II) is preferred. Mixed waste composting, with effective and appropriate pre-treatment of feedstock, may be considered as an interim solution; in such cases, stringent monitoring of the compost quality is essential.

3.2.1 SOLID WASTE MANAGEMENT RULES, 2016: GUIDANCE ON COMPOSTING

As per SWM Rules, 2016:

Clause 4 Duties of waste generator:-

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

(7) All gated communities and institutions with more than 5,000 sqm area shall, within one year from the date of notification of these rules and in partnership with the local body, ensure segregation of waste at source by the generators as prescribed in these rules, facilitate collection of segregated waste in separate

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streams, handover recyclable material to either the authorised waste pickers or the authorizsd recyclers. The bio-degradable waste shall be processed, treated and disposed off through composting or biomethanation within the premises as far as possible. The residual waste shall be given to the waste collectors or agency as directed by the local body.

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

Clause 15 Duties and responsibilities of local authorities:

(m) collect waste from vegetable, fruit, flower, meat, poultry and fish market on day to day basis and promote setting up of decentralised compost plant or biomethanation plant at suitable locations in the markets or in the vicinity of markets ensuring hygienic conditions;

(q) transport segregated bio-degradable waste to the processing facilities like compost plant, biomethanation plant or any such facility. Preference shall be given for on site processing of such waste;

(u) phase out the use of chemical fertilizer in two years and use compost in all parks, gardens maintained by the local body and wherever possible in other places under its jurisdiction. Incentives may be provided to recycling initiatives by informal waste recycling sector.

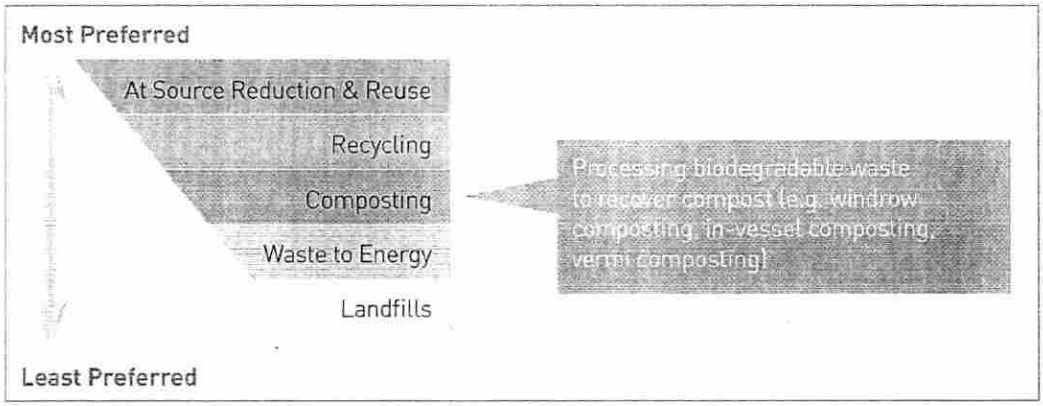
(v) facilitate construction, operation and maintenance of solid waste processing facilities and associated infrastructure on their own or with private sector participation or through any agency for optimum utilisation of various components of solid waste adopting suitable technology including the following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

a) biomethanation, microbial composting, vermi-composting, anaerobic digestion or any other appropriate processing for bio-stabilisation of biodegradable wastes;

3.2.2 COMPOSTING IN THE INTEGRATED SOLID WASTE MANAGEMENT FRAMEWORK

The third preferred choice in the ISWM strategy, i.e., adoption of resource recovery strategies and composting, ensures that waste is processed appropriately to facilitate further use of the material. Composting is a biological process of stabilising biomass either in the presence or absence of free oxygen, carried out by a host of microbes. Aerobic composting, which is carried out in the presence of air, is far more popular because it is much faster compared with the "trench" composting where direct access to air is denied. Processing of MSW by this process yields humus rich compost (organic manure) along with macronutrients and micronutrients for plants.

Figure 3.8: Composting in the Integrated Solid Waste Management Hierarchy



Composting is the third preferred choice in the ISWM hierarchy. It ensures that waste is processed appropriately to facilitate material recovery

Given the propensity of organic waste to contribute to environmental pollution in more ways than one, composting and other biological stabilisation processes, which would mitigate the impact of uncontrolled decomposition of organic MSW should be adopted by urban areas. Composting is an environmentally beneficial waste recycling mechanism and not a waste disposal mechanism.

3.2.3 BENEFITS OF COMPOSTING

- The real economic benefits of compost use include improved soil quality, enhanced water retention capacity of soil, increased biological activity, micronutrient content, and improved pest resistance of crops.
- Composting minimises or avoids GHG emissions from anaerobic decomposition of organic waste (such as in a large unturned heap).
- Composting increases the design life of other waste management facilities.
- Stringent design requirements and associated costs for catering to management of leachate from organic waste decomposition may be reduced in those landfills that do not receive organic waste.

Compost, because of its high organic matter content, is used as a valuable soil amendment thereby reducing dependence on chemical fertilisers

- Compost is particularly useful as organic manure; it contains macronutrients (nitrogen, phosphorous, and potassium) as well as micronutrients. When used in conjunction with chemical fertilisers, optimum results are obtained.
- The use of compost reduces the dependency on chemical fertilisers for agricultural operations. When used as a soil amendment, compost reduces the need for water, fertilisers, and pesticides. Compost acts as a soil conditioner, therefore supporting the long-term fertility of soil.
- Compost may be used to revitalise vegetation habitats and add life to marginal, impoverished soils and waste lands.
- Compost may also be used as a bio matrix in remediation of chemical contaminants and as a remediated soil in contaminated sites; compost helps in binding heavy metals and other contaminants, reducing leachate and bio-absorption.

3.2.4 NEED FOR MARKET IDENTIFICATION AND ANALYSIS

SWM Rules, 2016 lays emphasis has been on market development through appropriate mechanism.

Clause 7: Duties of Department of Fertilisers, Ministry of Chemicals and Fertilisers:-

(1) The Department of Fertilisers through appropriate mechanisms shall-

(a) provide market development assistance on city compost; and

(b) ensure promotion of co-marketing of compost with chemical fertilisers in the ratio of 3 to 4 bags: 6 to 7 bags by the fertiliser companies to the extent compost is made availablefor marketing to the companies.

Clause 8: Duties of Ministry of Agriculture, Government of India.- The Ministry of Agriculture through appropriate mechanisms shall-

(c) set up laboratories to test quality of compost produced by local authorities or their authorised agencies; and

(d) issue suitable guidelines for maintaining the quality of compost and ratio of use of compost visa-a-vis chemical fertilizers while applying compost to farmland.

The financial viability of compost plants is primarily dependent on the marketability of the compost at a reasonable price. For the low carbon soil (soil organic carbon) prevalent in India, there is a huge requirement of good quality compost for agriculture. Yet the present

demand for compost is very low. An analysis of the available markets and potential demand for compost is essential to decide the required size of the compost plant. An assessment of end user requirements of compost quality, as defined by the final use, is essential to arrive at the final design of the compost plant.

Market development for compost and proper quality monitoring are crucial. The following strategies can be applied for market development:

- The pricing mechanism for sale of compost should be assessed. Each state government should fix a minimum retail price for compost, which meets Fertiliser Control Order (FCO) 2009 standards, to ensure economic viability of these plants.
- All state and local government departments should be encouraged to promote the use of compost in parks, gardens, nurseries, and urban forestry projects.
- Apart from FCO compliant compost, a line of value-added compost may be developed by adding additional nutrients. One such example is phosphate rich organic manure (PROM), which may be used as replacement of chemical phosphatic fertilisers such as di-ammonium phosphate (DAP) and single superphosphate (SSP).
- Co-marketing of compost made from city garbage with chemical fertilisers in the ratio of 3–4 bags: 6–7 bags is suggested by the SWM Rules, 2016 and the Inter-Ministerial Task Force on Integrated Plant Nutrient Management (IPNM), vetted by the Supreme Court of India in 2006.
- The benefits of compost should be informed to farmers, who should be encouraged to partially substitute inorganic fertilisers with organic compost, as appropriate for their crop and specific soil.
- Opportunities for involving agricultural officers to generate awareness of compost usage among farmers should be looked into.

Both physical and chemical properties of the finished compost are to be considered. Decisions on pricing of the compost should be based on the size and location of markets. The distance to which the finished product may be transported will have a strong bearing on the landed price of compost.

An assessment of competing compost suppliers is also essential, especially in cases where it is estimated that the compost will need to be marketed beyond the vicinity of the plant.

An analysis of market demand for compost and its potential end-use determines the design, capacity and hence the financial viability of compost plants

Co-marketing of compost with chemical fertilizers by the fertiliser companies as a "Basket Approach" was recommended by Inter-Ministerial Task Force on IPNM (2005)

Successful market for compost depends on two major factors:

- producing consistent quality and quantity of compost
- identification of potential users

Pre-sorting and segregation of MSW is a pre-requisite for maintaining the quality of the compost produced

Analysis for Marketing Compost

- How much compost will your plant produce?
- Where will the compost be used and for what?
- Do you realize the importance of consistent quality control for building and maintaining the brand image of your compost?
- Does your plant have the necessary process flow and equipment to produce compost which is compliant with the relevant rules (e.g., FCO 2009, 2013)?
- Who are your potential customers? Consider the number of compost plants and quantity of compost produced in the state, while assessing the size of the potential compost market.
- What is the typical quality of compost required by the different categories of consumers?
- How much are your consumers willing to pay for the compost?
- Identify competing products for identified consumer uses and their prices.
- Identify compost transportation requirements and costs.
- Develop a marketing strategy.
- Relook at the size of the proposed compost plant and the size of the potential compost market.

3.2.4.1 CONSTRAINTS FACED BY THE COMPOSTING SECTOR IN INDIA

Composting of MSW started in the late 1970s when some mechanical compost plants were set up across the country. The concerned ULBs were the owner and operator of the compost plants. These facilities were replica of plants from the industrial countries without the necessary adaptation exercise; consequently, these capital-intensive facilities were heavily mechanised and faced maintenance problems. An evaluation of the mechanical compost plants was carried out by the National Environmental Engineering Research Institute (NEERI) during 1980–1982. Since the input garbage was mixed and the design was not adequate for removal of non-compostable fractions quality of the final product was poor, leading to lukewarm response from the market and poor unviable price.

The scenario changed in the early 1990s with the entry of the private sector—equipment fabricators, plant operators, etc. Mechanisation was reduced by almost eliminating the pre-processing stages (for e.g., the mechanical compost plant of the Municipal Corporation of Delhi, established in 1981). The machinery and equipment manufacturers introduced equipment at the post-screening stages, such as trommels with finer screen, air density separator (de-stoner), etc. to improve the quality of compost by better removal of small contraries, such as pieces

of glass and plastics, grit, coarse sand, etc. Bio-inoculum was sprayed over the windrows for suppressing bad odour. In the initial years, there were reports of good price of compost, leading to reported commercial viability. In the later years, the euphoria was replaced by the realisation that the good price belonged to the niche market of plantations and some cash crops. And with more and more operating plants, the bulk of the compost had to be sold to the farmers, who could not afford it.

The sector at present faces the following constraints:

i. compost quality standards (SWM Rules, 2016 and FCO series) are becoming increasingly stringent;

ii. majority of the collection of MSW is in the form of mixed waste;

iii. making quality compliant compost from mixed waste requires some equipment for refinement and quality control and higher production cost, but the yield is reduced as the quality standards are higher (10%–15%);

iv. all compost sold for application to food crops is mandated to be FCO compliant;

v. percentage of process rejects increases proportionally (30%–40%) unless the processing facility produces compost as well as refuse derived fuel (RDF);

vi. lack of knowledge and practical experience among the various stakeholders responsible for planning, execution, operation and maintenance (O&M), and marketing leads to inadequately designed plants, inefficient equipment, improper operation, and shortcuts from equipment design to operational protocol;

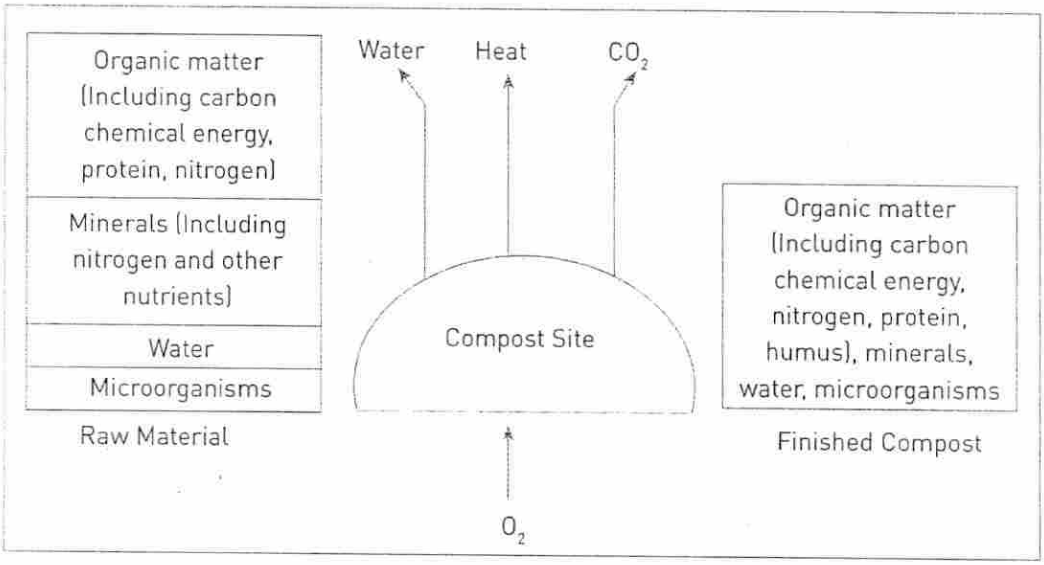
vii. after the product is ready (called "finished compost"), cost is incurred for bagging, transport, marketing (commission of the chemical fertiliser company, dealers, etc.). The final cost to the farmer is normally almost twice the price received by the compost plant operator;

viii. as of 2015, the total cost to the farmer is about Rs.4,000–Rs.5,000 per ton of finished compost (distance being the main price variant). This price is too high for the average farmer;

ix. the long-term benefits of soil conditioning properties of compost are not adequately appreciated by the farmers and other stakeholders.

