Ministry of Housing and Urban Affairs
Government of India

Swachh Bharat Mission - Urban

ADVISORY ON
MATERIAL RECOVERY FACILITY (MRF)
for Municipal Solid Waste

Central Public Health and Environmental Engineering Organisation
(CPHEEO)

Ministry of Housing and Urban Affairs
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www.swachhbharaturban.gov.in | www.cpheeo.gov.in

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Ministry of Housing and Urban Affairs
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Preface

One of the objectives of Swachh Bharat Mission- Urban (SBM-U) is the scientific handling of spiraling Municipal Solid Waste in urban India. Segregation at source followed by resource recovery is an established principle of waste management. SBM-U has been advising segregation at source and the same has taken root across the country today. It follows that the Material Recovery Facilities (MRFs) mandated under the SolidWaste Management Rules 2016 are implemented in a massive way to build-up on the benefits of segregation.

There is no doubt that MRFs will be a game-changer for Urban Local Bodies (ULBs) to achieve success in scientific solid waste management. MRFs are also essential building blocks for the 3R principles i.e. reduce, reuse, recycle which, in turn, is the foundation for resource efficiency and the creation of a circular economy. Moreover, this approach leads to improved public health and quality of life apart from generating jobs, integration of informal workers into the formal workforce, generation of revenue and creation of new products from waste streams finally leading to not just a Swachh (clean) but a Swasth (healthy), Sashakt (empowered), Sampann (prosperous) and Atmanirbhar (self-reliant) Bharat.

I congratulate the officers of SBM-U division and CPHEEO for bringing out this advisory which will be of great use by Chairpersons, Commissioners and Executive Officers etc of all ULBs.

Happy World Environment Day !

(Durga Shanker Mishra)

New Delhi
June 5, 2020

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GOVERNMENT OF INDIA
MINISTRY OF HOUSING AND URBAN AFFAIRS
NIRMAN BHAWAN

नई दिल्ली-110011, तारीख 20
New Delhi-110011, dated the 20

FOREWORD

With rapid urbanization, the issue of Municipal Solid Waste Management (MSW) in the country has emerged as a challenge with an estimated 65 million tonnes of MSW generated annually by around 400 million citizens residing in urban areas. Rule 15h of the Solid Waste Management Rules of 2016 mandates the setting up of "Material Recovery Facilities (MRFs) 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". While the thrust on the establishment of MRFs is clear, the rules do not go into the specifics of these facilities, their formation and effective functioning. A need was therefore felt to bring out an advisory that deals with the subject in detail including types of MRFs, its constituents, selection criteria for MRFs, process flow, amongst others. The document also presents select best practices from cities such as Indore, Ambikapur, Chennai, Dungarpur and Rajpura which can serve as a model and inspiration for other ULBs in their MRF journey.

Ultimately, it is our endeavor to help our towns and cities adopt the 3R mantra of reduce, reuse and recycle in principle and in practice thus leading to the creation of a circular economy. Establishment and optimum utilization of MRFs will not only reduce waste volumes but also result in cost savings, reduce environmental management efforts and generate livelihood opportunities for informal, local vendors and recyclers. Through effective resource recovery, we will not only encourage 'Green Consumerism' but create strong foundations for a sustainable ecosystem based on the 'zero-waste' approach.

I take the opportunity to thank and congratulate SBM-U Division and CPHEEO for their efforts to bring out this advisory which I am sure, will prove useful to all Urban Local Bodies and indeed, all practitioners of scientific solid waste management.

New Delhi
5th June, 2020

V. K. Jindal

(V.K. Jindal)

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Abbreviations

CBO	Community Based Organizations
CPCB	Central Pollution Control Board
CPHEEO	Central Public Health and Environmental Engineering Organization
C&D	Construction and Demolition
GHG	Green House Gas(es)
INR	Indian Rupee
ISWM	Integrated Solid Waste Management
kWh	Kilo Watt Hour
MT	Metric Tonne
MoHUA	Ministry of Housing and Urban Affairs
MNRE	Ministry of New and Renewable Energy
MoEFCC	Ministry of Environment, Forest and Climate Change
MRF	Material Recovery Facility
MSW	Municipal Solid Waste
MSWM	Municipal Solid Waste Management
NGO	Non-Government Organization
O&M	Operation and Maintenance
PA	Per Annum
PPP	Public Private Partnership
PVC	Polyvinyl Chloride
RDF	Refuse Derived Fuel
RWA	Resident Welfare Association
SBM	Swachh Bharat Mission
SCP	Secondary Collection Point
SHG	Self Help Group
SLRM	Solid Liquid Resource Management
SPCB	State Pollution Control Board
SWM	Solid Waste Management
TPD	Tons Per Day
ULB	Urban Local Body
WHO	World Health Organization
WtE	Waste to Energy

Definitions

1. “aerobic composting” means a controlled process involving microbial decomposition of organic matter in the presence of oxygen;

2. “anaerobic digestion” means a controlled process involving microbial decomposition of organic matter in absence of oxygen;

3. “authorization” means the permission given by the State Pollution Control Board or Pollution Control Committee, as the case may be, to the operator of a facility or urban local authority, or any other agency responsible for processing and disposal of solid waste;

4. “biodegradable waste “ means any organic material that can be degraded by micro-organisms into simpler stable compounds;

5. “bio-methanation” means a process which entails enzymatic decomposition of the organic matter by microbial action to produce methane rich biogas;

6. “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;

7. “bye-laws” means regulatory framework notified by local body, census town and notified area townships for facilitating the implementation of these rules effectively in their jurisdiction.

8. “census town” means an urban area as defined by the Registrar General and Census Commissioner of India;

9. “combustible waste” means non-biodegradable, non-recyclable, non-reusable, nonhazardous solid waste having minimum calorific value exceeding 1500 kcal/kg and excluding chlorinated materials like plastic, wood pulp, etc;

10. “composting” means a controlled process involving microbial decomposition of organic matter;

11. “co-processing” means use of non-biodegradable and non-recyclable solid waste having calorific value exceeding 1500k/Cal as raw material or as a source of energy or both to replace or supplement the natural mineral resources and fossil fuels in industrial processes;

12. “decentralized processing” means establishment of dispersed facilities for maximizing the processing of biodegradable waste and recovery of recyclables closest to the source of generation so as to minimize transportation of waste for processing or disposal;

13. “disposal” means the final and safe disposal of post processed residual solid waste and inert street sweepings and silt from surface drains on land as specified in Schedule I to prevent contamination of ground water, surface water, ambient air and attraction of animals or birds;

14. “domestic hazardous waste” means discarded paint drums, pesticide cans, CFL bulbs, tube lights, expired medicines, broken mercury thermometers, used batteries, used needles and syringes and contaminated gauge, etc., generated at the household level;
15. “door to door collection” means collection of solid waste from the door step of households, shops, commercial establishments , offices , institutional or any other nonresidential premises and includes collection of such waste from entry gate or a designated location on the ground floor in a housing society , multi storied building or apartments , large residential, commercial or institutional complex or premises;.

16. “dry waste” means waste other than bio-degradable waste and inert street sweepings and includes recyclable and non-recyclable waste, combustible waste and sanitary napkin and diapers, etc;

17. “facility” means any establishment wherein the solid waste management processes namely segregation, recovery, storage, collection, recycling, processing, treatment or safe disposal are carried out;

18. “handling” includes all activities relating to sorting, segregation, material recovery, collection, secondary storage, shredding, baling, crushing, loading, unloading, transportation, processing and disposal of solid wastes;

19. “inert” means wastes which are not bio-degradable, recyclable or combustible street sweeping or dust and silt removed from the surface drains;

20. “incineration” means an engineered process involving burning or combustion of solid waste to thermally degrade waste materials at high temperatures;

21. “informal waste collector” includes individuals, associations or waste traders who are involved in sorting, sale and purchase of recyclable materials;

22. “leachate” means the liquid that seeps through solid waste or other medium and has extracts of dissolved or suspended material from it;

23. “ local body” for the purpose of these rules means and includes the municipal corporation, nagar nigam, municipal council, nagarpalika, nagar Palikaparishad, municipal board, nagar panchayat and town panchayat, census towns, notified areas and notified industrial townships with whatever name they are called in different States and union territories in India;

24. “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 2for the purpose before the waste is delivered or taken up for its processing or disposal;

25. “non-biodegradable waste” means any waste that cannot be degraded by micro organisms into simpler stable compounds;

26. “operator of a facility” means a person or entity, who owns or operates a facility for handling solid waste which includes the local body and any other entity or agency appointed by the local body;

27. “primary collection” means collecting, lifting and removal of segregated solid waste from source of its generation including households,

shops, offices and any other non-residential premises or from any collection points or any other location specified by the local body;

28. “processing” means any scientific process by which segregated solid waste is handled for the purpose of reuse, recycling or transformation into new products;

29. “recycling” means the process of transforming segregated non-biodegradable solid waste into new material or product or as raw material for producing new products which may or may not be similar to the original products;

30. “redevelopment” means rebuilding of old residential or commercial buildings at the same site, where the existing

31. “refused derived fuel”(RDF) means fuel derived from combustible waste fraction of solid waste like plastic, wood, pulp or organic waste, other than chlorinated materials, in the form of pellets or fluff produced by drying, shredding, dehydrating and compacting of solid waste;

32. “residual solid waste” means and includes the waste and rejects from the solid waste processing facilities which are not suitable for recycling or further processing;

33. “sanitary land filling “ means the final and safe disposal of residual solid waste and inert wastes on land in a facility designed with protective measures against pollution of ground water, surface water and fugitive air dust, wind-blown litter, bad odour, fire hazard, animal menace, bird menace, pests or rodents, greenhouse gas emissions, persistent organic pollutants slope instability and erosion;

34. “sanitary waste” means wastes comprising of used diapers, sanitary towels or napkins, tampons, condoms, incontinence sheets and any other similar waste;

35. “secondary storage” means the temporary containment of solid waste after collection at secondary waste storage depots or MRFs or bins for onward transportation of the waste to the processing or disposal facility;

36. “segregation” means sorting and separate storage of various components of solid waste namely biodegradable wastes including agriculture and dairy waste, non-biodegradable wastes including recyclable waste, nonrecyclable combustible waste, sanitary waste and non-recyclable inert waste, domestic hazardous wastes, and construction and demolition wastes;

37. “solid waste” means and includes solid or semi-solid domestic waste, sanitary waste, commercial waste, institutional waste, catering and market waste and other nonresidential wastes, street sweepings, silt removed or collected from the surface drains, horticulture waste, agriculture and dairy waste, treated bio-medical waste excluding industrial waste, bio-medical waste and e-waste, battery waste, radio-active waste generated in the area under the local authorities and other entities mentioned in rule 2;

38. “sorting” means separating various components and categories of recyclables such as paper, plastic, cardboards, metal, glass, etc., from mixed waste as may be appropriate to facilitate recycling;

39. “transfer station” means a facility created to receive solid waste from collection areas and transport in bulk in covered vehicles or containers to waste processing and, or, disposal facilities;

40. “transportation” means conveyance of solid waste, either treated, partly treated or untreated from a location to another location in an environmentally sound manner through specially designed and covered transport system so as to prevent the foul odour, littering and unsightly conditions;

41. “treatment” means the method, technique or process designed to modify physical, chemical or biological characteristics or composition of any waste so as to reduce its volume and potential to cause harm;

42. “user fee” means a fee imposed by the local body and any entity mentioned in rule 2 on the waste generator to cover full or part cost of providing solid waste collection, transportation, processing and disposal services.

43. “waste generator” means and includes every person or group of persons, every residential premises and non residential establishments including Indian Railways, defense establishments, which generate solid waste;

44. “waste hierarchy” means the priority order in which the solid waste is to should be managed by giving emphasis to prevention, reduction, reuse, recycling, recovery and disposal, with prevention being the most preferred option and the disposal at the landfill being the least;

45. “waste picker” means a person or groups of persons informally engaged in collection and recovery of reusable and recyclable solid waste from the source of waste generation the streets, bins, material recovery facilities, processing and waste disposal facilities for sale to recyclers directly or through intermediaries to earn their livelihood.

1 Background

Urban India is facing an escalating challenge of providing the basic infrastructural needs of a growing urban population. According to the 2011 census, the population of India was 1.21 billion, out of which 31 % live in urban areas. It is projected that by 2050, half of India's population will live in urban areas. In addition, the total number of towns (statutory and census) in the country have increased from 5,161 in 2001 to 7,936 in 2011 and out of this, the statutory towns are 4378 at present. With the increasing population, municipal solid waste management (MSWM) in the country has emerged as a challenge not only because of the environmental and aesthetic problems, but also because of the huge quantities of municipal solid waste (MSW) generated every day, requiring scientific solution.

Due to rapid urbanization, the country facies a massive challenge in waste management. Urban India generates 54.75 million tons of municipal solid waste annually. Solid Waste Management (SWM) is an essential service provided by urban local bodies in the country to keep urban areas clean. However, most urban local bodies dump their solid waste at unregulated dump sites within or outside their jurisdiction, causing serious environmental hazards.

In order to expedite management of municipal solid waste management , the Ministry of Housing and Urban Affairs, (erstwhile Ministry of Urban Development) launched Swachh Bharat Mission (SBM) in 2014 which aimed to address the challenges in management of MSW and to support cities / towns in developing modern and appropriate systems within the Mission period. With the implementation of SBM, out of total MSW generation of 1.47 lakh TPD, 60 % waste is processed, an increase of about 260 % in processing in 5 years (as of March 2020). Out of 84,420 wards in the country, 79,139 wards i.e., (93.7 %) have door to door collection and 57,208 wards i.e., (67.7%) have 100 % source segregation.

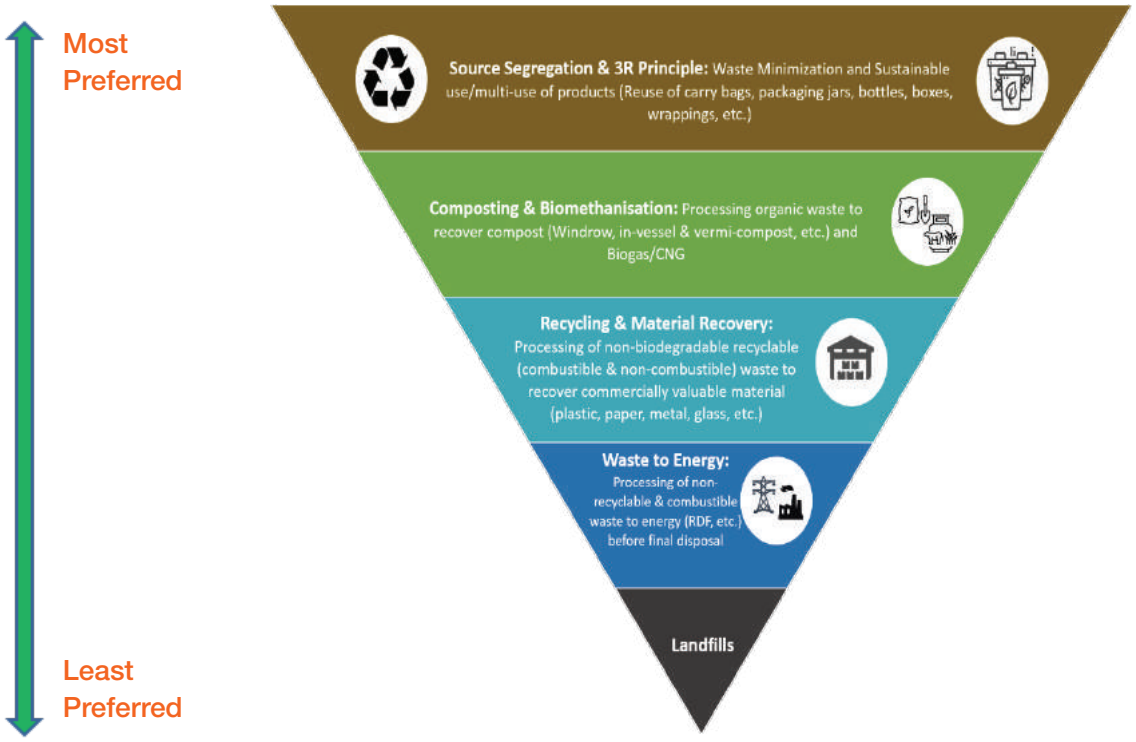
2 Municipal Solid Waste as per SWM Rules 2016

Solid waste means and includes solid or semi-solid domestic waste, sanitary waste, commercial waste, institutional waste, catering and market waste and other non-residential waste, street sweepings, silt removed or collected from the surface drains, horticulture waste, agriculture and dairy waste, allowable properly treated bio-medical waste but excluding industrial waste, bio-medical waste and e-waste, battery waste and radio-active waste generated in the area under the local authority's jurisdiction.

Solid Waste Management (SWM) is the science associated with the management of solid waste using the best principles and practices of public health, economics, engineering, conservation, aesthetics and other environmental considerations. The Integrated Solid Waste Management (ISWM) system is based on the waste management hierarchy (see figure below), with the aim to reduce the amount of waste being disposed, while maximizing resource recovery and efficiency.

2.1 3R approach for Waste Minimiza5tion

SWM is intricately linked to the 3R approach (reduce, reuse, and recycle), which preliminarily emphasizes the importance of waste reduction, reuse, and recycling side-by-side with waste processing or management. The adoption of 3R principles minimizes the amount of waste to be disposed, thereby also minimizing the public health and environmental risks associated with it.



Maximization of resource recovery at all the stages of solid waste management is advocated by this approach.

The 3R Approach is aimed at optimizing waste management in all the waste generation and management activities, involving all the stakeholders (waste generators, service providers, informal sector, regulators, government, and community or neighborhoods). The adoption of 3R minimizes the waste being handled by the ULB and reduces the public health and environmental risks associated with it.

The integrated solid waste management (ISWM) system is based on the waste management hierarchy (Figure 1), with an aim to reduce the amount of waste being disposed while maximizing resource recovery. Processing non-biodegradable waste to recover commercially valuable materials (e.g. plastic, paper, metal, glass, e-Waste recycling) and recovering energy before final disposal of waste (e.g. RDF, co-processing of combustible non-biodegradable dry fraction of MSW in cement plants, etc.)

Recycling diverts a significant fraction of municipal, institutional, and business waste away from disposal and, thereby, saves scarce natural resources and reduces environmental impacts and the burden on public authorities to manage waste. Recycling can generate revenues, which result in reducing overall costs for MSWM.

The key benefits of recycling are: (1) reduced volume of waste to be managed, (2) cost savings from sale of recyclables, (3) longer life span of landfills and (4) livelihood opportunities and enhancement for the informal sector, the recyclers and recycling industry.

2.1.1 Reduce

The concept of reducing the amount of waste generated by reducing consumption is essential to waste management hierarchy. The logic behind it is simple to understand – if there is less of waste generated, then there is less to recycle, reuse or to manage. The process of reducing begins with an examination of what is being used, what it is used for and by how much it can be reduced. It also involves modification of processes and packaging; substitution; minimization and elimination.

2.1.2 Reuse

The reuse of items (for multiple times) or re-purposing them for a use different from what they are originally intended for is the next essential thing in the waste reduction hierarchy. Items may be reused for one's own use (or reuse) or donated so that others can use them so that the gross consumption of materials is reduced and the waste generation thereof.

2.1.3 Recycle

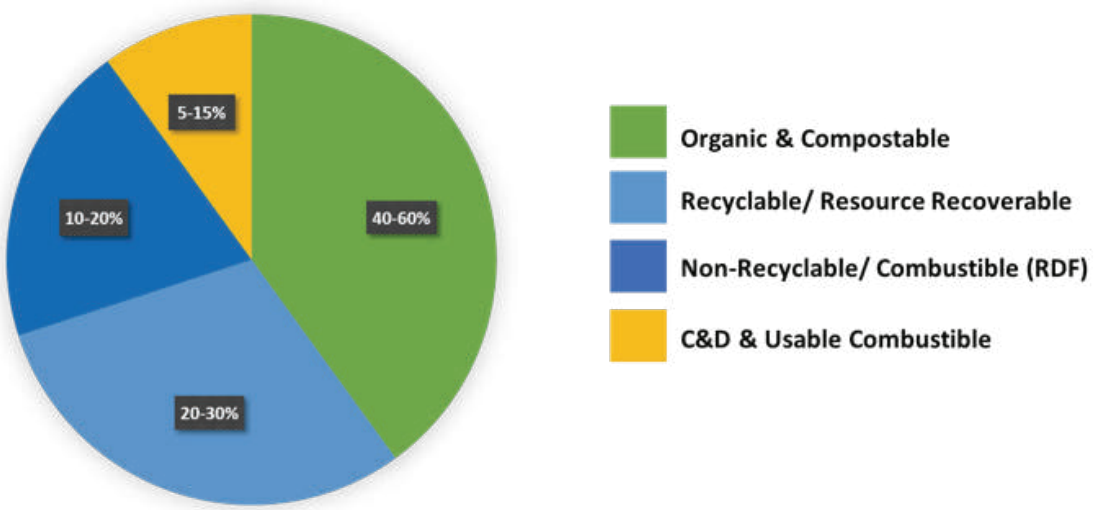
The last stage of the 3R waste hierarchy is to recycle. Recycling is the transformation of waste into a raw material for manufacturing a new item. There are very few materials on the earth that cannot be recycled, hence it is very effective in waste management. Thus, the 3R approach stands at the very top of the waste management hierarchy.