3.2.5 THE COMPOSTING PROCESS – PHASES AND CRITICAL PARAMETERS

Figure 3.9: Process of Aerobic Composting[13]



During aerobic composting, microorganisms oxidize organic compounds to carbon dioxide (CO_2), nitrite, and nitrate. Carbon from organic compounds is used as a source of energy while nitrogen is recycled. Due to chemical reactions producing heat, temperature of the mass rises.

Several biological, chemical, and physical processes contribute to the success of the aerobic composting (Figure 3.9). Understanding these processes is necessary for making informed decisions when developing and operating a composting plant.

3.2.5.1 BIOLOGICAL PROCESSES

The process of aerobic composting passes through two distinct stages of high significance: thermophilic stage (sanitisation) and mesophilic stage (decomposition).

The two distinct biological process stages observed during composting are:
- thermophilic stage
- mesophilic stage

Different organisms are known to play a predominant role in breaking down biodegradable constituents of MSW. The majority of microorganisms responsible for composting are already present in MSW. A succession of microbial growth and activity among the bacteria, fungi, actinomycetes, yeasts, etc. takes place during the process, whereby the environment created by one community of microorganisms encourages the activity of a successor group. Different types of microorganisms are therefore active at different times and locations within the windrow depending upon the availability of substrate, oxygen supply, and moisture content of the organic matter.

13 *On-Farm Composting Handbook*. Rynk, R., et al. 1992. Ithaca, New York: PALS Publishing Cooperative Extension.

(i) Thermophilic Stage (Sanitisation)

This is the first phase of composting wherein microorganisms decompose the easily degradable organic substances producing heat as a result of intense metabolic activity. In most cases with moisture content of 55%–60% and air voids of 20%–30% in the windrow, a temperature rise from 35°C to 55°C–65°C is achieved within 2–3 days.

- typically, thermotolerant fungi, thermophilic bacteria, and actinomycetes are the predominantly active microorganisms at this stage.
- windrows are turned at regular intervals to expose the material in the inner core to air so that temperature in these fresh sections rise again, and gradually the whole windrow is sanitised from pathogens.

Thermophilic Stage:
Moisture: 55%–60%
Temperature: 55°C– 65°C
Air voids: 20%–30%
Microorganisms: thermotolerant fungi, thermophilic bacteria, actinomycetes

(ii) Mesophilic Stage

- in the second stage, due to reduction in available nutrients and readily available carbon, the microbial activity reduces, causing a decline in the temperature of the heap. There is a shift in the type of active microbial species in the compost heaps.
- the composted material becomes dark brown during this stage due to humus synthesis and starts to stabilise

Mesophilic stage:
- temperature: moderate
- stabilisation of compost material

(iii) Curing Stage

- Curing of compost is done after the material from the windrow is screened. The screened material is then allowed to mature in the curing stage. This is a very important phase in the composting process. Microbial species degrading complex polymers, such as cellulose, lignin, and hemicelluloses, increase drastically during this phase.
- Bacteria represent 80% of this population. Free living nitrogen-fixing bacteria, denitrifiers, sulphate reducers and sulphur oxidizers are important constituents of the total microbial population.

Curing:
- Maturation Stage
- Lasts for 3-4 weeks
- Microbial species population increases drastically

3.2.5.2 CHEMICAL PARAMETERS

(i) **Moisture:** Moisture is a critical factor in establishing stable conditions conducive for composting because the microbes need moisture for survival and growth. Moisture tends to occupy the free air space between the decomposing particles. Hence, when the moisture content is very high, anaerobic conditions set in.

(ii) **Aeration:** The composting process requires adequate supply of oxygen for biodegradation by microorganisms. Under aerobic conditions, decomposition rate is 10–20 times faster than under limited oxygen supply or anaerobic conditions.

Compost pile should have enough void space to allow free movement of air as aerobic conditions fasten the composting process by 10–20 times and reduce generation of foul smell

High oxygen levels in air voids are maintained within waste piles or windrows through turning and mixing at regular intervals. In static piles, anaerobic conditions may be created due to the utilisation of available oxygen by microorganisms and production of CO_2 during decomposition of the waste. This could result in a buildup of anaerobic microorganisms, resulting in foul smell.

(iii) Carbon-to-Nitrogen Ratio

- MSW in India has an initial carbon-to-nitrogen (C/N) ratio of around 30:1, which is ideal for decomposition. The organisms involved in stabilisation of organic matter utilise about 30 parts of carbon for each part of nitrogen. C/N ratio below 25:1 results in production of foul smell and a higher C/N ratio will result in impeding the decomposition process.
- Whenever the C/N ratio is less than the optimum, carbon source such as straw, sawdust, paper are added.
- Higher C/N ratios may be reduced by adding biodegradable material having high nitrogen content, such as non-edible oil cakes, green biomass, etc. It is not preferable to add slaughter house waste to MSW waste piles, as they require specific closed systems or in-vessel systems.

C/N ratio of 30:1 is ideal for decomposition. C/N ratio below 25:1 results in foul smell while higher C/N ratio impedes decomposition

3.2.5.3 PHYSICAL PROCESSES

(i) **Temperature:** Under properly controlled conditions, temperatures are known to rise beyond 70°C in aerobic composting. This increased temperature results in increased rate of biological activity, resulting in faster stabilisation of the material. However, if the temperature rise is very high, due to inactivation of the organisms and enzymes, the rate of activity may decrease.

Temperature plays a critical role in composting by increasing rate of biological activity resulting in faster stabilisation

High temperature also helps in destruction of some common pathogens and parasites. Ambient air temperatures have little effect on the composting process, provided the mass of the material being composted can retain the heat generated by the microorganisms under aerobic condition. If the process is so controlled that the temperature is kept at 55°C or above for at least 3 days, destruction of pathogens and parasites can be ensured.

(ii) **Particle Size:** The optimum particle size should have enough surface area for rapid microbial activity, but also enough void space to allow air to circulate for microbial respiration. The feedstock composition can be manipulated to create the desired mix of particle size and void space.

3.2.6 MUNICIPAL SOLID WASTE FEEDSTOCK FOR COMPOSTING

The segregated wet fraction of MSW (comprising mainly biodegradable waste), vegetable market waste, and yard waste is the preferred feedstock for compost plants. However, where door-to-door segregation of dry and wet fractions is not practiced, it is possible that mixed MSW reaches the plant. In such instances, pre-sorting and segregation of the organic fraction from the mixed fraction is a critical step in ensuring adequate quality of the processed compost. Presence of contaminants hampers the activity of the microbes and reduces the final quality of compost; it is essential to keep street sweepings and drain cleaning material out of the feedstock, which is a major source of contaminants. This can be done through organisational arrangements in the ULB. Street sweepers should not mix their waste with MSW collected from households and establishments.

MSW feedstock for composting should essentially include the segregated wet fraction of waste. Vegetable market waste and yard waste, being rich in organic content, are a preferred feedstock

MSW feedstock should be delivered at a well-defined area within the plant. This area is essential for overall smooth functioning and regulated flow of MSW feedstock into the processing area. The tipping area should have adequately sized shed (sides open) to receive predetermined quantities of waste daily. Unregulated storage of waste should be avoided. Garland drains leading to a leachate collection tank connected to the leachate treatment system are essential at the tipping floor. Bulky items like bed mattress, tires, large pieces of fabric (e.g., sarees) and thin plastic film, large toys, pieces of asbestos, fibre reinforced plastic (FRP), branches of tree, etc. have to be pulled out before the waste moves on to the pre-sorting section.

Storage area should be large enough to handle daily and weekly variations in waste quantity and should be provided with sheds to cater to wet weather conditions

In large plants receiving above 300 TPD of MSW, some designers prefer to provide a shallow pit to increase the volumetric capacity within the same footprint. However, in warm countries, pits may cause odour problem if it is not emptied regularly and if leachate is not pumped out every day and the pit is not thoroughly cleaned occasionally.

Under certain conditions, buffer storage may be required:

- High floating population—places of tourism and religious importance
- Festive occasions or large gatherings—rallies, meetings, etc.
- No uniform collection and transportation on a daily basis, clearing of a backlog, etc.

However, such buffers should be planned very carefully mainly because holding raw waste for more than a day attracts vectors, causes odour nuisance, and leachate. Therefore, such buffer areas should be planned only if it is essential due to the above conditions and should not normally be more than one day. Instead, it would be more convenient to build additional capacity in pre-sorting line and compost pad area.

The compost pad and the curing area for semi-finished compost are the most convenient buffer areas.

3.2.7 PRE-PROCESSING OF MIXED MUNICIPAL SOLID WASTE

MSW segregation and pre-processing are essential for composting

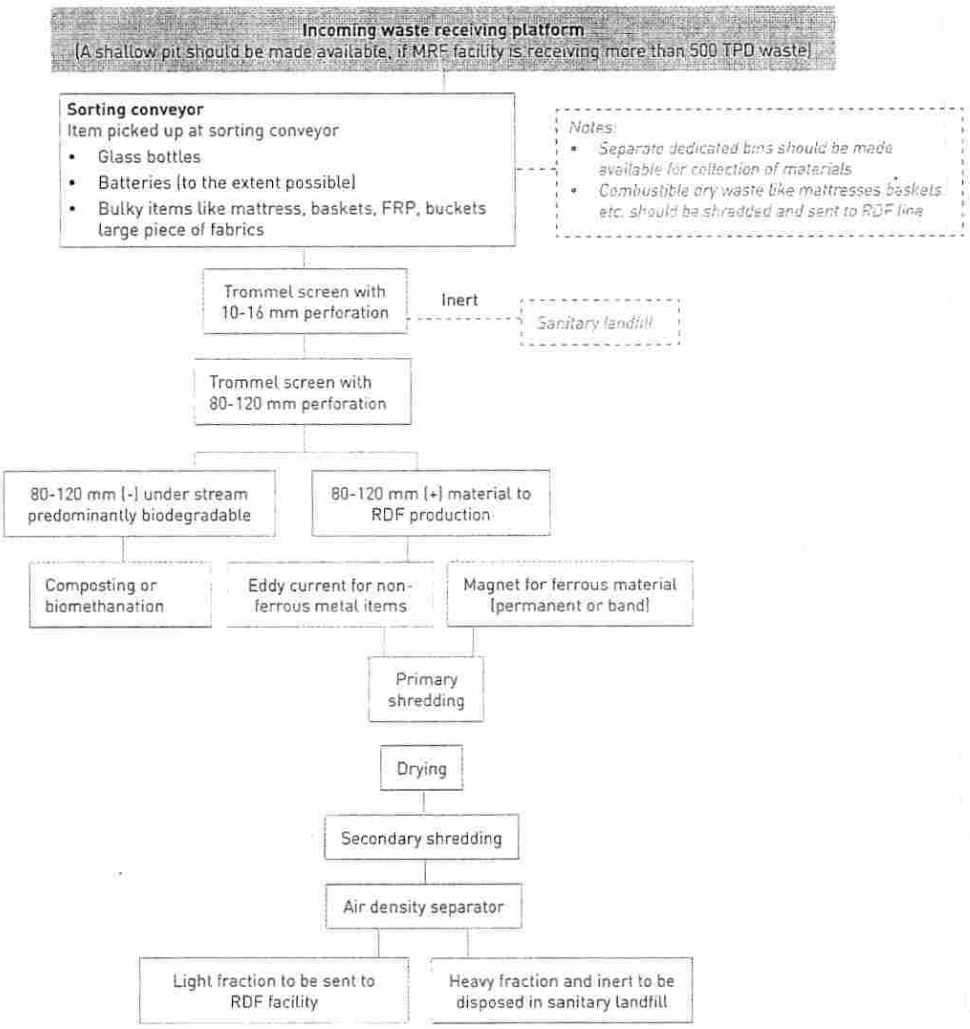
Typically, mixed MSW received at the compost plant consists of 40%–50% non-biodegradable material. Pre-processing of mixed MSW is crucial for preparing FCO-compliant compost. In case source segregated waste or dedicated waste from fruit and vegetable market is received, pre-sorting can accordingly be minimal and therefore the capital and O&M cost are less and the yield of compost is higher than in the case of mixed waste. Pre-processing serves the following purposes:

- separation of the mixed material into different streams, which are suitable for specific products—biodegradable for composting, combustible dry material for RDF, separation of recyclable material on sorting belt (glass, metal, etc.); and
- reduction of cross-contamination of the material to make different products.