The scientific management of MSW leads to improved public health and quality of life apart from generating jobs, generating revenue and new products from waste streams. World Health Organization (WHO) has observed that 22 types of diseases can be prevented / controlled by improving the MSW management system. This will indirectly save huge financial resources currently spent on health and medical services.

Further, the scientific MSWM through MRFs also provides job opportunities to women and the informal sector. The informal sector includes both the "kabadi" system or scrap dealers and waste pickers that help reduce environmental impacts by improving resource recovery and reducing waste quantities for disposal. Their integration into

2.2 Broad Categorization of MSW

2.3 Composition of Municipal Solid Waste



the formal MSW management system through resident welfare associations (RWAs), community-based organizations (CBOs), non-government organizations (NGOs), self-help groups (SHGs) and private sector will contribute to the reduction of the overall MSW management costs, provide support to the local recycling industry and create new job opportunities. MRFs are vital cogs in the integration of informal workers in MSWM.

2.4 Material Recovery Facility (MRF) in SWM Rules 2016

As per the SWM Rules, 2016 “Materials Recovery Facility” (MRF) means a facility where non-compostable solid waste can be temporarily stored by the local body or any person or agency authorized by any of them to facilitate segregation, sorting and recovery of recyclables from various components of waste by authorized informal sector of waste pickers, informal recyclers or any

other work force engaged by the local body 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 kabadiwalas, local recyclers and scrap dealers. The items that cannot be sold to the kabadi system are discarded and become part of the MSW.

2.5 Dry Waste as per SWM Rules 2016

As per the SWM Rules 2016, Dry Waste is defined as "waste other than bio-degradable waste and inert street sweepings and includes recyclable and non-recyclable waste, combustible waste and sanitary napkins and diapers, etc."

2.6 Duty of ULB to set up MRF as per SWM Rules 2016

As per the SWM Rules 2016, it is the duty and responsibility of the ULB to setup material recovery facilities (MRFs) or secondary storage facilities with sufficient space for sorting of recyclable materials to enable informal or authorized 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 (MRFs).

3. What is Material Recovery Facility (MRF)

A material recovery facility (MRF) accepts waste materials, whether source segregated or mixed, and further separates, processes and stores them for later use as raw materials for remanufacturing, reusing and reprocessing

Material Recovery Facility (MRF) is also known as Material Reclamation Facility or Material Recycling Facility. An MRF is a place where waste collected from the doorstep in a segregated manner is further segregated and various components of recyclable waste recovered from it for recycle or resale.

The waste material is basically segregated into different streams of waste fractions (paper, plastic, packaging paper, bottles etc.) which is sold to intermediaries who supply bulk material to the recycling industries. MRFs require medium to large storage spaces depending on their capacity to temporarily store sorted recyclables which can be made available to recyclers in bulk at higher resale value.

In mechanized MRFs, the entire process is carried out with sophisticated systems and equipment that enable efficient separation of large quantity of material into different fractions.

The main function of the MRF is to maximize the quantity of recyclables processed, while segregating materials that will generate the highest possible revenues from the recycling market. MRF also helps in segregating combustible fraction (RDF), non-recyclables and inert from the dry waste stream. These fractions may be utilize/reused as –

- Recyclables – Reuse/ reprocessed
- Non-recyclables - Road making/ plastic to oil
- RDF - Waste to Energy/ Cement Industries
- Inert - C&D plant/ daily cover of SLF

3.1 Need of Material Recovery Facility (MRF)

Municipal Solid Waste (MSW) is the trash or garbage that is discarded from various sources i.e., Domestic, Commercial, Institutional, Industrial/ Trade etc. in day to day activities. Aforementioned waste management hierarchy indicates that the least preferred option of ISWM is disposal of waste in landfills. SWM 2016 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. All options of waste minimization should be utilized before appropriate treatment technologies are selected and implemented. With the aim to reduce the amount of waste being finally disposed, and maximizing resource recovery and efficiency, Material Recovery Facilities (MRFs) need to be established within the ULBs.

A Material Recovery Facility (MRF) is an infrastructure to receive, sort, process and store recyclable/ non recyclables/ RDF and inert materials, with the aim to maximize the quantity of recyclables processed, while producing materials that will generate the highest possible revenues in the market and maximize the reuse of other segregated fraction in different processes/ industries. It is the responsibility of the ULB to set up material recovery facilities with enough space for sorting of recyclable materials as a follow up of source segregation of waste at-least as Dry and Wet waste in their SWM.

MRFs serve as intermediate processing step between the collection of recyclable materials from

waste generators and the sale of recyclable/ non-recyclables/ RDF/inert materials to the recycling market and for other processes and industries .

3.2 Advantages of MRF

Recycling prevents a significant fraction of municipal, institutional and bulk waste from being dumped or disposed in landfills. It results in the availability of scarce resources as well as reducing environmental impacts and the burden of waste management on public authorities. If the necessary market mechanisms are established, recycling can generate revenue, contributing to the cost recovery in the municipal solid waste service provision. It helps the ULB by reducing waste volumes and results in cost savings in the collection, transportation and disposal infrastructure, longer life span for landfills/reduced requirement of land, reduced environmental management efforts and generates livelihood opportunities for informal, local vendors/recyclers in the recycling industry.

3.3 Types of Material Recovery Facility by Ownership and Operations

MRFs may be publicly owned and operated, publicly owned and privately operated, or privately owned and operated. Jointly owned and jointly operated MRFs are also possible.

There are basically two types of MRFs: Mixed and Dry/Clean, based on waste received:

3.3.1 Mixed MRF

Unsegregated, mixed waste with biodegradable and non-biodegradable material is collected and sent to the MRF processing facility. At the mixed MRF, the mixed waste stream may be segregated manually or mechanically to separate recyclable material from compostable and inert wastes. Compostable matter and recyclable materials may then be processed separately, and residual inert wastes are sent to the landfill. Receiving mixed waste (recyclable materials combined with other municipal solid waste) that requires labor intensive sorting activities to separate recyclables from the mixed waste. The MRF unit can use a combination of manual, hybrid and machine-based sorting .

3.3.2 Dry MRF or Clean MRF

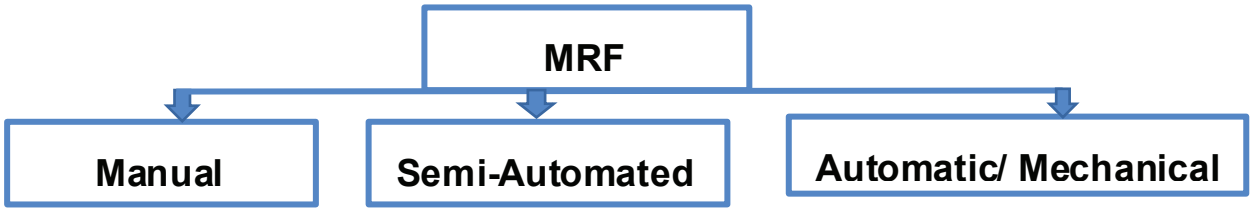
A facility that receives source segregated or commingled recyclable materials (recyclable materials that are already separated from other main solid waste or wet waste). A “clean” MRF reduces the material contamination and can recycle more materials than mixed MRFs. Dry segregated material is received in a commingled form consisting of a combination of paper, cardboard, magazines, plastics etc. and commingled containers (plastic, glass, metal, etc.), among other materials. The first stage of processing typically uses manual labor or equipment that separate waste materials into various streams (metal, paper, plastic, containers, etc.). These recyclables are also sorted by using automated machines when quantities to be handled are large.

Depending on the scale of operations, type of operations and the level of mechanization in the facility, MRFs may be classified as manual, semiautomatic or mechanized.

3.3.3 Manual MRF

In manual MRFs, sorting process is carried out manually. This type of MRFs are suitable for small quantities of MSW like 5-10 TPD only. Sometimes, these Material recovery facilities are also termed

MRFs can be further categorized in terms of the type of operations / technology employed



as Solid Liquid Resource Management (SLRM) centers. These SLRM centers received waste either in mixed form or in wet and dry waste streams. In SLRM centers processing of wet waste can also be carried out depending upon the land availability and location.

3.3.4 Semiautomatic MRF

This type of Material Recovery Facilities has combination of manual and mechanized operations. Semi-automated MRF can cater for 10- 100/200 plus TPD of segregated waste. Semi-automated MRFs also work as secondary collection points in which after segregation of wet & dry streams, further transportation of MSW is carried out in compacted manner to save on transportation cost.

3.3.5 Mechanical / Automated MRF

Mechanized material recovery facilities are fully mechanized/ automated facilities for material recovery in large quantities (>100 TPD) with least human intervention. These facilities are best suitable for segregation of recyclables/non-recyclables/ RDF/inert, when only source segregated dry waste is coming to the facility. These mechanized plants have limitations to segregate mix MSW if the wet/ mix waste is more than 20% of the total received waste.

3.4 Selection of MRF

The configuration of MRF processing line is critical to the overall quality of the materials segregated. It depends on several factors including the quality and quantity of incoming waste (segregated or mixed) and required specifications for the end products and also the land available. Selection of MRF depends largely on ULBs capabilities- its financial conditions and its linkage to market/ industries for sale of byproducts. It is pertinent to note that every given the specific conditions, every ULB has requirement of tailormade types of MRFs. ULBs have to adopt the type of MRF as per their specific requirement depending upon the following aspects:

- Waste Quantity
- Waste characterization
- Availability of land
- Capital and Operational cost of facility (including cost of Manpower)
- Provisions/ Linkages for sale of recyclables and by products
- Type and linkage of final treatment/disposal facility

3.5 Siting Criteria for MRF

Ideally the MRF shall be located close to both the source of the MSW generation and the industries that will use the recycled materials since the minimization of travel distances is important for reducing costs. In order to be located near the residential areas, the facility must be both environmentally and aesthetically acceptable. A buffer space with trees / shrubs will help improve aesthetics and decrease any noise pollution.

- MRFs need to be located close to existing roads, but traffic blocks resulting from the movement of waste collection trucks should be considered and avoided.
- These facilities must be near or within urban areas that generate the inputs to be processed for recyclables.
- If the development area is zoned, MRFs are preferably located in an industrial zone or close to a sanitary landfill to facilitate efficient movement of waste from various generators and disposal of residual waste.
- MRFs should be sited, considering the local geographical features, in a safe manner
- Flood-prone areas should not be selected.

3.6 Authorizations/ Permissions Required

The permissions have to be sought from the State Pollution Control Board (SPCB) in the form of consent to establish, consent to operate, etc. Later, an annual report needs to be given to the SPCB / Pollution Control Committee (PCC). The various forms can be in the SWM Rules 2016 and the Plastic Waste Management Rules 2016. There may be exceptions for small capacity MRF's.

3.7 Pictorial presentation of Type of MRF

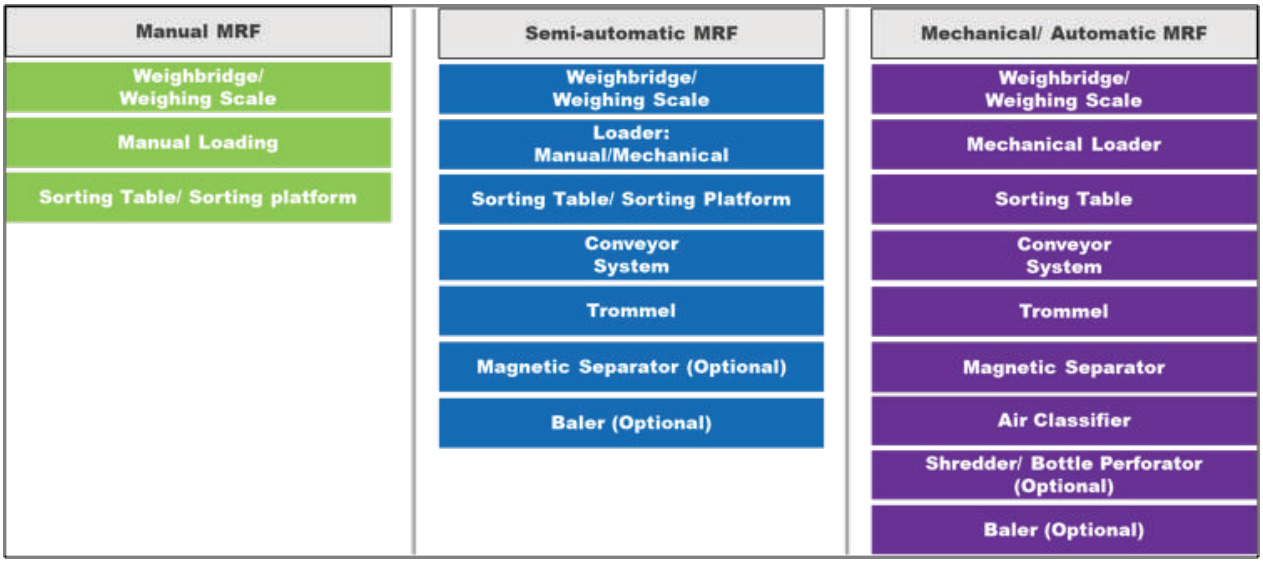


Figure: Basic equipment / Necessary processes in different types of MRFs

However, the ULBs are to contact their respective SPCB/PCC to understand these in greater detail and comply with the same. In addition, there will be other requirements such as factory license and utility connections.

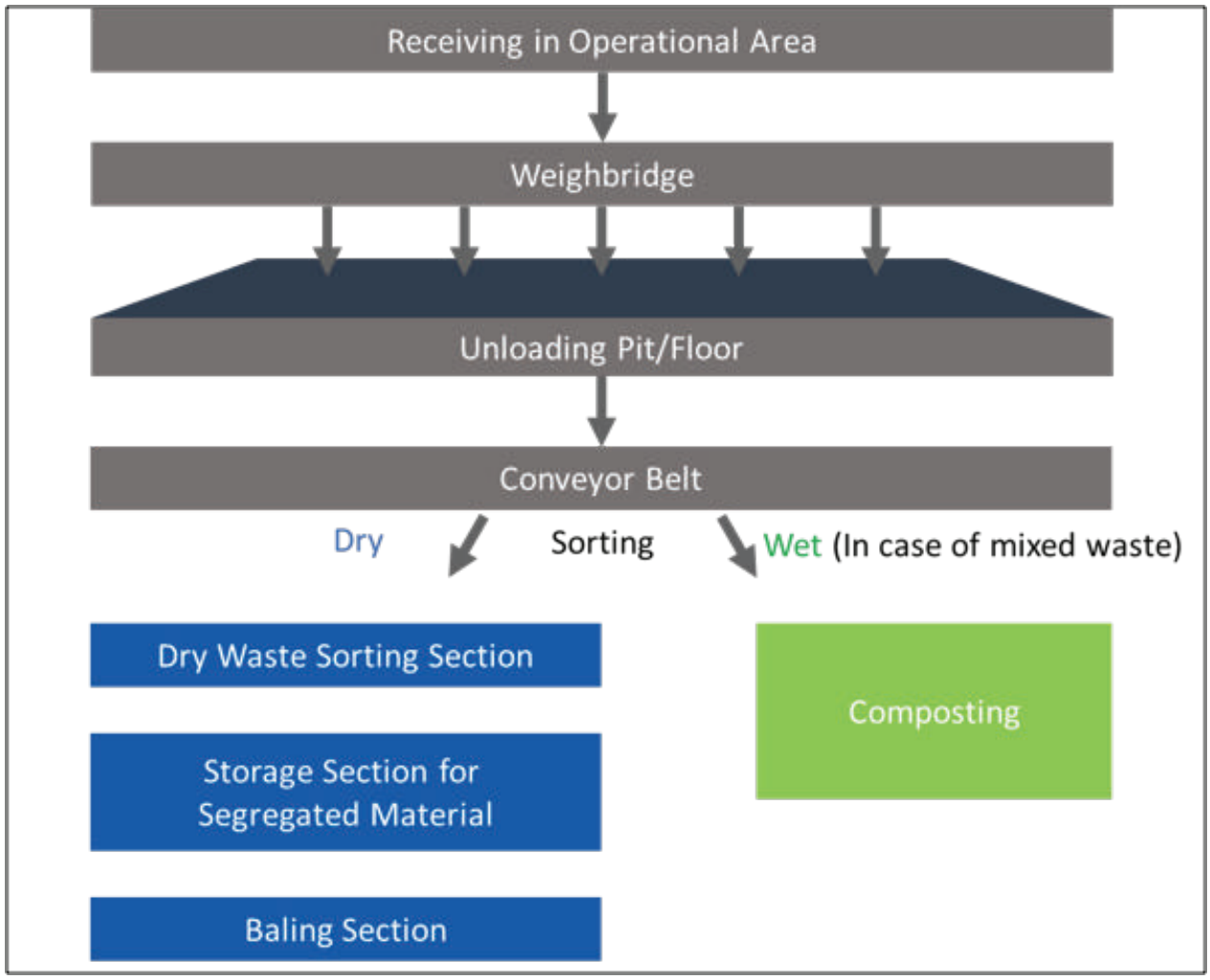
3.8 Constituents in an MRF can be as follows:

- MRF is situated within a warehouse-type building with concrete flooring and enclosed by a perimeter fence for security.
- It should have the following components:
- Weighing scale / Weighbridge
- Changing/Washroom/Rest rooms and creche, as required
- Receiving or tipping area
- Sorting/processing area
- Storage area for recyclables
- Residual storage area
- Admin/ Record room/First Aid Room
- Fire Extinguishing facilities
- It should also be provided with the basic connections for water and electricity and with adequate space for the entry and exit of waste transporting vehicles. Provisions for toilet/ change/washrooms must be included.
- The warehouse design should minimize the placement of columns that could interfere with the efficient movement of materials and equipment and should facilitate the installation of higher ceilings.
- Receiving areas should have the capacity to receive at least 2 days' waste storage space for the MRF's processing capacity in anticipation of equipment breakdown and to provide materials for the second-shift operation, if required.

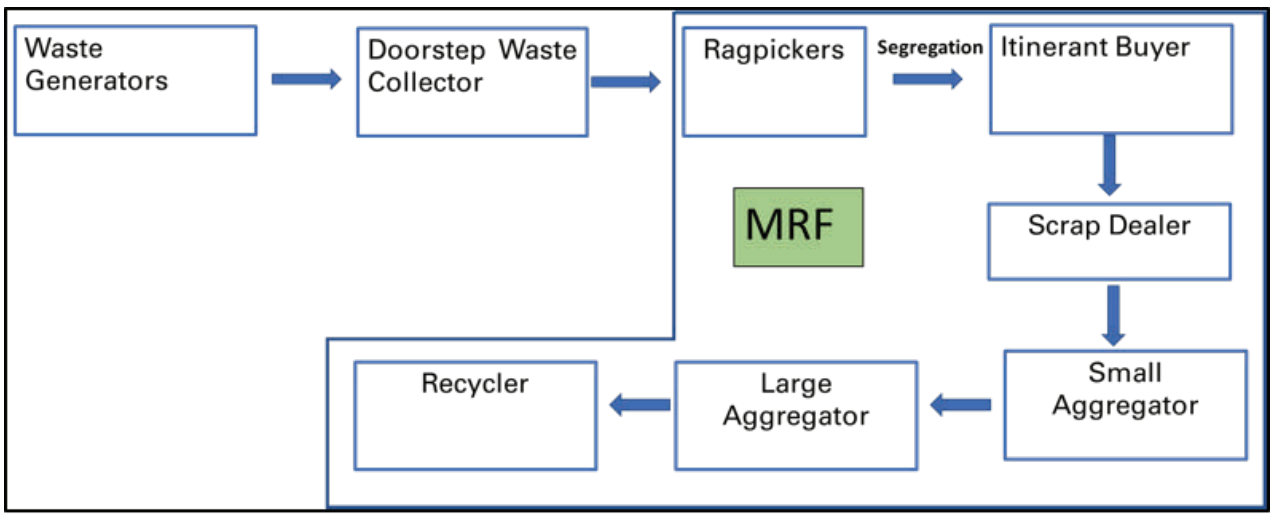
3.10 General Categories of dry Waste Segregation in MRF :

S.No	Paper	Plastic Items (non PVC)	Plastic items (PVC)
1	Glass Items	Rubber Items	Metal Items (Ferrous)
2	Leather Items	Thermocol	Aluminium Coated Paper
3	Wooden Items	X-ray Films	Clothes
4	Cardboards	Jute bags	Electronic Items
5	Aluminium Coated Plastic	Metal Items (Non-ferrous)	Medical Waste/ Tablet Cover

3.9 Standard Process Flow of MRF



3.11 Typical Value Chain of MRF



3.12 Unit Processes in MRF

The MRFs employ varying combinations of manual and mechanical processes, based on the type of facility, availability of equipment and labour, and associated cost implications. MRFs employing manual labour for sorting operations have relatively

lower costs but may operate at lower efficiencies compared with mechanical sorting facilities. An MRF, depending on the level of complexity, will consist of a combination of processing units in varying degrees of mechanization:

(a) Pre-sorting: Waste sorting or processing in the facility through manual or mechanical pre-sorting is essential to separate out these bulky/ large pieces and packets of 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 mechanized sorting unit of the facility. Mechanical, bulky waste sorters are also used in semi automated and automated MRFs.