Pre-processing has a high economic value as it recovers recyclables, reduces contaminants, lowers processing costs and also ensures quality of compost

The pre-processing section is designed on the basis of average composition of the incoming waste, quantity, space available for pre-sorting, and whether only composting or a combination of compost and RDF is targeted. Following Figure 3.10 illustrates the various steps involved in pre-processing of mixed MSW.

Figure 3.10: Pre-processing of Mixed Municipal Solid Waste[14]



Sorting: The level of sorting feedstock depends on several factors including the source of feedstock, the end use of the product, and the operations and technology involved. Sorting in a well-designed compost or RDF plant consists of hand sorting on a sorting belt, followed by mechanical sorting in one or more trommels. Mixed waste is fed onto a slow-moving (5 m per minute) conveyor belt. Items not suitable for the trommel, such as glass bottle, metal container, any hazardous material like containers of paint, etc. are taken out by hand and put in appropriate bins. The workers should be provided with gloves to avoid injury. The thickness of the moving waste pile on the conveyor belt should be less than 15 cm (for better manual sorting) and the removed material stored in segregated vats or large containers. This is usually recyclable material or material with high calorific value, which can be further processed to recover the energy content. Metals are then removed from the waste by either a suspended magnet system or a magnetic pulley.

Sorting results in recovery of recyclable material with high calorific value

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

Remaining mixed waste is subjected to mechanical separating devices such as a segregating trommel, where material passing through the screen (80–100 mm) is utilised for compost production. An additional trommel of 200 mm screen may be required as an add-on for plants with a capacity of over 500 TPD of waste, which is placed before the trommel with 80–100 mm apertures.

The purpose of a trommel is to segregate materials on the basis of size through cascading action. For effective segregation, it is necessary that the material undergoes sufficient number of turns inside the trommel and, at the same time, gets sufficient fall depth for good cascading action. Therefore, the length and the diameter of the trommel are very important. Normally for MSW, a trommel with a length of 10 m and a diameter of 2.5 m and above would be desirable. At the same time, there should be no axle passing through the trommel in the middle; the drive for the trommel has to be external.

Table 3.3 outlines mechanical separation technologies that are currently used in MSW composting. Details of these processes are discussed below.[15]

Pre-processing technologies:

- Screening-controls the size of feedstock
- Magnetic separation-removes ferrous metals
- Eddy-current machines-separates aluminium and other non-ferrous metals
- Air classifiers-removes heavier fractions like glass and ceramics

Table 3.3: Pre-processing: Sorting of Mixed Municipal Solid Waste Feedstock

TECHNOLOGY	MATERIALS TARGETED
Screening	Plastics, paper, cardboard, metal
Magnetic separation	Ferrous metal
Eddy current separation	Nonferrous metal
Ballistic separation	Plastic, paper, glass, gravel

Screening: Screens are used to control the size of feedstock. They separate small dense material such as food scrap, glass, and plastics from the bulky light fraction of the feedstock. Trommel screens are commonly used for initial material processing at MSW facilities.

Magnetic separation: Magnetic separators create magnetic fields that help in removing ferrous metals from the feedstock as it travels along conveyors. The efficiency of magnetic separators depends primarily on the quantity of materials processed and the speed at which they pass through the magnetic field.

Eddy current separation: Eddy current machines separate aluminium and other non-ferrous metals from MSW. These machines generate a high energy electromagnetic field that induces an electrical charge in non-ferrous metals and forces these materials to be repelled from non-charged fractions of the feedstock material. The feedstock should be conveyed to eddy current machines after magnetic separation to

15 *Composting Yard Trimmings and Municipal Solid Waste*. United States Environmental Protection Agency, 1994 Washington, DC.

minimise contamination by metals. Eddy current machines are not usually used in India, since metals are not usually found in waste.

Air Classifiers: Air classifiers separate feedstock material based on density differences, i.e., the heavier fractions (metals, glass, ceramics, etc.) are removed from the lighter materials. The heart of an air classification system is an air column or throat into which the materials stream is fed at a specified rate. A large blower sucks air up through the throat, carrying light materials such as paper and plastic or fine dry compost, which then enter a cyclone separator where they lose velocity and drop out of the air stream. Heavy materials fall directly out of the throat or column.

Ballistic separation: Ballistic or inertial separation separates constituents based on density and elasticity differences. This can be applied for segregating materials on compost stream or RDF stream. However, it is more suitable for RDF stream for separating grit and other heavy inert material. Compost feedstock is dropped on a rotating drum or spinning cone, and the resulting trajectories of glass, metal, and stone, which depend on density and elasticity, bounce the material away from the compost feedstock at different lengths.

Additional inoculum: Inoculum (bacterial culture) is also added to the feedstock to improve efficacy of the process.

Adding inoculum may be an issue because of its cost implications. However, inoculum enhances composting process and also helps in suppressing foul odour

Indicative Equipment Required for Pre-Processing

- **Loader:** Tractor mounted front-end loaders or pay loaders are used to deliver the raw feedstock to conveyors. These vehicles have a shovel-like attachment at the front of the machine which can be raised by a hydraulic mechanism to lift feedstock material and release material onto the conveyors or into piles.
- **Conveyors:** Conveyors are mechanical systems with belts that slowly pass over rotating wheels. Conveyor belts are used in the sorting or separation phase of composting to facilitate manual removal of non-compostable material. The width of the conveyor belt should be narrow enough for workers to reach its centre.
- **Screens:** Screens are primarily used for separating large material from the feedstock. Different screens used are the following:
  - **Trommel screens:** Long, cylindrical screens are placed at an angle to facilitate material movement through the perforated screen. Material smaller than the grate fall through and material with larger diameters than the grate pass through the trommel. As the trommel screens rotate, a brush is passed over the top of the screen to remove lodged materials and prevent clogging of the screen.
  - **Rotary screens:** Feedstock is loaded onto spinning, perforated discs in this system. Oversized material are scattered from the screen because of the

spinning action. Undersized material fall through the perforations in the discs. However, trommels are preferred for better performance and cleanliness.

- **Magnetic recovery systems:** With these systems, a magnetic field removes ferrous metals from the rest of the feedstock material. The following types of magnetic separators are commonly used:
  - **Overhead belt magnets:** Cylindrical magnets are installed over a conveyor belt which carries feedstock and separates out ferrous materials.
  - **Drum magnets:** Drum magnets are placed over a conveyor belt; ferrous metals in the feedstock that pass under the rotating drum are attracted to the magnet and stick to the drum.

3.2.8 COMPOSTING TECHNOLOGIES

Technologies for composting can be classified into the following general categories:

- windrow composting;
- aerated static pile composting;
- in-vessel composting;
- decentralised composting (bin and box composting); and
- vermicomposting.

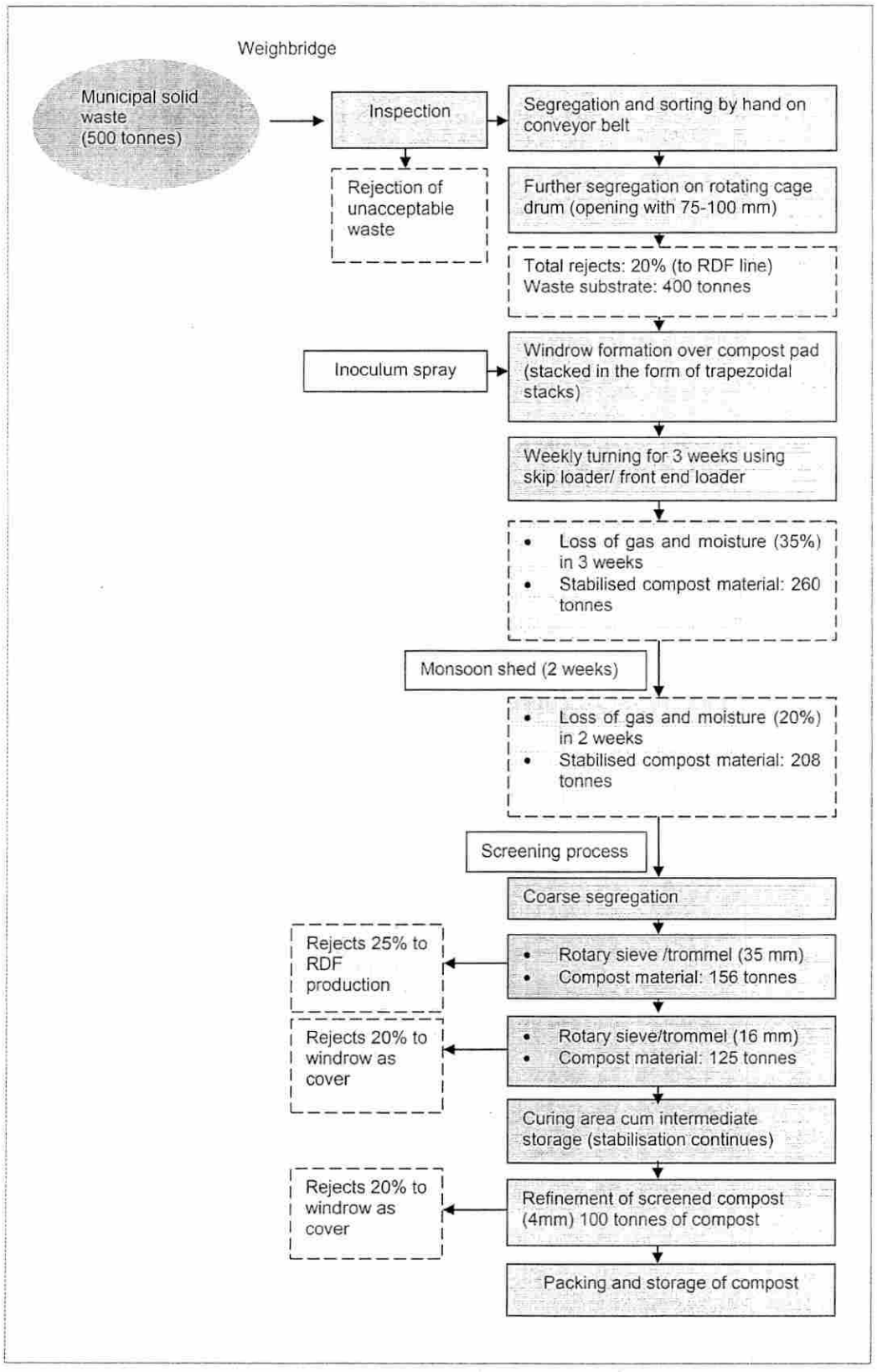
3.2.8.1 WINDROW COMPOSTING

Windrow composting process consists of placing the pre-sorted feedstock in long narrow piles called windrows that are turned on a regular basis for boosting passive aeration. The turning operation mixes the composting materials and enhances passive aeration. Figure 3.11 gives an overview of the windrow composting process although the figures presented may vary with the characteristics of the waste, design of the plant, and the rigorousness with which the standard operating process is followed. Compost yield of 10-15% is more common from mixed municipal solid waste.

3.2.8.2 KEY PERFORMANCE INDICATORS FOR WINDROW COMPOST PRODUCTION

Figure 3.11 depicts a process flowchart for a 500 TPD plant, indicating 20% process efficiency. While 20% efficiency is possible under good operational conditions, the typical efficiency of a windrow compost plant receiving segregated organic solid waste is around 18%–20%, i.e., for an input feedstock of 100 TPD of segregated waste, it should be able to produce 18–20 tonnes of finished compost. Where mixed waste is received as input feedstock, compost yield of 10%–15% is expected.

Figure 3.11: Process Flowchart and Mass Balance for Aerobic Windrow Composting of 500 Tonnes Per Day of Waste[16]



16 "Composting Municipal Solid Waste: the Indian Scenario", Mazumdar, N. (2007), International Journal of Environment Technology and Management, 7 (3-4).

3.2.8.3 UNIT OPERATIONS IN WINDROW COMPOSTING

Compost pad should be impervious, have a drainage system to collect leachate for treatment and have an appropriate gradient to route the leachate to the collection point

Compost pad (platform): The pre-processed MSW (Section 3.2.7 of Part II) is transferred onto the compost pad into windrows. The compost pad is an area where the windrows are stacked. The compost pad must be stable, durable, and impervious, so it is constructed with an appropriately designed combination of reinforced cement concrete (RCC) and plain cement concrete (PCC). The compost pad shall have a slope of about 1% to drain the excess water (storm water or leachate) from the windrows into a leachate collection tank. The leachate tank is placed in the lowest corner of the compost pad area. This leachate should be reused for recirculation of nutrients and for maintaining the moisture content of windrows. Figure 3.11 describes unit operations in windrow composting.

The following factors have to be considered in the location and design of the composting pad:

- The base has to provide a barrier to prevent the percolation of leachate and nutrients to the subsoil and groundwater.
- The surface has to facilitate equipment movement even during wet weather conditions.
- The surface area has to accommodate waste for 5 weeks, with sufficient room for equipment to maneuver and an area to establish a static pile for curing compost.