(b) 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 specialized equipment for segregation of commingled municipal waste. Mechanical sorting typically employs the following processes:

1) **Screening:** Screening achieves an efficient separation of wastes into two or more size distributions. Two types of screens are used in MRFs- disc screens and trommels.

2) **Ferrous metal separation:** In the second stage, electromagnets are used for separating ferrous metals from mixed waste.

3) **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.

4) **Non-ferrous metal separation:** The non-ferrous metal separator segregates zinc, aluminium, copper, lead, nickel, and other metals from commingled waste. An eddy current separator removes non-ferrous items from the waste based on their electrical conductivity.

5) **Segregation of non-recyclables and Combustibles:** Segregation of non-recyclables and combustibles fractions can be done manually / mechanically to enhance the efficiency and earning of facilities.

6) **Optical system (sensor based):** 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.

7) **Size reduction:** Sorted materials after segregation, if large for further use or processing and should be reduced to smaller sizes.

8) **Baling:** Sorted & sized materials are baled for further processing or use.

4 Proposed Material Recovery Facilities for different cities

This section of advisory covers the proposed MRFs for different categories of ULBs. ULBs have been categorized against the population range. The details are listed below to provide better understanding regarding MRFs and the type of MRF required for cities.

(i) Population Range – up to 50,000

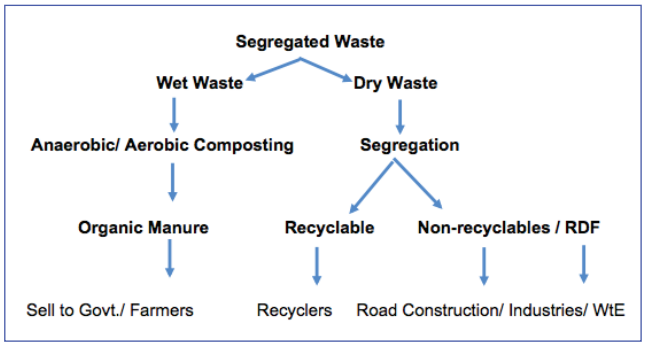
Waste generation- ULBs having population in the range of 1- 50,000 and waste generation of approximately 15 to 20 tons per day (TPD), assuming more than 50% of door to door collection and Segregation of waste.

Waste characterization of MSW: In this population range, ULBs normally have less than 50% of dry waste and more than 50% of wet waste. There are possibilities that ULBs are collecting certain percentage of mixed waste.

MRF Component	Indicative value
Design Capacity	3-5 MRFs in a ULB, (1, 2, 5 TPD each) as per the ULB's requirement
Manpower	10-12 per MRF
Area Requirement	1500-2500 sqm (Approx.) This area includes basic infrastructure of segregation shed, utilization/ processing area for wet waste, admin / record room, parking of door to door vehicles and storage area for segregated recycles.
Indicative Capital Investment	Rs. 15-30 lakhs per facility excluding cost of land
Operation Cost	Rs. 15-17 lakhs per year includes honorarium/ salary and regular repair, maintenance cost and consumables.

Proposed Solution- Manual MRF cum Solid Liquid Resource Management (SLRM) center. These facilities will take care of both dry waste stream as well as wet waste fraction. These proposed facilities can also segregate the mixed waste.

Suggested Process Flow- To manage the source segregated wet and dry fraction of MSW or some quantity of mixed MSW. The proposed process flow is mentioned below:



(ii) Population Range- 50,000- 1,00,000

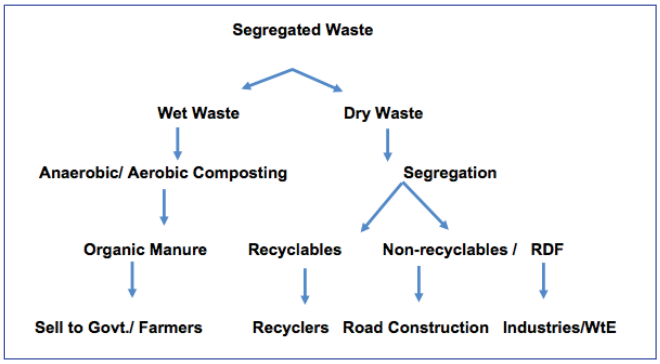
Waste generation- ULBs having population in the range of 50001- 100,000 and waste generation of approximately 35 to 40 tons per day (TPD), assuming more than 50% of door to door collection and Segregation of waste.

Waste characterization of MSW: In this population range, ULBs normally have less than 50% of dry waste and more than 50% of wet waste. There are possibilities that ULBs are collecting certain percentage of mixed waste.

Proposed Solution- Manual MRF cum Solid Liquid Resource Management (SLRM) center. These facilities will take care of both dry waste stream as well as wet waste fraction. These proposed facilities can also segregate the mixed waste.

MRF Component	Indicative Value
Design Capacity	3-5 MRFs in a ULB, (1, 2, 5, 10 TPD each) as per the ULB's requirement
Manpower	16-18 per MRF
Area Requirement	1500-4000 sqm (Approx.) This area includes basic infrastructure of segregation shed, utilization/ processing area for wet waste, admin / record room, parking of door to door vehicles and storage area for segregated recycles.
Indicative Capital Investment	Rs. 15-45 lakhs per facility excluding cost of land
Operation Cost	Rs. 20-23 lakhs per year includes honorarium/ salary and regular repair, maintenance cost and consumables.

Suggested Process Flow- To manage the source segregated wet and dry fraction of MSW or some quantity of mixed MSW. The proposed process flow is mentioned below:



Photographs of Some Manual MRFs / SLRM Centre

(iii) Population Range 1,00,001- 5,00,000

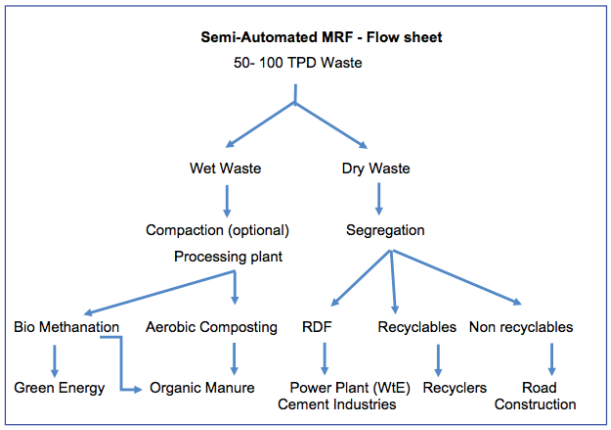
Waste generation- ULBs having population in the range of 1,00,001- 5,00,000 and waste generation of approximately 200 tons per day (TPD), assuming more than 50% of door to door collection and Segregation of waste.

Waste characterization of MSW: In this population range, ULBs normally have more than 50% of dry waste and less than 50% of wet waste. It is assumed certain percentage of mixed waste is coming along with source segregated waste.

Proposed Solution- Semi automated MRF can be a sustainable solution for these ULBs. These Semi automated MRFs can also be used as waste transfer stations with addition of some compaction equipment and hook loaders. Compaction of segregated waste/ inert will help in reducing the cost of transportation simultaneously air pollution and release of green house gases (GHGs) by reducing the number of trips of trucks.

MRF Component	Indicative Value
Design Capacity	2-5 MRFs in a ULB, 50, 75, 100 TPD each as per ULB's requirement
Manpower	25-30 per MRF
Area Requirement	6000-8000 sqm (Approx.) This area includes basic infrastructure of segregation shed, utilization/ processing area for wet waste, admin / record room, parking of door to door vehicles and storage area for segregated recycles.
Indicative Capital Investment	Rs. 4.5-6 crores per facility excluding cost of land
Operation Cost	Rs. 60-70 lakhs per year includes honorarium/ salary and regular repair, maintenance cost and consumables.

Suggested Process Flow- To manage the source segregated wet and dry fraction of MSW or some quantity of mixed MSW the proposed process flow is mentioned below:



Photographs of Some Dry Waste MRFs

(iv) Population Range 5,00,001- 10,00,000

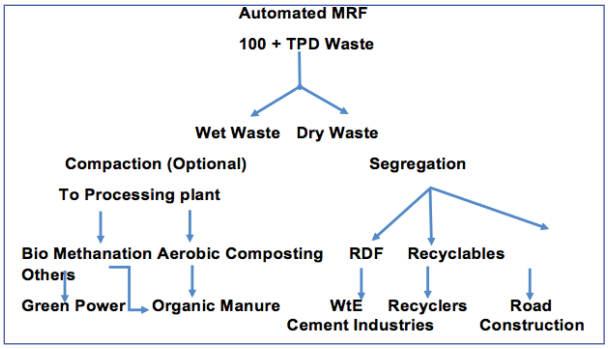
Waste generation- ULBs having population in the range of 5,00,001 – 10,00,000 and waste generation of approximately 200-500 tons per day (TPD), assuming more than 50% of door to door collection and Segregation of waste.

Waste characterization of MSW: In this population range of cities normally have more than 55% of dry waste and less than 45% of wet waste. It is assumed that certain percentage of mixed waste is coming along with source segregated waste.

Proposed Solution- Semi automated MRF may be a sustainable solution for this type of ULBs. Compaction of received waste can also be done at these MRF centers to reduce transfer cost. Compaction of segregated waste/ inert will help in reducing the cost of transportation simultaneously reducing air pollution and release of greenhouse gases (GHGs) by reducing the number of trips of trucks. These plants can be operated on PPP model.