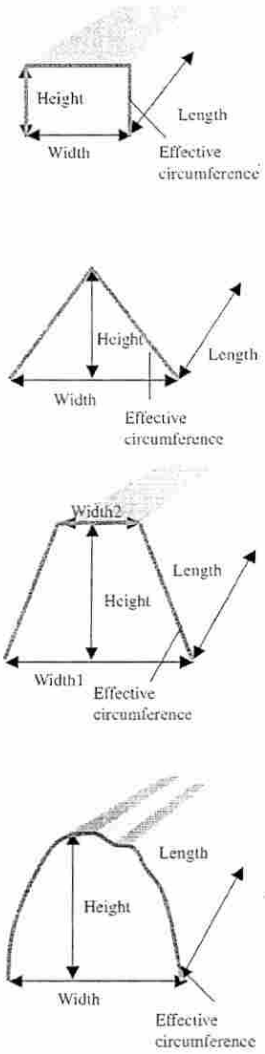
Windrow composting is the most economical and widely accepted composting process

The height to base width ratio of the windrow depends basically on the angle of repose of the material. Windrows are typically trapezoidal in cross section.

The space between windrows should be sufficient for movement of the windrow turning machine. Normally, it is 1–3 metres. Figure 3.12 below illustrates calculation of windrows sizes. Detailed designing and area required for compost pad is given in Annexure 4.

In general, as the average windrow shape is between an oval and trapezoid, a factor of 0.66 is assumed to estimate windrow volumes. Therefore, the equation for volume of the windrow is: Volume = height x width x length x 0.66.

Figure 3.12: Windrow Sizing Calculations[17]



Rectangle

Volume = Height x Width x Length

Effective circumference= 2 x height + width

Mass = Volume x Bulk Density

Triangle

Volume = Height x Width x Length x 0.5

Effective circumference= $2\sqrt{\text{height}^2 + (\text{width}/2)^2}$

Mass = Volume x Bulk Density

Trapezoid

Volume= Height x (Width1+Width2) x Length x 0.5 *

Effective circumference = $2 \times \left(\sqrt{((\text{width2}-\text{width1})/2))^2 + \text{height}^2}\right) + \text{width2}$

Mass = Volume x Bulk Density

Oval

Approximations:

Volume = Height x Width x Length x 0.75 *

Effective circumference= $2.3 \times \sqrt{\text{height}^2 + (\text{width}/2)^2}$

Mass = Volume x Bulk Density

** In general, as the average windrow shape is between an oval and trapezoid, a factor 0.66 is assumed to estimate windrow volumes and so the equation for volume becomes:*

Volume = Height x Width x Length x 0.66

Size, shape and spacing of windrows depend on turning practices:

- Bucket loaders: high windrows
- Turning machines: low and wide windrows
- Manual labour: small scale windrows

Windrow Formation: The size, shape, and spacing of windrows depend on the equipment used for turning. For example, bucket loaders are used to build high windrows, whereas turning machines create low and wide windrows. Manual labour is also used for windrows of a smaller scale, where additional equipment costs and use of machinery are not feasible.

Windrow Turning: Windrows are turned frequently to maintain aerobic conditions inside the pile. Windrow turning is a mechanised operation. Generally, pay loaders (wheel or tracked) or tractors with hydraulic

Windrow dimensions should allow conservation of heat generated during composting process while also maintaining diffusion of air to the deeper portions of the windrow

17 Compost Facility Operator Manual; Available at: http://www.transformcompostsystems.com/pdfs/Transform%20Compost%20Operator%20Manual%20teaser.pdf

Windrows should be turned frequently, once a week over 5 weeks, to maintain aeration and porosity to enhance degradation

attachments are used to scoop the material from one windrow to make a new pile in an adjacent location on the compost pad, while placing and mixing the material. Other equipment such as front-end loaders or windrows re-shifters may also be used for turning windrows. Windrow turning ensures that outer layers of piles are moved to inner layers. This process is repeated once every week for 5 weeks; high temperatures within the windrow (55°C–65°C) sanitise the material. During the rainy season where the interstitial spaces are filled with water, more frequent turning is necessary (interval of 3–4 days).

Regular turning of the windrows helps oxygenate the pile; breaks up particles to increase surface area; improves the porosity to prevent settling and compaction; and allows trapped heat, water vapour, and gases to escape. In general, the more frequently a pile is tuned, the more quickly the composting process is completed. However, too frequent turning has two disadvantages: (i) formation of heated pile in the core area being hampered (necessary for pathogen kill), and (ii) additional costs resulting from equipment and associated energy use. A balance is therefore to be achieved between number of turnings and cost of production.

A turning schedule should be established based on the rate of decomposition, moisture content, porosity of the material, and the desired composting time (often a function of land availability). Normally, once a week turning is done but more frequent during rainy season (once in 3–4 days).

In general, each windrow should be allowed to stay on the compost pad for 35 days; at the end of the 35th day, the compost is ready for use. Each windrow should have a flag board depicting the age of the waste. Fresh incoming waste is always depicted as "Age 1." The numbering on the windrow changes from Age 1 to Age 2 on the second day, Age 2 to Age 3 on the third day, and so on. Each windrow may be turned manually or mechanically. This turning process has to be done every 7th day. Hence, only those windrows having a flag board showing Age 7, 14, 21, and 28 should be turned.

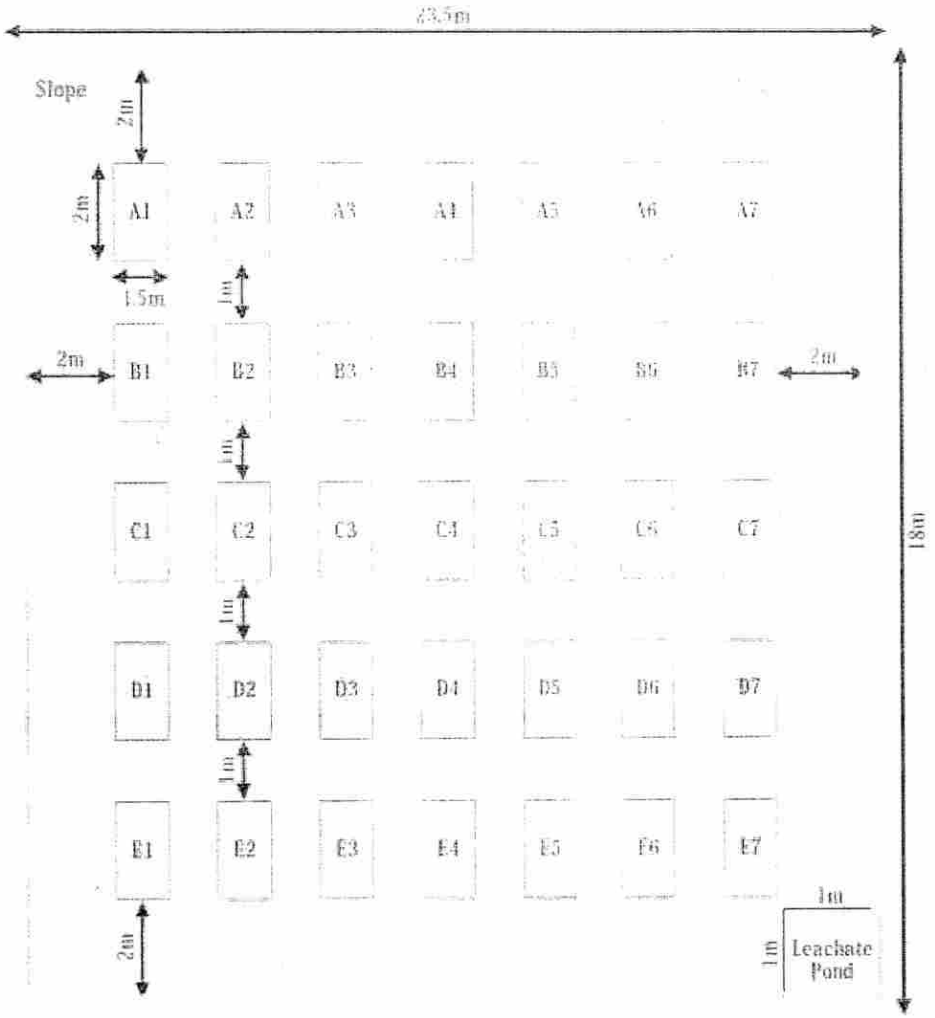
Frequency of turning depends on:

- moisture content,
- porosity of material,
- rate of microbial activity, and
- desired composting time

Figure 3.13 below illustrates an indicative arrangement of windrows. Incoming waste on day 1 is placed in pile A1. Waste that comes in on day 2 is placed in pile A2, waste on day 3 in pile A3, and so on. On the 7th day after receiving the first batch of waste A1, the pile or windrow is turned or mixed, and the pile is moved to location B1. On the 14th day, pile B1 is turned or mixed and moved to C1, and so on. Pile D1 will therefore be moved to E1 on the 28th day. On the 35th day, the compost pile from E1 should be screened for further refinement. Each of the piles or windrows A2 to A7 are managed similarly. Waste that is received on 8th day is placed in the initial location of pile A1, since this pile would

already move to B1 on the 7th day, hence this location would be free to receive a new pile or windrow.

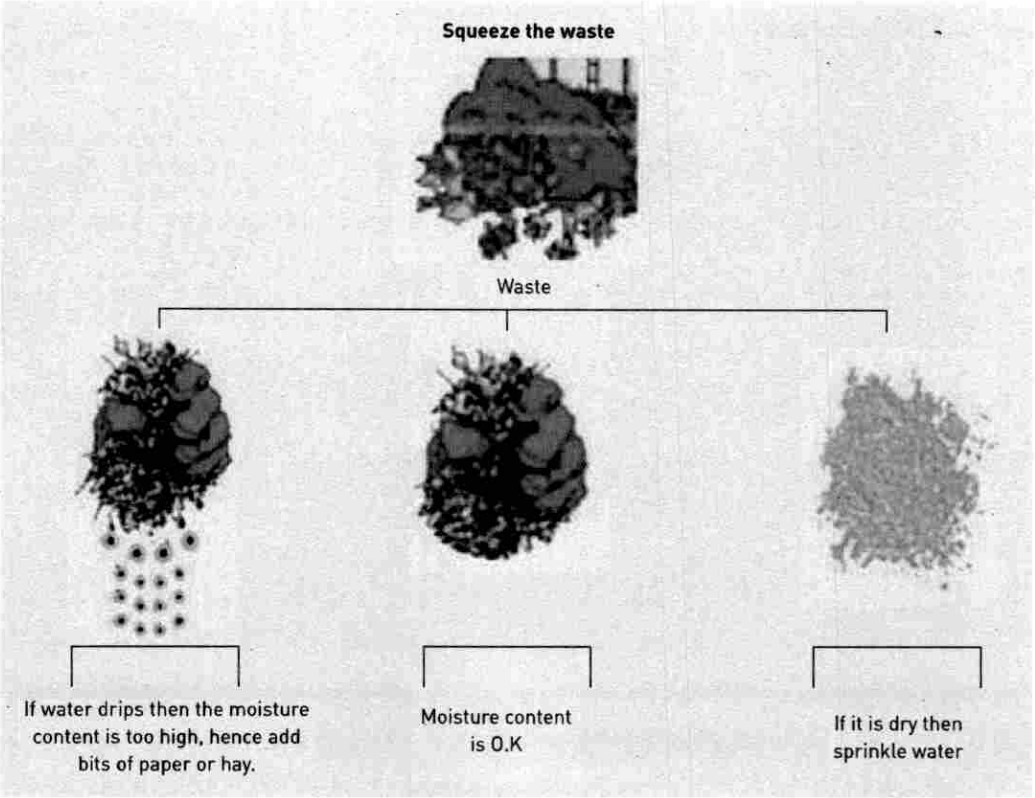
Figure 3.13: Arrangements and Turning of Windrows[18]



Fresh water or leachate stored in the leachate tank should be sprinkled during the turning process to maintain the moisture content of the waste. Figure 3.14 depicts a quick and simple method to test moisture content.

18 IEC brochure for windrow composting, GIZ (2012).

Figure 3.14: Squeeze Test to Estimate Moisture Content[19]



Temperature should also be monitored and maintained within 55°C–60°C. This is important because low or high moisture and variation in temperature can slow down the composting process.

On the 35th day, the compost is successively sieved through two stage screening system of 35 mm followed by 16 mm. Screened material coming out of this section is uniform in texture but contains semi-solid organic compost, which requires further stabilisation. The rejects from the 35 mm screen are sent to the RDF and the screened material is sent to the 16 mm screen. The rejects from the 16 mm (16 mm+) screen are to be put back on the windrow as protective covering from bird menace and vermin, and for odour control, as illustrated in Figure 3.11.

Curing of screened material for at least 3 weeks in a covered area ensures complete maturation of compost

Curing: Screened material coming out of the coarse segregation section requires further maturation and moisture control for producing a product that is beneficial for plants and soil. The degree of maturity is determined through either oxygen uptake or CO_2 production rate.

Maturity may also be determined through a simple test, wherein the material is placed in a plastic bag and moistened to 60% water content, the mouth of the bag is then closed. The plastic bag containing the moist material is allowed to sit for 24–48 hours at room temperature (30°–35°C). If foul odours are released when the bag is opened at the end of

19 IEC brochure for windrow composting, GIZ (2012).

24–48 hours, it indicates that the material is not fully matured and needs to undergo further decomposition.

The cured material does not release odours because of carbon stabilisation during aerobic decomposition of biodegradable material in the windrow. Microbial activity continues during the curing phase also, but at a lower rate compared to the main composting phase.

Nevertheless, also during curing, the supply of adequate oxygen is ensured through passive movement of air through the pile and moisture content is maintained within 25%–30%. The curing piles are placed either in a storage area or covered area for a minimum duration of 2 weeks. In general, the area needed for the curing process is one quarter of the size needed for the windrow or composting process. The completely cured well-composted material does not release foul odour and is ready for final screening and for the preparation of the finished product for marketing.

Mature and high quality compost should have a C/N ratio of around 20. Compost with either higher or lower C/N ratio is not beneficial to the soil

Compost Refinement: At the end of composting phase, the material usually contains 30%–35% moisture. The composting is normally taken to be complete when the active decomposition stage is over and the carbon-to-nitrogen (C/N) ratio is around 20.

The refinement section also consists of a feeder conveyer and a trommel with 4 mm perforations. The screened product less than 4 mm is passed through air density separator (ADS) or de-stoner to remove sand and grit. Then the compost can be put in bags and stored for sale. The remaining material greater than 4 mm should be put on top of the fresh incoming waste heap to speed up the process of composting and for absorbing excess leachate. The residue material from the ADS is inert laced with fine organic material. This should be kept out of the composting stream. This material can be used for landscaping.

Final compost product should be less than 4 mm. Remaining material should be put on the incoming waste heap to hasten the composting process

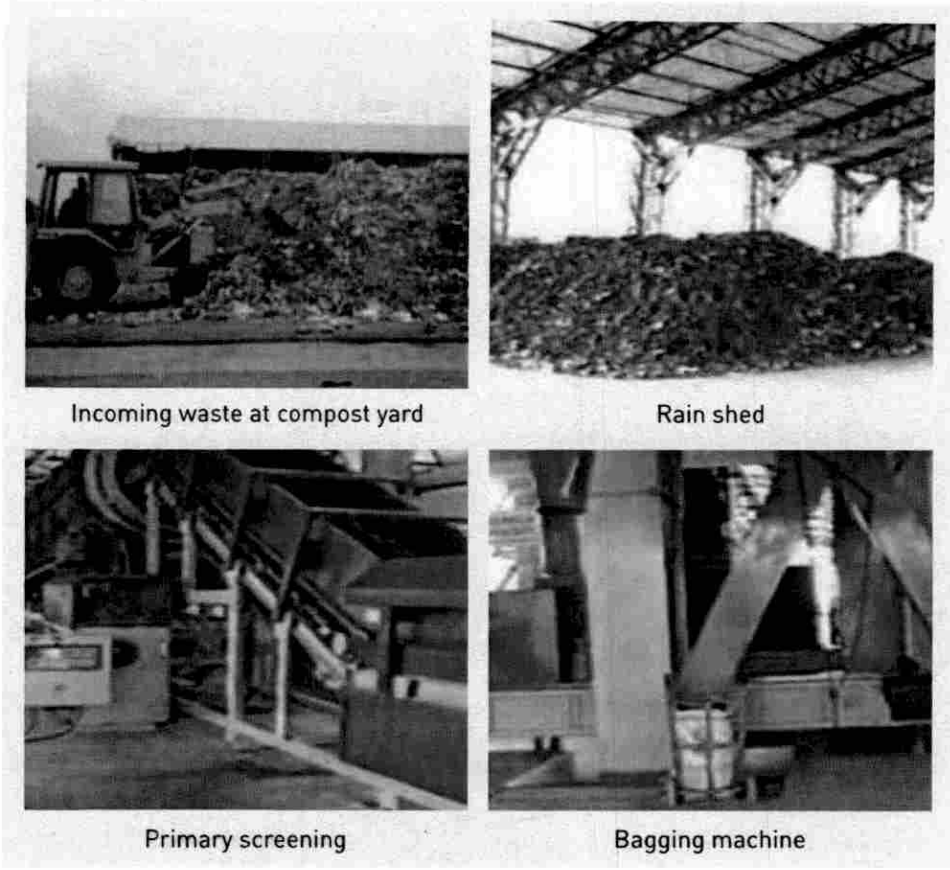
The finished product is dark brown with an earthy smell, fragile, and rich in organic matter content and nutrients.

Value-added product can be produced depending on the market demand by enriching compost with beneficial microorganisms and nutrient sources such as rock phosphate, pyrite, etc. The product is bagged and dispatched for marketing to be used on farmer's fields.

Based on the desired end use, the compost should comply with specifications of the Fertiliser Control Order (FCO), 2009 & 2013 and SWM Rules, 2016.

Bruhat Bengaluru Mahanagara Palike (BBMP) has proactively set up 7 new processing plants producing compost and crude RDF at several locations through State Government funding and nodal agency KUIDFC. The complete construction has been done by the BBMP and then handed over to private operators for O&M through competitive bidding.

Figure 3.15: Unit operations in windrow composting[20]



Leachate produced should be collected and used for moistening the waste heap

Leachate Management: Leachate is generated during composting as the biodegradable matter is fermented. It is a thick liquid with strong odour with very high biochemical oxygen demand (BOD) and chemical oxygen demand (COD). However, it has moisture and nutrients, which can be put to good use. Leachate can be treated biologically. Control of leachate is a very important part of operating a compost plant safely. But design of an effective treatment for leachate is tricky.

For open aerobic composting windrows, leachate formation is low during non-rainy season, and it can be rolled back into the windrows by placing partially composted relatively dry material around the windrows every day and pushing the absorbed leachate back to the windrows. With a good standard operating procedure (SOP), this is possible and beneficial for composting, as this step puts back some of the nutrients and microbes back into the composting windrows.

During rainy season, depending on the rainfall, the leachate gets diluted with rain water and significant volume is generated, which is beyond the capacity of a leachate treatment plant designed for fair weather. If the design is done for rainy season, the facility is completely under utilised during rest of the year and its cost is very high. For strong

20 Taken from Nashik Waste Processing Facility, Nashik Municipal Corporation.

leachate, single step treatment may be inadequate. Dilution with fresh water followed by treatment in a stabilisation pond requires large space and is not suitable for places near habitation (possible vector breeding).

In high rainfall areas, it is necessary to cover the windrows either temporarily (using water proof cover) or permanently using sheds which have side cladding at the top with the roof and low wall at ground level but otherwise open from the sides. Great care has to be taken to design the height of the shed because adequate ventilation is necessary. The design has to balance the higher cost of a heavy structure needed for high wind load and the need for adequate ventilation. Due to low height, fully covered windrows in high rainfall areas suffer from slower process and higher moisture leading to difficulty in screening.

Multilayered patented fabric covers are available, which allow moisture to go out (causing odour) but the larger molecules are held back. Such covers can be made a permanent feature, either in the form of direct cover over the windrows or in tent-like formations, within which the compostable material is stacked.

Another efficient way of controlling moisture is by using aerated static pile technology, where there is direct control over aeration and consequently on leachate generation.



Typical Equipment Required for Windrow Composting[21]

- **Loader:** Tractor mounted front-end loaders or pay loaders are used to deliver the pre-processed feedstock to form windrows. Loaders are multifunctional and can be used for some other purposes, such as maintaining the site, piling the cured compost, and loading the finished compost product into trucks or trailers for sale.
- **Windrow turner:** Loaders can be used to turn the compost windrows; however, specialised compost windrow turners are much faster and do a better job of mixing the entire windrow. If space is limited at a compost facility site, a loader is a preferred option to make windrows higher and wider. Windrow size need not be limited to suit the specialised compost turners. There are numerous turners available that are dependent on the desired windrow height and width; production capacity; and desired means of operation (self-propelled, loader mounted or pull type, and power take-off driven). Typically, windrows vary from 2 to 3 metres in height and 5 to 8 meters in base width for plants receiving 100 tonnes per day (TPD) or more of waste.
- **Screener:** A trommel screen is desired at the end of the curing process to screen the finished compost for a suitable particle size. This will remove any larger undesirable items and will fluff up the finished product to ensure a suitable compost quality.
- **Bagging:** Bulk supply of compost is usually put in 50 kg bags.

21 Operation Manual for the Establishment of a Commercial Composting Facility, Prepared by Brent Hansen Environmental in co-operation with the City of Brandon, USA; Available at: http://www.composting.ca/files/op_manual.pdf

3.2.8.4 AERATED STATIC PILE COMPOSTING

Aerated static pile technology requires mechanical aeration of composting piles

In the case of aerated static pile composting, forced aeration is used to spread excess air through the windrows unlike the aerobic windrow composting, where aeration is achieved by turning the windrows so that new cut sections are exposed to air. The composting piles are placed over a network of pipes connected to a blower, which supplies the air for composting. Air can be supplied under positive or negative pressure. When the composting process is nearly complete, the piles are broken up for the first time since their construction. The compost is then taken through a series of post-processing steps.

Unlike aerobic windrow composting, the aerated static pile has direct control over aeration. This is the strength of this system, which can be used to reduce the fermentation time and also save precious fuel (diesel) used by the turning equipment. It has also been noted that leachate generation is significantly reduced in case of aerated static pile system.

As compost piles are not turned frequently, feedstock should be mixed with bulking agents like rejects from trommels, straw and wood chips to ensure air circulation

Preparation of Feedstock: As the aerated static pile does not receive periodic turnings, the selection and initial mixing of raw materials is critical to avoid poor air distribution and uneven composting. It should be ensured that the feedstock is mixed with a stiff bulking agent such as straw or wood chips. Other possible bulking agents and amendments for static pile composting could include rejects from the 16/14 mm pore size trommels, peat moss, crop residues, bark, leaves, etc.

Pre-processing ensures porosity by removing thin plastics in the raw materials and hence facilitates efficient air circulation

Pre-processing: Aerated static piles can produce excellent compost, provided two basic operating conditions are met:

- The pile of raw material has adequate porosity.
- The airflow system is efficient and provides adequate air flows during the active composting period.

Pre-processing of raw MSW for composting in aerated static pile involves:

- separation and removal of oversize, non-compostable inert materials;
- size reduction through chipping, grinding, or shredding if necessary; and
- blending with composting trommel rejects, wood chips, and other bulking agents to allow proper air distribution.

Detailed pre-processing requirements are discussed in detail in Section 3.2.7 of this chapter.

Process: The blended material is placed in stationary or static piles. The piles are constructed above an air source, such as perforated plastic pipes, aeration cones, or a perforated floor. Aeration is accomplished

either by forcing or drawing air through the compost pile. It is very important that the pile should be placed after the floors are first covered with a layer of decay-resisting bulking agents such as wood chips or rejects from the 16 mm trommel.

Pre-processing involves:

- Segregation
- Size reduction
- Blending with bulking agents

The size of the pile depends on the material to be composted, air flow capabilities, and the type of handling equipment. The initial height of the piles should be about 1.5–2.5 m high, depending on material porosity, weather conditions, and the reach of the equipment used to build the pile. Extra height is advantageous in lower temperatures as it helps retain heat.

It may be necessary to top off the pile with 15 cm of finished compost or bulking agent to provide insulation. This layer protects the surface of the pile from drying, insulates it from heat loss, discourages flies, and filters ammonia and potential odours generated within the pile.

Controlled mechanical aeration enables construction of large piles, thus reducing the demand for land

The air supply blower either forces air into the pile or draws air out of it. Forcing air into the pile generates a positive pressure system, while drawing air out of the pile creates negative pressure. The blowers are controlled by a timer or a temperature feedback system similar to a home thermostat. Air circulation in the compost piles provides the needed oxygen for the composting microbes and also prevents excessive heat buildup in the pile. Removing excess heat and water vapour cools the pile to maintain optimum temperatures for microbial activity. A controlled air supply enables construction of large piles, which decreases the need for land.

It is suggested to cover the top of the pile with finished compost or bulking agent to ensure insulation, destruction of pathogens and suppression of odours

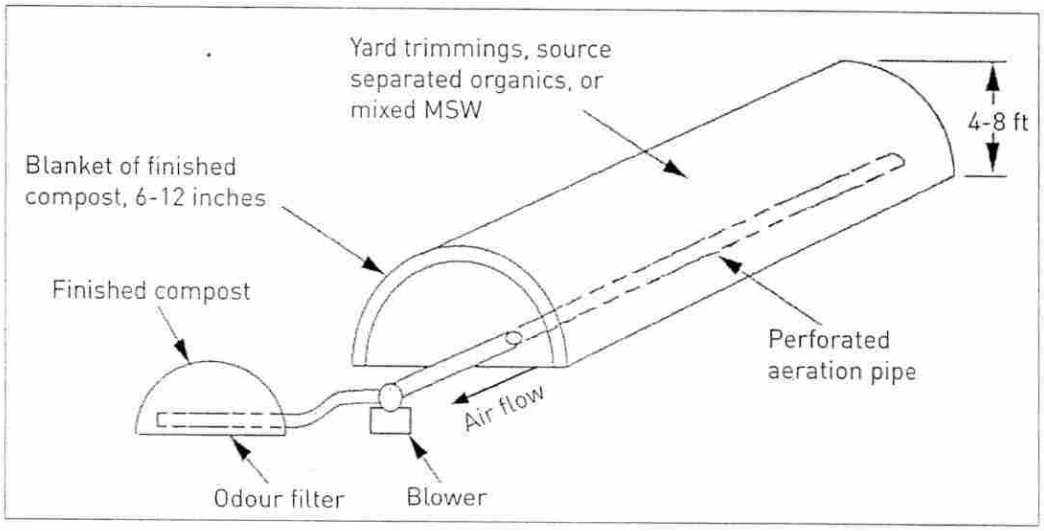
Blowers used for aeration serve not only to provide oxygen, but also to provide cooling. Blowers can be run continuously or at intervals. When operated at intervals, the blowers are activated either at set time intervals or based on compost temperature. Temperature-set blowers are turned off when the compost cools below a particular temperature. Blower aeration with temperature control allows for greater process control than windrow turning.