MRF Component	Indicative Value
Design Capacity	2-5 MRFs in a ULB, 100 TPD each as per ULB's requirement
Manpower	25-30 per MRF
Area Requirement	8000-10000 sqm (Approx.) This area includes basic infrastructure of segregation shed, utilization/ processing area for wet waste, admin / record room, parking of door to door vehicles and storage area for segregated recycles.
Indicative Capital Investment	Rs. 6 crores per facility excluding cost of land
Operation Cost	Rs. 70-80 lakhs per year includes honorarium/ salary and regular repair, maintenance cost and consumables.

Suggested Process Flow- To manage the source segregated wet and dry fraction of MSW or some quantity of mixed MSW with compaction of segregated waste to minimize the transportation cost. The proposed process flow is mentioned below:



(v) Population Range 10,00,000 Plus

Waste generation- ULBs having population in the of 10,00,000+ and waste generation of approximately 500+ tons per day (TPD), assuming more than 75% of door to door collection and Segregation of waste.

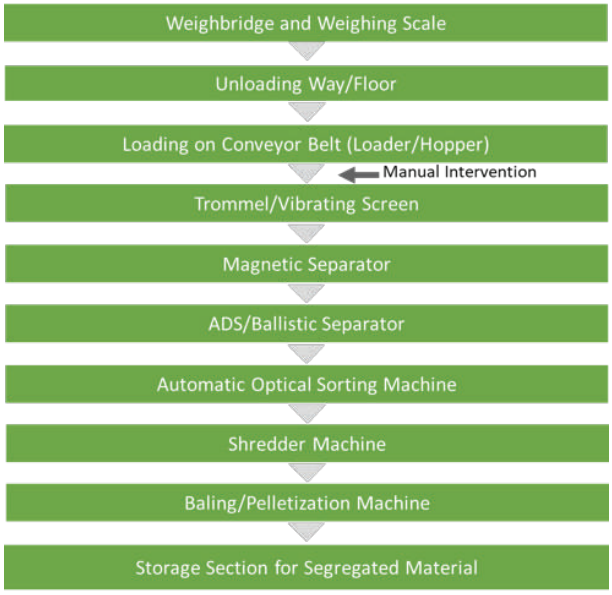
Waste characterization of MSW in this population range of ULBs normally have more than 60% of dry waste and less than 40% of wet waste. It is assumed certain percentage of mixed waste is coming along with source segregated waste.

Proposed Solution- Automated / fully mechanized MRF can be a sustainable solution for this type of ULBs. Automated/ fully mechanized MRF have some limitation in segregation of mixed waste hence it is required to that all the automated MRFs will receive only dry waste.

It is proposed to have these facilities on each of the municipal zone of the city having waste generation more than 250 TPD to optimize segregation, transportation cost and sustainability. These plants can be operated on PPP model.

MRF Component	Indicative Value
Design Capacity	2-7 MRFs in a ULB (or as per requirement) 100-200-300 TPD each
Manpower	35-50 per MRF
Area Requirement	10000-20000 sqm (Approx.) This area includes basic infrastructure of segregation shed, utilization/ processing area for wet waste, admin / record room, parking of door to door vehicles and storage area for segregated recycles.
Indicative Capital Investment	Rs. 18-20, 24-26 and 29-31 (for 100,200,300 TPD respectively) crores per facility excluding cost of land
Operation Cost	Rs. 65-.80 Lakhs/month includes honorarium/ salary and regular repair, maintenance cost and consumables.

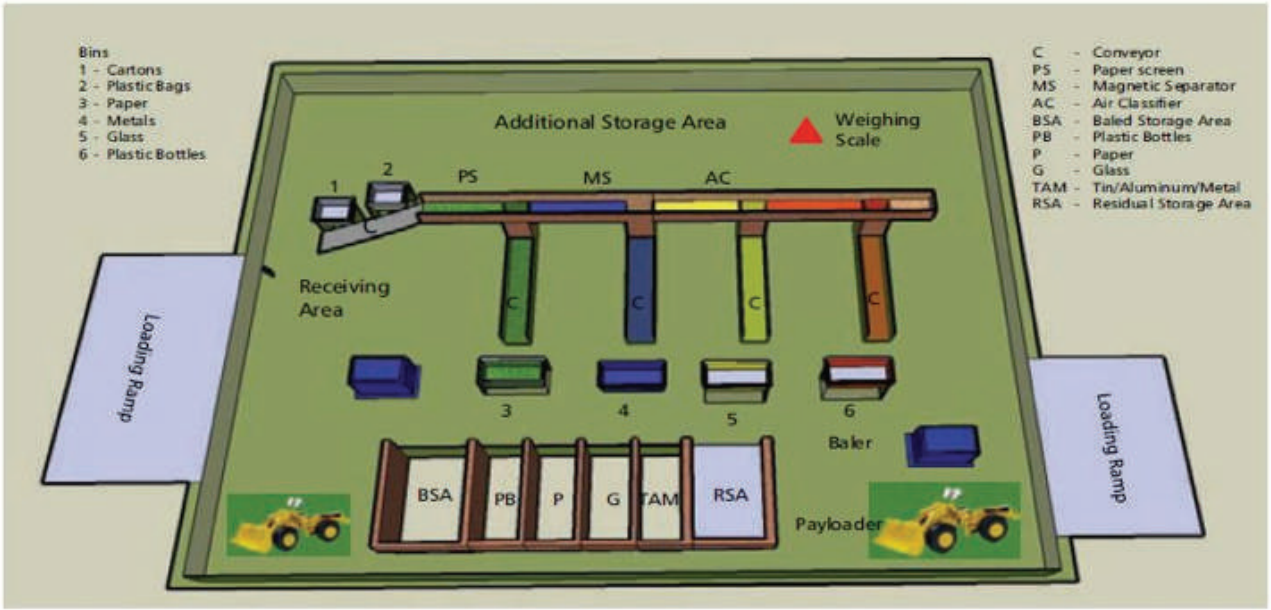
Suggested Process Flow- To manage the source segregated dry fraction of MSW with least/ minimum quantity of mixed MSW with compaction of segregated waste to minimize the transportation cost. The proposed process flow is mentioned below:



Photographs of Some Automated / Mechanical MRFs

Proposed MRF Systems in brief

Population Range	Waste Generation (TPD)	Indicative% of Dry Fraction (incl. plastic waste)	Capacity of MRF	Area Required	Proposed Infrastructure/ Type of MRF	Per Facility Indicative capital Investment (excluding cost of land) in INR
Up to 50,000	15-20 TPD	<50%	1-5 TPD each capacity as per requirement of ULB	1500-2500 Sqm	Manual MRF	15-30 lakhs
50,001-1,00,000	Up to 40 TPD	<50%	2-10 TPD each capacity as per requirement of ULB	1500- 3000 Sqm	Manual MRF	15-45 lakhs
1,00,001 - 5,00,000	Up to 200 TPD	50 - 55%	50, 75, 100 TPD Each	6000- 8000sqm (1.5-2.0 acres)	MRF – Semiautomatic	4.0- 6.0 Cr
5,00,001-10,00,000	Up to 400 TPD	50- 55%	100+	8000- 10000 (2.0-2.5 acres)	MRF – Semiautomatic	5.0-6.0 crores
10,00,001 – 20,00,000	Up to 1000 TPD	55-60%	100+	10000-12000 sqm (2.5- 3.0acres)	Semiautomatic / Automated MRF	6.0 Crs / 18- 20 Crs
20,00,001 Plus	More than 1000 TPD	55-60%	100/200/300	10000-20000 sqm (2.5- 5.0acres)	Automated MRF	Rs. 18-20, 24-26 and 29-31 (for 100,200,300 TPD respectively)



5 List of Equipment at Semi- Automated or Automated MRF

To effectively handle the day-to-day operations for sorting segregated dry waste for & resource recovery, the following equipment/ instruments will be needed.

No	Equipment	Intended Use
1	Weighbridge	Weighing of large quantities of incoming waste
2	Weighing scales	Weighing of incoming waste and sorted recyclables
3	Sorting tables	Manual sorting and segregation of recyclables
4	Loaders	Loading of incoming waste into conveyor system, sorting tables; Loading of baled recyclables into outgoing vehicles; Moving of residual or rejected waste out of the facility to the processing/ disposal site
5	Conveyor with hopper	Receiving waste from loader and movement of waste for segregation in to select recyclables
6	Conveyor system	Mechanized and regulated movement of waste for segregation
7	Trommel	Segregation of dry waste or recyclables based on particle size
8	Magnetic separator	Separation of ferrous-bearing metals
9	Air classifier	Separation of materials such as paper and plastic based on size, shape, and density
10	Bottle perforator	Perforation of plastic bottles prior to compaction to optimize baling
11	Bailer	Compaction and binding of recyclables
12	Forklift	Movement of baled waste within MRF

However, even in Manual MRF certain equipment like weighing scale, sorting table, air classifier, baler could be present.

6

A. Sound Practices in MRFs

Do's at MRF

1. A regular check on the working, performance and maintenance etc, of the processing machinery shall be done once in a month.
2. Indoor air quality and adequate lighting shall be monitored continuously for healthy working environment
3. Provision of suitable exhausts/vents/scrubbers, etc.
4. Adequate fire protection measures
5. All workers covered under social security and insurance scheme's
6. Compulsory use of Protection gears
7. Good Hygiene and Sanitation practices including safe drinking water
8. MRF kept Clean and Tidy
9. Ensure Proper Segregation and Low Rejects
10. Periodic Meetings of workers for drills, training
11. Keeping detailed logbook of MRF
12. Good housekeeping and cleaning all machinery after use
13. First Aid

B. Practices Prohibited at MRFs

Dont's at MRF

1. No Inflammable objects in premise
2. No Smoking
3. No Child Labor
4. Pregnant women to avoid operating machinery
5. Avoid Water and Electricity Wastage
6. No Discrimination
7. No Littering
8. No animals allowed
9. Do not Burn Waste
10. No explosives or firearms in MRF
11. Keep hands away from moving parts of machinery
12. Do not wear loose clothing around machinery
13. Avoid long term storage of RDF

7 Safety Practices adopted at MRF

The process of collection, segregation, transportation and recycling involves exposure to contaminants and hazardous waste. The safety aspects to be considered are mentioned in Annexure 3.