In well-designed and operated aerated static pile composting system, odour is much less than the aerobic windrow composting system. Even then odours from the exhaust air could be controlled by filters. The suction method of aeration allows better odour control than positive pressure aeration, particularly if the air is directed through an odour filter. An odour filter is essentially a pile of finished compost that has an affinity for odour causing molecules. The disadvantage of using suction is that not as much air can be pulled through the pile as can be pushed through using positive pressure. Figure 3.16 illustrates composting in an aerated static pile.

A top layer of matured compost could also act as an odour filter

Height of pile helps in retaining heat and should be ideally at least 1.5 m to 2.5 m

Figure 3.16: Aerated Static Pile[22]



Aerated static pile technology usually takes 6-12 weeks for producing mature compost

The temperatures in the inner portions of a pile are usually adequate to destroy a significant number of pathogens and weed seeds. The surface of piles, however, may not reach the desired temperatures for destruction of pathogens because piles are not turned in the aerated static pile technology. This problem can be overcome by placing a layer of finished compost 6–12 inches thick over the compost pile.

Producing compost using this technology usually takes 6–12 weeks depending on pre-processing of feedstock, air movement, and temperature control.

Post processing of compost involves separation of wood chips from the finished products through trommel screen

Post processing: The compost produced needs to undergo post-processing as it is mixed with bulking agents like wood chips. A trommel screen is used to separate the bulking agent from the finished product, which is fine-grained and uniform compost. The size of the compost particles depends on the usage, and the quality should comply with the specifications of FCO, 2009 and 2013 and SWM Rules, 2016.

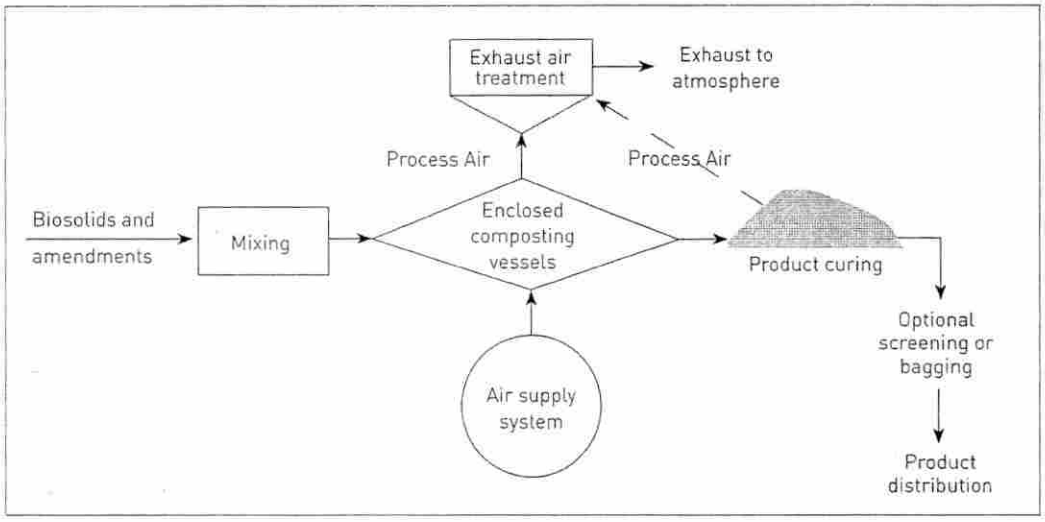
3.2.8.5 IN-VESSEL COMPOSTING

Composting takes place in single or multi-compartment vessels that provide mixing, aeration and moisture to waste feed

In-vessel composting systems enclose the feedstock in a chamber or vessel that provides adequate mixing, aeration, and moisture. There are several types of in-vessel systems available: drums, silos, digester bins, and tunnels. These vessels can be single or multi-compartment units. In some cases, the vessel rotates; in others, the vessel is stationary and a mixing or agitating mechanism moves the material around. Most in-vessel systems are continuous-feed systems, although some operate in a batch mode. Figure 3.12 below is a depiction of the in-vessel composting process.

22 Decision Maker's Guide to Solid Waste Management- Vol I, USEPA (1995). Available at: http://www.epa.gov/osw/nonhaz/municipal/dmg2/chapter7.pdf.

Figure 3.17: Composting Process in In-Vessel Composting[23]



In-Vessel composting is recommended especially for kitchen and canteen food waste

MSW Feedstock: The ideal feedstock for in-vessel composting will be organic MSW commingled with food waste, which is highly biodegradable. In fact, in-vessel composting is recommended especially for kitchen and canteen food waste and even slaughterhouse wastes.

Pre-processing: In-vessel systems vary in their requirements for pre-processing materials: some require minimal pre-processing (e.g., food waste), while others require extensive pre-processing (mixed waste). All in-vessel systems require further curing after the material has been discharged from the vessel.

Types of In-vessel reactors:

- Vertical plug flow and horizontal plug flow: feedstock is loaded on a periodic basis
- Agitated bin: feedstock is loaded and agitated continuously

Process: In-vessel composting is accomplished inside an enclosed container or vessel. Mechanical systems are designed to minimise odour and process time by controlling environmental conditions such as airflow, temperature, and oxygen concentration.

There are several types of in-vessel composting reactors: vertical plug flow, horizontal plug flow, inclined rotary drum type, and agitated bed.

In vertical plug flow systems, the feedstock is introduced into the top of the reactor vessel, and compost is discharged out at the bottom by a horizontally rotating screw auger. Air is introduced in these systems either from the bottom and travels up through the composting mass where it is collected for treatment, or through lances hanging from the top of the reactor.

In horizontal plug flow systems, the compost feedstock and bulking agent mixture are loaded into one end of the reactor. A steel ram pushes the mixture through the reactor. Air is introduced and exhausted

23 Biosolids Technology Fact Sheet – In Vessel Composting of Biosolids (2000), USEPA. Available at: http://water.epa.gov/scitech/wastetech/upload/2002_06_28_mtb_invessel.pdf).

through slots in the floor of the reactor. Compost is discharged from the end of the reactor opposite the ram.

Since composting takes place in an enclosed vessel, all environmental conditions can be controlled to enhance composting. Minimal odour and leachate generation are observed

In the rotary drum type, the composting mass is introduced through a hopper from the higher end. The material gets stabilised fast due to the cascading process and the air flow introduced in the drum. The material goes out in 5–7 days and cured further for 2 weeks followed by screening.

The agitated bed reactors are typically open topped; the feedstock is loaded from above. The composting mass is periodically agitated using a mechanical device, and air is introduced through the floors of the reactors. The vessel is emptied when the feedstock processing is complete.

The detention time in the vessel varies from 3–10 days. Curing period of 2–3 weeks is required after the active composting period. Since in-vessel facilities are highly rated and highly capital-intensive, the design involves a shorter residence period inside the vessel followed by a relatively longer curing period outside the vessel.

In vessel composting requires at least 12-14 weeks to produce mature compost

A major advantage of in-vessel systems is that all environmental conditions can be carefully controlled to allow rapid composting. These systems, if properly operated, produce minimal odours with little or no leachate. In addition, the air supply can be precisely controlled. Some units are equipped with oxygen sensors, and air is preferentially supplied to the oxygen deficient portion of the vessel. In-vessel systems enable exhaust gases from the vessel to be captured for odour control and treatment.

3.2.8.6 DECENTRALISED COMPOSTING

As per SWM Rules, 2016:

Clause 15: Duties of local authorities

(m)collect waste from vegetable, fruit, flower, meat, poultry and fish market on day to day basis and promote setting up of decentralised compost plant or biomethanation plant at suitable locations in the markets or in the vicinity of markets ensuring hygienic conditions;

(t) involve communities in waste management and promotion of home composting, bio-gas generation, decentralised processing of waste at community level subject to control of odour and maintenance of hygienic conditions around the facility;

(v) facilitate construction, operation and maintenance of solid waste processing facilities and associated infrastructure on their own or

with private sector participation or through any agency for optimum utilisation of various components of solid waste adopting suitable technology including the following technologies and adhering to the guidelines issued by the Ministry of Urban Development from time to time and standards prescribed by the Central Pollution Control Board. Preference shall be given to decentralised processing to minimize transportation cost and environmental impacts such as-

a) biomethanation, microbial composting, vermi-composting, anaerobic digestion or any other appropriate processing for bio-stabilisation of biodegradable wastes;

Colony level and ward level decentralised composting should be promoted by ULBs for source separated organic household waste from very small quantities (upto 20 TPD)

Transportation of MSW through cities is a big issue. Decentralised composting is one of the options to reduce the burden of transportation of MSW in the urban local body (ULB).

Decentralised composting is the composting of source separated organic waste in limited quantities from households, apartments, neighbourhoods, markets, gardens, or the entire ward. The decentralised composting approach reduces transportation costs and makes use of low-cost technologies based mainly on manual labour.

Decentralised composting can be practiced in either box or bin depending on the quantity of waste feed and cost implications

Decentralised composting facilities generally handle waste from very small quantities up to 20 TPD depending on the size of the community and volume of compostable waste material in the waste stream.

Bruhat Bengaluru Mahanagara Palike (BBMP) has clearly specified in its Solid Waste Management Plan that urban local bodies (ULBs) should give directions for installing composting units in every apartment to process wet waste.

Municipal Solid Waste Feedstock: The feedstock for decentralised composting should include kitchen waste like food, fruit, and vegetable leftovers (rich in nitrogen content); and yard waste like leaves, twigs, straw, and paper (rich in carbon content).

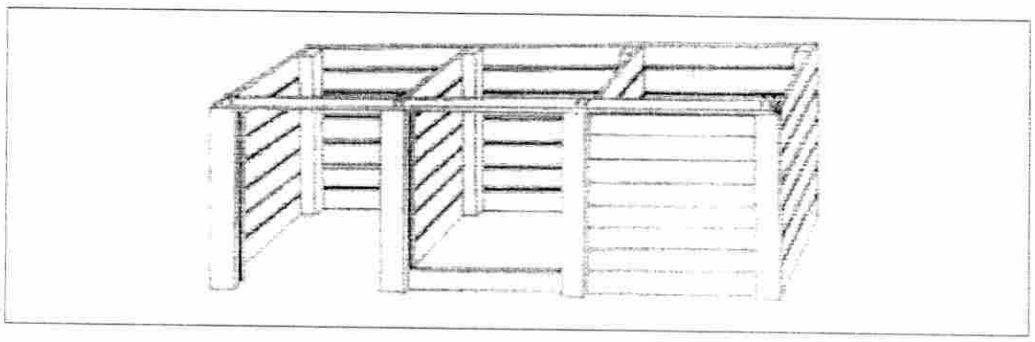
Pre-processing: The waste that reaches the decentralised composting facility should be segregated at source so that only minimal sorting at the facility is required.

Processing: Decentralised composting can be practiced using box or bin composting. Box composting is typically carried out at the community level, whereas bin composting may be practiced at individual household level as well.

3.2.8.6.1 Bin Composting

Depending on the quantum of input material, the size of the bin may be decided. A series of bins may be used to accommodate all incoming waste, as shown in Figure 3.18. The bottom of the bin should be covered with a thick layer (15 cm) of coarse material, such as twigs, broken pieces of stone, or mulch, if available. Over this drainage layer, the feedstock is to be placed in layers. The feedstock should ideally contain a mix of garden or yard waste, kitchen waste, dried leaves, and paper. Water may be sprinkled to keep the heap moist. Care should be taken not to add excess water; the heap should not be wet. Excessively wet conditions can be prevented by placing more dried waste like dried leaves, twigs, and paper. Finished compost may be sprinkled on top to provide the required inoculum and to contain odour. This waste should be turned regularly to hasten the composting process. High temperatures are produced upon turning once every 5–10 days. This also helps to kill larvae and weed seeds, and provides a conducive environment for decomposer organisms. The composting process may take between 45 days and 6 months, depending on the feedstock and turning condition.

Figure 3.18: Bin Composting[24]



3.2.8.6.2 Box Composting

Box composting is practiced at the local community level and can cater to wastes up to 3–5 tonnes. The total space requirements for box are lower than for the windrow technology. The slab on which the boxes are built should be sealed and sloped towards one side. Leachate collection channels should be constructed, leading the leachate away from the boxes toward a central collection point. To improve oxygen supply to the pile within the boxes, the box wall contains gaps between the bricks. The base of the box should be perforated and resistant to corrosion to ensure aeration and drainage of excessive water from the pile. The base should be equipped with small polyvinyl chloride (PVC) pipes or a coated metal grid to facilitate aeration and drainage of excessive water

24 Composting Methods, Ministry of Agriculture, Food and Fisheries, British Columbia (2004).

from the pile. Perforated PVC pipes placed vertically inside the box provide additional oxygen exchange within the composting material.

Indicative cross sections for a 3-tonne compost box with shed, a composting box, and drainage and aeration for box composting are shown in Figure 3.19, Figure 3.20, and Figure 3.21.

The sorted organic waste is loosely spread in layers of 20 cm into the box, around the vertical aeration pipes. If one box is not sufficient, the remaining waste has to be spread in a second box. Assuming an input load of 3 TPD of organic waste, two boxes are filled within 5–6 days. The boxes receive one layer of waste per day. Every time a layer is added, it is loosely mixed with the previous layer using a fork or shovel. When the box is full, the waste is left for 40 days to go through a thermophilic-mesophyllic composting process similar to the windrow system.

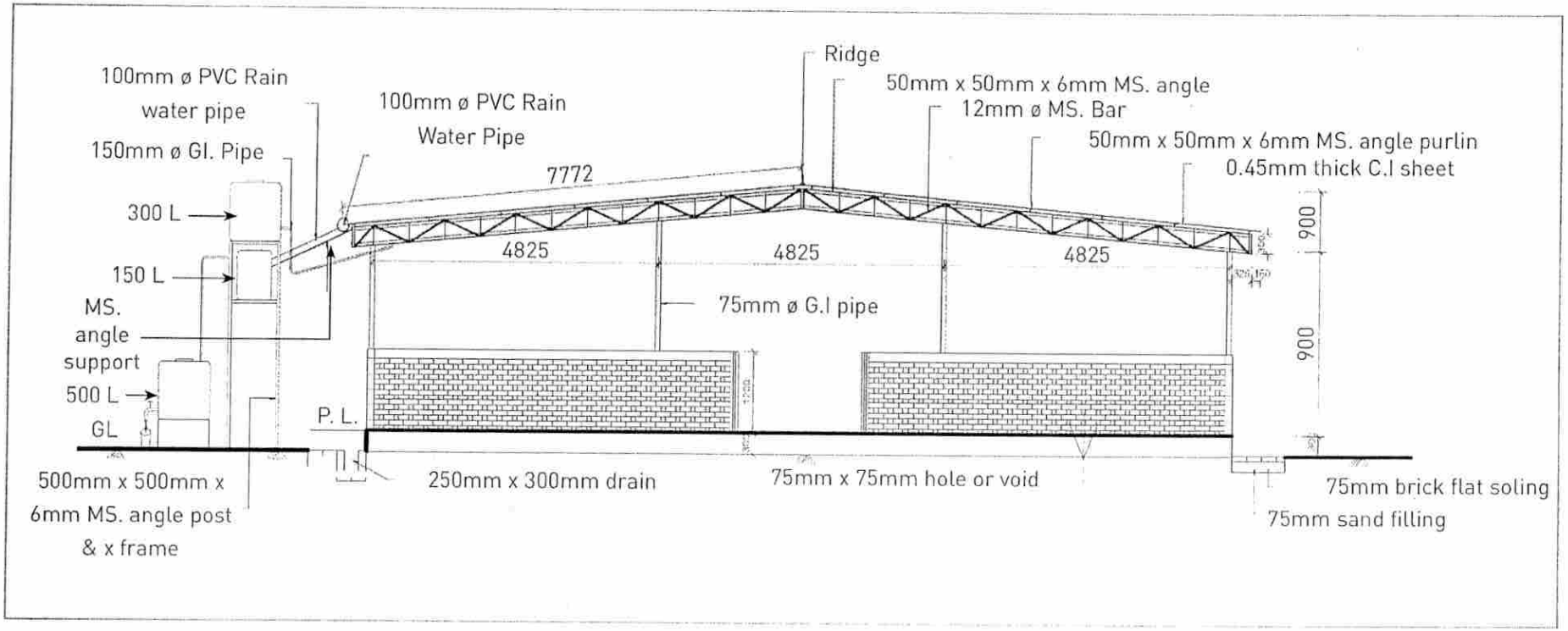
Temperature and moisture are frequently monitored. If the material is too dry, water is to be sprayed over the compost and the material is leveled again. Since the waste is thoroughly mixed with coarse material like straw, passive aeration takes place and there is no need to turn the waste. After 40 days, one side of the box is opened and the fresh compost is removed from the box and stored as a pile for further maturation.



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Figure 3.19: Cross Section of Typical 3 Tonne Composting Box[25]



25 Decentralised composting for cities of low and middle income countries – a user's manual; Available at: http://www.ircwash.org/resources/decentralised-composting-cities-low-and-middle-income-countries-users-manual

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Figure 3.20: Typical Cross Section of Composting Box[26]

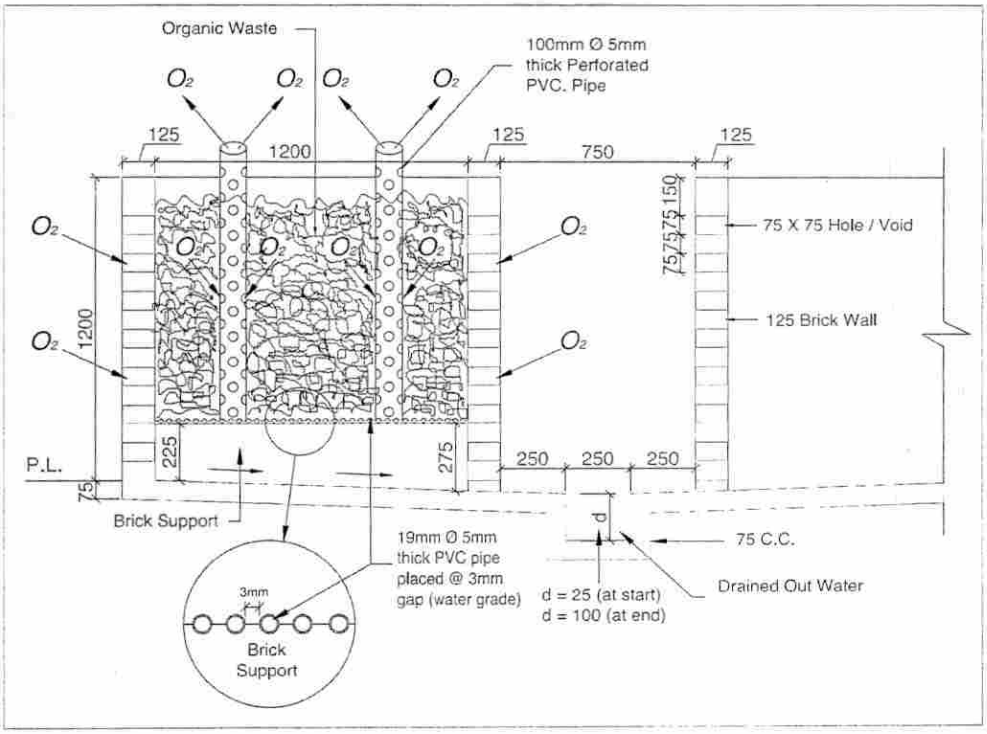
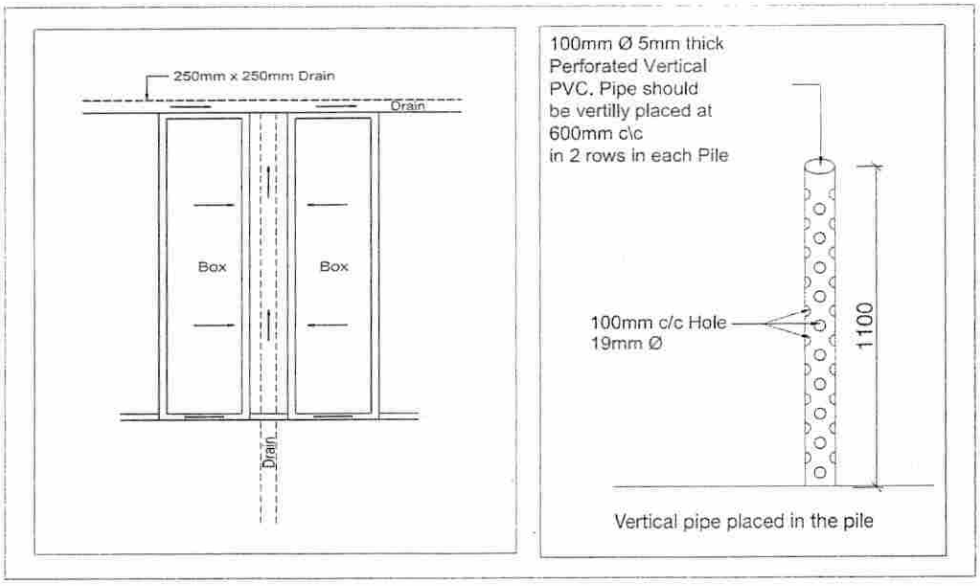


Figure 3.21: Cross Section of Drainage Channels and Vertical Pipes[27]



Screening: The mature compost has a rather coarse texture. The particle size of the compost strongly depends on the size and composition of input material. Further screening is required to produce finer compost. A flat frame sieve or a rotating drum sieve is used for screening. Each size and type of sieve with its particular mesh size is suited for a particular throughput and application. Selection of screen sizes is dependent on the desired final compost characteristics.

26 Ibid.

27 Ibid.

Decentralised Composting in a Residential Colony

At General Pool Residential Accommodation (GPRA) Complex, New Moti Bagh, New Delhi, a novel model of decentralised solid waste management facility has been established with the support from the Ministry of Urban Development and National Buildings Construction Corporation. The decentralised facility receives around 1.5 tonnes of household waste from 1,100 households and 1 tonne of garden and horticultural waste on average. The waste is collected and segregated at the site where wet organics is processed in a shredder prior to its treatment in the organic waste converter (OWC) unit (patented equipment). The shredded organic waste is processed in the OWC for 20–30 minutes and is converted into homogeneous odour-free material. After treatment in OWC, the homogeneous waste is stored in curing trays for 15 days. The trays are equipped with water sprinklers that are automatically timed for sprinkling twice a day. At the end of 15 days cycle, the organics are ready to be used as compost and is used as organic fertilizer for the gardens inside the complex. Garden and horticultural waste is pelletized and sold as biofuel. Plastics from waste are converted into mixture of liquid fuel, which is close to light diesel oil. Other types of recyclables like glass, paper, etc. are sold to recyclers. It is estimated that about 15–20 tonnes of output (compost and pellets) are produced per month yielding about Rs.2,00,000–Rs.2,50,000 lakhs.

This model may be replicated for large gated community with necessary financial support. More information is available at http://gpwm.strikingly.com/#new-moti-bagh.



Biomechanical Composting Technology for Processing 0.5 to 3.0 Tonnes Per Day of Waste

A typical batch aerobic digester shreds, cuts, and homogenizes segregated organic waste. The segregated organic waste along with coarse waste such as garden pruning, bones, etc., are shredded in shredding machine prior to feeding into the digester. The organic waste is homogenized with appropriate bio-culture and organic absorbent (e.g., dry leaves, and grasses) media. The process involves mixing and initiation of aerobic digestion of organic waste with inoculants in the machine chamber. Then the material is taken out and stacked in a rack for composting for about 3 weeks, where arrangement for periodic water drip is made. Temperature achieved during the process ensures control of pathogens. Raw compost is formed, having uniform colour and soil with structured coarse material free of bad odour.

The end product is recommended for urban agriculture, terrace gardens, parks, and urban forests.

The batch aerobic digester system requires a three-phase power supply for running the shredder and the aerobic digestion chamber. Periodic maintenance of the machine is essential for continuous operations.

Critical operating factors influencing the performance of a batch aerobic digestion chamber include presence of adequate moisture and absorbent media to ensure sufficient structural space within the material to facilitate continuous aerobic conditions. Temperature and moisture control are critical factors to be monitored continuously.

An Institutional Model for Decentralised Waste Management: Miranda House, University of Delhi

Miranda House, University of Delhi has had a paper recycling plant since 2004. However, an effort of the college towards creating a zero-waste campus was started in 2013 by the initiative of MH Vatavaran, the Environment Society, with encouragement and active support from the Principal. Under this initiative, the college has set up a composting unit in addition to the paper recycling unit. The handmade paper unit is managed by operating staff specially employed by the college, while the operation of the composting unit has been contracted out to GreenBandhu—the firm which installed the plant—for 1 year.

The composting facility manages about 150 kg of organic waste on a daily basis including waste from the hostel kitchen and canteen, as well as horticultural waste. The segregated kitchen waste that is received at the plant sometimes needs further segregation. This segregated waste is pulverized and dewatered, mixed with horticulture waste and cured compost, and put in covered containers for composting. The final product is utilized for the college garden, and the surplus manure is bought by the service provider at the rate of Rs. 5 per kg.

The handmade paper unit consisting of a shredder, beater, univat, screw press, and calendering machine handles the paper waste from the college. On average, approximately 12–15 sheets are produced per day. Initially, file folders, gift envelopes, and carry bags were being produced. The college is now experimenting with producing printing quality handmade paper for internal use.

The overall cost for the installation of the composting facility was Rs. 4,00,000, and the college pays Rs. 5,000 and Rs. 1,200 per month to the service provider as salary for an operator and a helper respectively. Approximately 50 kg of compost is produced on average every day. The cost for installation of the currently functional handmade paper unit is approximately Rs. 4,50,000.

Section 1.4.5.8 of Part II contain case studies of successful decentralised SWM initiatives.