Safety Practices			
No	**Hazard**	**Precaution**	**Cure**
1	Cuts and injuries due to presence of broken glass, sharps, needles which may lead to septic wounds and tetanus	Use of Safety Gloves	Medical help should be immediately sought in case of injury
2	Exposure to fumes causing irritation of nose, throat and lungs.	Suitable masks should be used by the Safaii Mitra while working at Swachhta	Medical help should be immediately sought
3	Contact with faecal matter and the risk of contracting gastrointestinal diseases and worm infestations	Along with wearing gloves, sanitizers should always be carried and used	Medical help should be immediately sought
4	Vulnerable to blood borne diseases if hospital waste is collected	Gloves should be worn and direct contact with any waste (especially faecal matter and hospital waste should be avoided)	Medical help should be immediately sought
5	Exposure to sun, radiation and rain	Areas with radiation should be avoided.	In case of contact with any radioactive waste, they should immediately contact a doctor
6	Callosities on the fingers observed		Should immediately contact a doctor
7	Health problems like body ache, leg ache due to long distances travelled	Can be provided with a garbage truck to pick up waste	

7.1 Hygiene Practices

It is mandatory to provide a safe working environment for staff, working personnel and any other occupants or visitor at the MRF.

1 Keep the MRF dry & clean always
2 Keep sorting & storage area dry and free from pest & flies
3 Regularly spray disinfection liquid as better prevention practices
4 All working personnel and any other occupant at the MRF must use reusable safety gloves, boots and mask. It is advisable to wear uniform while working.
5 Use disposable mask & gloves for visitors.
6 Make provision for hand wash and disinfectant, hands must be washed with soap before eating/ leaving the MRF.
7 Monthly cleaning & Pest-Control Treatment routine has to be fixed within the MRF and should be followed without ignorance.

7.2 First Aid Box

This is only for designing a basic first aid kit and its components and should not be taken as a first aid procedure or training. It is important to have a well-stocked first aid kit at the MRF to deal with minor accidents and injuries. The first aid kit should be kept in a cool and dry place out of the reach of children.

A basic first aid kit should contain:

a. Emergency telephone numbers for emergency medical services 1092/102/108
b. Bandages in a variety of different sizes and shapes
c. Small, medium and large sterile gauze dressings
d. A box of adhesive bandages
e. Crêpe rolled bandages
f. Safety pins
g. Disposable sterile gloves
h. Tweezers, scissors
i. Micro-porous, sticky tape
j. Thermometer (preferably digital)
k. Cream or spray to relieve insect bites and stings
l. Antiseptic cream
m. Directions for requesting emergency assistance

7.3 Other Important Guidelines

a. The entrance and exit should be kept clear always
b. The emergency exits should be kept clear always and should never be used for any temporary/ permanent activity
c. A minimum safe distance between two machineries as advised by the manufacturer.
d. From maintenance perspective, min 1-metre clearance around each equipment.
e. Shed should be constructed with the stipulated structural stability and always keep out rain
f. The MRF should be certified by a structural engineer/local ULB engineer and the fire department as per rules.

8 Case studies

8.1 Indore – Automated MRF- Case Study for the Population range >10 Lakhs

Indore Municipal Corporation (IMC)

>10 lakh population

Capacity: 300 TPD

Fully automated Mechanized Plant

Nepra Resource Management Pvt Ltd. provides waste management services in the MRF. The Company reuses, reduces, and recycles wastes including chemical industrial wastes. The Material Recovery Facility in Indore is a fully automated, mechanized MRF. The waste is sorted in 13 categories with the help of optical sorting technology and robotics. The project is set up on PPP Model.

Capex – INR 25 cr
Opex – INR 70-80 lakhs per month
Land - 4.5 acre, Operations Start date – September 2019

8.2 Chennai Dry waste MRF: Case Study for the Population range >10 Lakhs (Zone Wise)

Chennai

>10 lakh population

Average MRF Capacity: 5TPD

Manual MRF

The waste is directly collected from the households by sanitary workers and the dry waste is segregated as saleable and non-saleable, where in the saleable waste is sold by the sanitary workers to vendors and the non-saleable fraction is sent to cement factory for use as fuel. The domestic hazardous waste and E-Waste is collected separately and stored in resource recovery facility and regularly disposed to TNPCB authorized facilitator. The project is made at a total capital cost of INR. 18 lakhs. Capex, Opex, and land required per facility is as below:

Capex- Rs. 40 lakhs | Opex- Rs. 23 lakhs per year | Land- 4000 sqm

8.3 Ambikapur Mixed Waste MRF/SLRM- Case Study for the Population range 1-5 Lakhs

Ambikapur

1-5 lakh population

Capacity: 5 TPD

Manual MRF (Dry and Wet)

The source segregated waste is directly collected from the households by the workers in compartmentalized tricycles and taken to the facility. At the facility, secondary segregation takes place into 20 inorganic categories (paper, plastic, etc.). This followed by baling, packing, weighing and subsequent record keeping. Recyclables are sold and non-recyclables are compressed and sold for use as RDF.

Operation Start Date: March 2015

Capex- Rs. 35 lakhs | Opex- Rs 5 lakhs per month | Land- 2000 sqm

8.4 Rajpura Manual MRF- Case Study for the Population range 50k-1 Lakh

Rajpura

50,000 - 1 lakh population

Capacity: 20 TPD

Manual MRF (Dry)

Rajpura town is divided into 5 zones, each zone has its own MRF with running compost pits for the area. The town has deployed rickshaws and rag pickers to carry segregated waste from the house holds to the respective MRFs and compost pits. Wet waste is put in the compost pits and recovered dry waste is kept in the MRFs, where it is further segregated and sold by the rag pickers.

Capex: INR. 65 lakhs
Opex: INR. 2 lakhs per month
Land: 1500- 2000 sqm, Operations Start date – September 2019

8.5 Dungarpur Manual MRF- Case Study for the Population range <50 Thousand

Dungarpur

<50,000 population

Capacity: 10 TPD

Manual MRF (Dry and Wet)

Dungarpur uses a centralized dry waste processing facility. The facility is used for secondary segregation of dry waste which is collected through door to door vehicles in residential areas in the morning and commercial areas in the evening. Dry waste is segregated into 8 categories like plastics, paper, poly (aluminum coating and plain), metal, glass, cloth, coconut shells and RDF (Refuse derived fuel). RDF waste is sent to Cement Industry through NEPRA Environment Solutions, Ahmedabad (Gujrat). The inert waste left after secondary segregation of Dry waste is disposed through Sanitary landfill facility. No waste goes to the open landfill. All the waste is processed through waste processing facility. The dry waste is sold to the recycler at a fixed price after secondary segregation. MRF has helped in reducing the load on processing infrastructure and landfills. The Informal waste pickers have been integrated with this facility so that a permanent income is set up for these workers and their livelihood is assured. Nearby free accommodation and toilet facility is also provided by ULB to Waste pickers.

Capex- Rs. 40 lakhs | Opex- Rs. 23 lakhs per year | Land- 4000 sqm
Operations Start date – October 2017

Annexure -1

Details of MRF Equipment

Weighbridge

A weighbridge is used to weigh the vehicles and their contents. By weighing the vehicle both empty and when loaded, the load carried by the vehicle can be calculated. A weighbridge is usually mounted permanently on a concrete foundation or on inbuilt steel foundation along with a digital

display of the weight of the vehicle.

Platform weighing Scale with printing slip

This is platform weighing scale with a built-in thermal printer with auto print facility. This machine

will provide a slip after weighing with the details fed by the operators (e.g. Operator name/seller name/ Product name along with details of rate and cost).

The Conveyor System

It operates in a semi mechanized method for selective picking of recyclables. Different fraction of non-biodegradable waste such as PET bottles, glass bottles, plastic, metal, polythene, paper and inert materials are separated on the belt conveyor. Since the waste is moving and not piled in a place effective segregation takes place on a conveyor belt. The ergonomic work design of conveyor belt helps minimize the fatigue of monotonous work of the waste handlers and ease the process of segregation. Belt conveyor system is the most common type of conveyor system utilized for solid waste since they can effectively move materials up the inclines and are extremely versatile.

Ferrous Metals Separation

Magnetic separation is a well-proven and established technology and is an essential

component of every MRF, whether manually or mechanically intensive. Magnetic separation removes the ferrous metals from the other commingled recyclables based on the attraction between ferrous metals and the magnet.

Screening

Screening is employed to separate materials of different sizes into two or more size distributions. Screens will function to separate oversized and undersized materials as a pre- processing technique for other unit operations within the MRF. The types of screens used in the MRF can be disc screens and trommels.

Disc screens are flat screens that consist of an array of disks that spin on shafts. Disc screens move the materials across the screen by means of the disc rotation, which allows materials to be fed directly onto the screen. This feature makes the disc screen less likely to cause glass breakages compared to other screens. The disc screen also offers adjustability in the opening size and can be self-cleaning. Disc screens are most effective when the fine material to be removed is denser than the larger materials; the larger materials are relatively rounded and will not prevent passage of the fines to the screen.

Whereas, trommels are rotating cylindrical screens that are inclined at a downward angle with the horizontal. Material is fed into the trommel at the elevated end and the separation occurs while the material moves down the drum. The tumbling action of the trommel effectively separates materials that may be attached to each other. Length, angle and diameter of the drum, depth of the material and the speed of rotation are important specifications in configuring the trommel to accomplish the desired goals. If necessary, the trommel can have steps that function to carry the materials to a higher location within the drum at lower rotational velocity. Two-stage trommels may be used to first remove small items along the initial length of the cylinder and then separate larger items over the remaining length of the cylinder.

Air Classification

Air classification is utilized to separate light materials from heavier materials through the use of an air stream of sufficient velocity to carry away the lighter materials. A vertical zig zag air classifier with a rotating drum feeder may be used in the MRF to separate aluminium, cartons and plastics from glass. A cyclone separator may also be used in conjunction with the air classifier to remove the lighter separated fraction from the air stream after it exits the classifier throat. The cyclone separator uses a centrifugal action that results from the airflow through the cyclone to move the materials to the walls of the separator. The materials then slide down the walls to the exit. However, there are the following sub processes involved in handling plastic related waste.

a) Cleaning using air blower method

b) Shredding of the thin plastic, multilayer plastic, packaging plastic
c) Grinding of hard plastic (optional)
d) Agglomeration of the shredded plastic for use in extruder
e) Extrusion of the agglomerated plastic in lumps

Air Blower

An air blower is used for dry cleaning of thin plastic/ multilayer plastic of dust and moisture. Air is forced through a channel by an air blower to separate the jumbled material and remove dust and moisture from the waste. Waste is manually fed through the feed hopper and is blown off by the air stream and cleaned materials are released through the discharge hopper.

Shredder

Dry and dust free thin plastic is shredded into 2-4 mm flakes using thin plastic shredder. These

shredders tear up the plastic into small pieces/ flakes, preparing them for recycling into other products. Shredded plastic is easier to use in road construction and is the feed/raw material for the agglomeration stage. Shredder includes cutting tools welded on the shaft, connected to an AC Motor.