3.2.8.7 VERMICOMPOSTING

As per SWM Rules, 2016:

Clause 15: Duties and responsibilities of local authorities:-

(t) involve communities in waste management and promotion of home composting, bio-gas generation, decentralised processing of waste at community level subject to control of odour and maintenance of hygienic conditions around the facility;

(v) facilitate construction, operation and maintenance of solid waste processing facilities and associated infrastructure on their own or

with private sector participation or through any agency for optimum utilisation of various components of solid waste adopting suitable technology including the following technologies and adhering to the guidelines issued by the Ministry of Urban Development from time to time and standards prescribed by the Central Pollution Control Board. Preference shall be given to decentralised processing to minimize transportation cost and environmental impacts such as-

a) biomethanation, microbial composting, vermi-composting, anaerobic digestion or any other appropriate processing for bio-stabilisation of biodegradable wastes;

Vermicomposting is the process of using earthworms and micro-organisms to turn kitchen waste into black and nutrient rich humus

Vermicompost is the castings of earthworms. In the present context, vermicomposting is the process of composting the biodegradable fraction of MSW with the help of earthworms, resulting in the production of vermicompost which can be used in agricultural fields as a soil conditioner and nutrient supplier. Vermicompost is richer in plant nutrients compared with normal compost prepared from similar material; it has some cocoons which develop into worms when put in the soil and continues to do their work of conversion. Vermicompost draws better market price as compared with compost and, in addition, sale of worms can bring in additional revenue. The worms can be further utilised for initiating a fresh vermicomposting process and also as bait for fishing. The efficiency of vermicomposting process depends on selection of proper species of earthworms and their optimal growth.

Commonly used earthworms:

- Pheretima elongata
- Lampito mauritii
- Eisenia fetida
- Perionyx excavatus
- Eudrilus eugeniae

Vermicomposting is typically suited for managing smaller waste quantities. It is an ideal technology for towns that generate up to 50 TPD of MSW which is thoroughly segregated either at source or in the plant. The worm species that are considered efficient for conversion of waste are *Eisenia fetida, Perionyx excavatus, Lampito mauritii, Eudrilus eugeniae, Lumbricus rubellus, Pheretima elongata*, etc.

Municipal Solid Waste Feedstock: Kitchen waste is the preferred feedstock for vermicomposting; however, some materials like meat waste, greasy and oily food, and dairy products tend to foul the bed and cause bad odour. Other suitable feedstock are vegetable market waste, garden waste, cow dung, and agricultural waste. In fact, stabilised cattle manure is very useful in preparing the bed and initiating the vermicomposting process.

Vermi bed or pit: A vermicompost pit of any convenient dimension can be constructed in the backyard or garden, field, or shed. It may be a single pit, two or four interconnected pits, or preferably above ground chambers with proper water outlets. However, the depth or height should not be more than 0.75 m so that the bottom part also gets some aeration and the earthworms are not put under a heavy moist load. Two

important points to keep in consideration while vermicomposting are the protection of the worms from predators (ants, birds, snakes, etc.) and maintenance of high temperature (above 40°C) and dry environment (low moisture below 40%). Temperature of 20°C–30°C and moisture of about 70% is ideal for most of the earthworm species employed for vermicomposting. This means that the climatic conditions should be conducive unless the whole process is carried out in a carefully controlled climate. Carbon-to-nitrogen (C/N) ratio of 15–35: 1 is suitable. Typical density of earthworms should be 1–4 kg per m^2 on average.

Vermicomposting takes place at 20-30°C which is the most favourable temperature for ensuring survival of earthworms

The vermin bed is a multilayered chamber lined with coarse sand or gunny bags, or straw and stalks at the bottom, above which a 15–20 cm layer of lightly moist composted cattle manure is placed. Some operators prefer to mix loamy soil with the composted manure. Suitable number of earthworms are introduced in this layer. After 1–2 days, segregated biodegradable waste is introduced. In small operations, the waste can be directly put over the cattle manure in thin layers. The worms move up to reach the waste material which is their food. The bed is covered loosely with wet gunny bags or palm fronds or any available material, serving two purposes: (i) moisture is retained, and (ii) darkness is maintained as the worms usually want to stay away from light. One has to take care that any material containing toxic matter or heavy metals does not get into the vermin bed.

Worm casting or vermicast should be stored in sacks for at least a month to ensure complete maturation before being applied to soil

For large operations, it is necessary to pre-compost the input material so that the heat generated during the initial phase gets dissipated and the material cools down to ambient conditions. Pre-composting is best done in aerobic windrows or aerated static piles for faster results. Building up a large workforce of worms is essential for processing large quantity of waste.

Under Indian conditions, the entire cycle of vermicomposting takes about 10 weeks. In case of pre-composted material, about 7-8 weeks is required. For harvesting, great care is required to ensure that the worms are not injured. Coning of the vermicompost is done when the worms move downwards to the bottom. The vermicompost is carefully scooped out from the top. As the pit progressively gets emptied, the last 15–20 cm layer which retains the worms is used for next load of waste to be treated. Commonly encountered problems, as well as possible causes and solutions are tabulated below in Table 3.4

Since earthworms are very sensitive towards heavy metals, it is very important to ensure that waste feed is not contaminated

Table 3.4: Vermicomposting- Problems, Possible Causes and Solutions[28]

PROBLEMS	POSSIBLE CAUSES	SOLUTIONS
Foul odour	Overfeeding	Remove the excess food, remove meat or dairy products if any
	Not enough air circulation or anaerobic conditions	Fluff up or loosen bedding
	Bed too wet	Add bedding to absorb moisture
Flies	Waste exposed	Bury the waste completely
Ant infestation		Immerse the base or feet of the vermi bed in water
		A barrier of chalk or petroleum jelly may repel the ants
		If bedding seems dry, add water
Mite infestation		Avoid adding foods with high moisture content
Worms are dying or crawling away	Bed too wet	Do not water till it reaches appropriate moisture
	Bed too dry	Sprinkle water till it turns moist
	Excess temperature, not enough air, not enough food	Sprinkle water till it turns moist and temperature drops, add waste appropriately
	Bed packed tightly	Turn bed and make it fluffy

3.2.9 YARD WASTE COMPOSTING

As per SWM Rules, 2016:

Clause 15: Duties and responsibilities of local authorities:-

(p) collect horticulture, parks and garden waste separately and process in the parks and gardens, as far as possible.

ULBs should ensure that horticulture waste in parks and gardens should be used in the most optimum ways to minimise the cost of collection and transportation of such waste. Yard waste such as leaves, grass clippings, straw, and nonwoody plant trimmings can be composted on site, thereby reducing the amount of waste to be handled by ULBs. However, some of these contain higher percentage of lignocellulosic material which takes much longer time for composting process to complete, e.g., straw, dried stems, etc. These can be readily converted into mulch in shorter time.

In places where large quantities of horticultural waste are generated, e.g., leaves and pruning, especially during rainy, autumn, and spring seasons, it may be a good idea to convert such leftover material into mulch which could not be composted.

28 IEC brochure for Vermicomposting, GIZ (2012).

Feedstock: Leaves, grass clippings, and weeds make good compost. Additionally, fruit and vegetable scraps can also be composted. Woody brown materials such as autumn leaves are high in carbon while green, moist material such as grass clippings are high in nitrogen.

- high nitrogen 'green' ingredients include grass clippings, weeds, fruit and vegetables, coffee grounds, tea bags, eggshells, manure, alfalfa hay or meal.
- high carbon 'brown' ingredients include autumn leaves, straw, cornstalks, wood chips, saw dust, pine needles.

Using approximately three parts of 'brown' material to one part 'green' material optimises the composting process and prevents odours from developing.

Process: Barrel or drum composter can be used for composting to save space and hasten decomposition. Bins made of wire, wood, or even garbage cans with drainage holes can be used for the purpose. It should be ensured that the bins are rodent resistant and have a secure cover. The bottom of the pile should consist of coarse material like corn stalks to build in air passages. Alternating layers of 'brown' and 'green' material with shovel full of compost or farmyard manure on top of each layer should be added. Shredding of leaves and twigs will shorten the composting time. A nitrogen source like manure should be placed on top of this layer to increase microbial activity and hasten the process. Water should be added to the pile to keep it moist; however, care should be taken to prevent waterlogging. The pile should be turned every few days to provide aeration and prevent odours. A properly mixed and adequately turned compost pile does not produce odour.

If only leaves are to be composted, layering is not required. Fallen leaves can be added as they are collected and should be moistened. However, addition of manure will be required to hasten decomposition.

Generally, the compost from a well-managed pile made up of shredded material under warm conditions will be ready in about 2 months. When the compost is ready, the pile will be reduced to half of its original size and will have an earthy smell to it. Table 3.5 lists some of the common problems encountered during yard waste composting and their solutions.

Table 3.5: Yard Composting-Problems and Solutions[29]

PROBLEMS	POSSIBLE CAUSES	SOLUTION
Material in the bin not decomposing or not heating up at all	• Not enough nitrogen • Not enough oxygen • Not enough moisture	• Add enough nitrogen-rich sources like manure, grass clippings, or food scraps • Mix the material regularly • Add water to moist the pile
Matted leaves or grass clippings are not decomposing	• Poor aeration due to self compaction, especially when wet • Lack of moisture	• Loosen material with rake • Avoid adding thick layers of same material. • Shred material before mixing
Stinks like rancid butter, vinegar, or rotten eggs	• Lack of oxygen • Bin is too wet or compacted • Presence of cooked food	• Turn the material to provide aeration • Add coarse dry material like straw, hay, or leaves to soak excess moisture and mix well
Vermin problem or fly larvae	• Inappropriate material (meat, dairy products) • Bin is too wet • Poor aeration	• Adjust the moisture by adding dry material or ash. • Place the bin where there is sun so that heat can destroy fly larvae, weed seeds, and other pathogens. • Change to fly-proof closed bin with enough aeration.
Odour like ammonia	• Not enough carbon	• Add brown material like dried leaves, straw, hay, shredded paper, etc.
Attracts rodents, flies, or other animals	• Inappropriate material (meat, oil, bones) • Material like fresh food scrap is too close to the surface of the bin	• Remove inappropriate materials from compost bin. • Switch to a rodent-proof safe bin.

29 Practical Action, "Home Composting Bins". Available at: http://practicalaction.org/media/preview/12742/lng:en.

3.2.10 SUMMARY: CRITERIA FOR SELECTION OF COMPOSTING TECHNOLOGIES

The choice of composting technology depends on a number of criteria which include quantity of waste to be processed, land requirement, climatic conditions, stability, energy requirements, financial implications, monitoring requirements, and aesthetic issues. Table 3.6 gives a brief overview of different composting technologies.

Table 3.6: Summary of Different Composting Technologies[30]

PARAMETERS	WINDROW	AERATED STATIC PILE	IN-VESSEL	VERMICOMPOSTING
General	Simple technology for large scale application	Effective for farm and municipal use	Large-scale systems for commercial applications	Small scale
Amount of input waste per day to be treated	1–500 tonnes	1–500 tonnes	1–300 tonnes	upto 50 tonnes
Land requirement	8 ha for 500 TPD including buffer zones	5 ha for 500 TPD (Less land required given faster rates and effective pile volumes)	4 ha for 500 TPD (Limited land due to rapid rates)	2 ha for 50 TPD
Time	8 weeks	5 weeks	4 weeks (3–5 days in vessel; 3 weeks to mature)	8 -10 weeks
Ambient temperature	Not temperature sensitive	Not temperature sensitive	Not temperature sensitive	Temperature sensitive (20°C–40°C ideal range, maximum 40°C)
Energy input	Moderate	Moderate (2-3 hours aeration)	High	Low
Financial implications	Moderate	Costly	Very costly	Moderate but purchase of exotic earthworms suitable for MSW vermicomposting are expensive
Odour and aesthetic issues	Odour is an issue if turning is inadequate	Moderate but controls can be used such as pile insulation and filters on air system	Minimum due to equipment failure or system design failure	None

30 Expert Committee for the revision of MSWM Manual (2014).

3.2.11 MONITORING OF COMPOST PLANTS

Routine testing and monitoring is an essential part of any composting operation. Monitoring the composting process provides information necessary to maintain a high-quality operation. At least the following parameters should be monitored:

- windrow temperature (daily);
- oxygen concentrations in the compost mass (daily);
- moisture content (daily); and
- full analysis as per FCO, 2009 and 2013 for each batch after preparation of finished compost.

Compost should meet standards set by FCO, 2009 and its amendments before being used as soil conditioner

Compost quality should be monitored by the operator of the compost facility per batch of compost being sold to the market. If the facility does not have sufficient laboratory capacity to perform all the tests, National Accreditation Board for Testing and Calibration Laboratories (NABL) accredited laboratories should be contracted to perform these tests on a regular basis. Compost that does not meet specified standards should be put to uses other than for application to food crops. A standard operating procedure for windrow composting is given in Annexure 5.

3.2.11.1 QUALITY PARAMETERS FOR COMPOST PRODUCTION

Standards for PROM are included in the FCO, 2013

The compost which is to be used as fertiliser for food crops should abide by the more stringent FCO, 2009, while compost used as a soil conditioner and for other purposes should at least meet the requirements of SWM Rules, 2016. Phosphatic fertiliser is in short supply in the country. The use of phosphate rich organic manure (PROM) can reduce the use of phosphatic fertilisers to some extent; PROM is formed by the mixing of rock phosphate with MSW derived compost. The FCO, 2013 specified quality standards for PROM, while retaining the standards specified in FCO, 2009 for organic compost.

As per SWM Rules, 2016, Table 3.7 specifies the compost quality standards. Table 3.8 presents the standards for vermicompost quality as specified by the FCO, 2009.

Prevention of cross contamination of organic material with inerts and street sweeping coupled with appropriate pre-sorting and segregation of raw material for composting will, to a large extent, ensure that heavy metal contamination is minimised in the finished compost.