Agglomeration & Extrusion

Plastic extrusion is a process for converting plastic materials from solid to liquid states and reconstituting them as certain finished components. The material is gradually melted by the energy generated by turning screws and by heaters arranged along the barrel. Generally, materials like polyethylene (PE), polypropylene, acetal, acrylic,

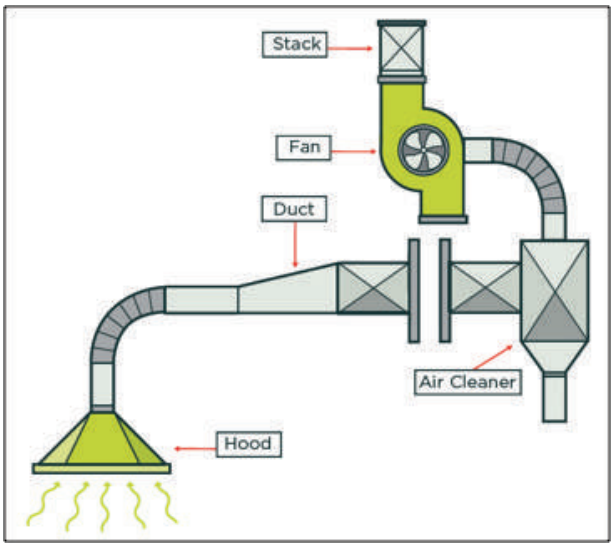
nylon (polyamides), polystyrene, polyvinyl chloride (PVC), acrylonitrile butadiene styrene (ABS) and polycarbonate undergo extrusion process where the raw material (shredded waste Plastic) is melted and formed into a continuous flow.

Size Reduction

Size reduction is the unit operation for mechanically reducing the size of waste materials. It is carried out through shredding, grinding and milling. Since the effectiveness of many unit operations within the MRF depends on keeping the materials as large as possible, size reduction will only be utilized after all separation is accomplished.

Compactors

Compaction increases the density of the recovered materials so that the materials can be stored and transported with cost effiwciency through the minimization of volume in each load. The level and



method of compaction are determined by market specifications since different markets/ recycling industries want to receive materials baled, shredded or loose.

Baling

The plastic / PET bottles being low weight and high-volume material, handling huge quantity of plastic waste in limited space could be challenging.

The baler machine is used to compress high volume of plastic waste / PET bottles, into rectangular bales and bind them. Rectangular bales are best for space saving because of their shape and are usually raised by a forklift. Bales are easy and safe to transport.

Mechanical Baler

Mechanical balers are typically used to compact similar types of waste, such as office paper, corrugated fibreboard, plastic foil, and cans for sale to recycling companies. These balers are made of steel with a hydraulic ram to compress the material loaded. Some balers are simple and labour-intensive but are suitable for smaller volumes. Other balers are very complex and automated and are used where large quantities of waste are handled.

There are different balers used depending on the material type. After a specific material is crushed

down into a dense cube, it is tied as a bale by a thick wire and then pushed out of the machine. This process allows for easy transport of all materials involved.

Two-ram baler closed door: A two-ram baler is a baling machine that contains two cylinders and can bundle and package most commodities except for cardboard and clear film. This baler is known for its durability and can take in more bulky material.

Single-ram baler: A single-ram baler is a baling machine that contains one cylinder. Because this baler is relatively smaller than the two-ram baler, it is best for small and medium ULBs.

Manual Baler Hand press

The hand baler machine is manual equipment used for making bales of materials including plastic, paper, cardboard, farm-waste, etc. It is a single person operating equipment with the provision of a spring-loaded compressing lever, to make bales effectively, with the help of which the lever is positioned perfectly to dump the waste into the baler and start compression. Over time the improved designs have rendered it a lot easier to tie the form/ bales keeping the lever locked, thereby improving the compaction efficiency. It is mobile with its wheels.

Features:

- No Electricity required.
- Easy Mobility with the provision of Wheels.
- Slotted door for easy tying of Bales.
- Maintenance Free.
- Economical Unit.
- Easy Operation.
- Aids in Waste Management and effective Utilization of Space.

Types of Waste Materials that can be baled:

- Plastic Wraps.
- Cotton
- Stretch Wraps.
- Multi-Layered Plastic.
- Farm Waste including Hay Waste, etc.
- Cardboard.
- Paper Waste.
- Shredded Paper

Coconut shredder

Coconut husk is a waste that also needs to be handled. The dried coconut husk is shredded to make coco peat.

The coconut shredder is a motorized shredding machine used to shred coconut husk, dried leaves, branches etc. to make coco peat.

Typical Technical Specifications of Equipment's in the MRF

The setting up of MRF involves selection of proper equipment for an efficient processing at the center. In order to select the type of equipment

a technical specification is needed. Accordingly, brief indicative specifications of various equipment are shown below.

Flat Segregation Conveyor Belt:

Particulars	Technical Specification
Length x width x height	7.65 m x 7.65 m x .8m
Rotor	0.4 m
Production capacity	5 MT / shift
Speed	Speed control from 1.6m/min to 9 m/min
Bearing	Pedestal type
Stand	Mild steel
Conveyor belt	Heavy rubber
Motor	3.7kW
Applicability	Flat bed, Automated for manual dry waste segregation. Provision for seating arrangements for workers while sorting
Accessories and parts	Should be equivalent to IS quality standards. Detailed specification of each accessories and parts to be mentioned by the supplier.
Erection and commissioning	By Supplier
Transport, packaging, forwarding, insurance, etc.	By supplier
After sales service	One-year free service with parts for total machine after commissioning
Applicable taxes	As per GST

Baling Machine:

Particulars	Technical Specification
Automation	Automatic
Capacity force	65 MT
Bale size (length x width x height)	.7m x .7m x 1m
Working pressure	138 Bar
Cycle time	25 min per bale
Bale weight	70 to 100 KG
No. Of cylinders	2
Piston thickness	110 mm
Motor	7.46 kW
Oil tank capacity	210 litre
Production capacity per day	2500 to 3000 kg
Applicability	All types of plastics- PET, HDPE, LDPE, MLP, Paper, Clothes
Accessories and parts	Should be equivalent to IS quality standards and supplied by branded companies. Detailed specification of each accessories and parts to be mentioned by the supplier.
Erection and commissioning	By Supplier
Transport, packaging, forwarding, insurance, etc.	By supplier
After sales service	One year free service with parts for total machine after commissioning
Applicable taxes	As per GST

Weighbridge:

Particulars	Technical Specification
Dimension (Length x width)	3m x 1.8m
Capacity	Maximum 5 MT
Type	Electronic Pit less
Applicability	Should accommodate vehicle like Auto, Tata Ace, trucks, cars and generate weighing Slip
Accessories and parts	Should be equivalent to IS quality standards. Detailed specification of each accessories and parts to be mentioned by the supplier.
Erection and commissioning	By Supplier
Transport, packaging, forwarding, insurance, etc.	By supplier
After sales service	One year free service with parts for total machine after commissioning
Applicable taxes	As per GST

Shredding / Grinding Machine:

Particulars	Technical Specification
Applicability	Shredding / grinding of all 7 categories of plastic wastes
Automation	Automatic
Throat size (length x width)	38-51cm x 35.5 – 46cm,
Blades	6 nos. (4 nos. rotor blade + 2 nos. fixed blade)
Blade size	46 x 13cm
Rotor shaft	Equibalanced shaft
Shredding capacity	200 to 250 kg/hr
Mesh hole size	13 mm
Production output	3-4mm
Applicability	Shredding of all type of hard plastics - PET, HDPE, LDPE
Motor (Power requirement)	15-22.5 kW
Body	Made of mild steel and cast iron
Pully and balance wheel	Cast Iron
Stand	Mild steel
Hopper type	Easily accessible
Accessories and parts	Should be equivalent to IS quality standards and supplied by branded companies. Detailed specification of each accessories and parts to be mentioned by the supplier.
Erection and commissioning	By Supplier
Transport, packaging, forwarding, insurance, etc.	By supplier
After sales service	One year free service with parts for total machine after commissioning
Applicable taxes	As per GST

Air Blower:

Particulars	Technical Specification
Length x Width x Height	2.5 x 1.8 x 14m
Weight	400 kg
Body	3 mm sheet
Production capacity	150 kg / hr
Applicability	All soft plastics
Motor	7.46 kW
Rotor dimension	35.5 cm dia , 1.83m length
Rotor rod	8 nos.

Pully	B Section 25.5 cms (B section belt required)
Bearing	Pedestal type
Accessories and parts	Should be equivalent to IS quality standards. Detailed specification of each accessories and parts to be mentioned by the supplier.
Erection and commissioning	By Supplier
Transport, packaging, forwarding, insurance, etc.	By supplier
After sales service	One year free service with parts for total machine after commissioning
Applicable taxes	As per GST

Agglomeration Machine:

Particulars	Technical Specification
Applicability	All thin plastics, Multi-layer plastics and Styrofoam
Automation	Automatic
Inner diameter	63.5- 76.2cm
Height	76.2 – 90 cms
Bearing housing type	3 bearings
Production capacity	200 – 250 kg / hr
Blades	10 nos. (2 rotor + 8 starter blade)
Blade size	20 cms
Blade material	HCHC (High Carbon High Chromium)
Rotor shaft	Equi balanced shaft
Motor	30-37 kW
Body	Mild steel
Hopper type	Easily accessible one
Frame	Heavy mild steel frame
Accessories and parts	Should be equivalent to IS quality standards. Detailed specification of each accessories and parts to be mentioned by the supplier.
Erection and commissioning	By Supplier
Transport, packaging, forwarding, insurance, etc.	By supplier
After sales service	One-year free service with parts for total machine after commissioning
Applicable taxes	As per GST

Extrusion Machine:

Particulars	Technical Specification
Applicability	for specific categories of plastic wastes
Automation	Automatic
Screw rod	100 - 120 mm hardened alloy steel screw
Length	2.75- 3.7 m
Barrel	Hardened barrel structure
Heaters	Electrical heaters
Hopper	50 kg capacity hopper
Gear box	8 nos. (EBH – 160 Extruder Helical Gear box)
Production capacity	75 – 100 kg / hr
Applicability	All thin plastics, Multilayer Plastic & Styrofoam
Motor	11- 15 kW
Frame	Structural strong frame
Control panel	Complete machine Control panel board
Accessories and parts	Should be equivalent to IS quality standards. Detailed specification of each accessories and parts to be mentioned by the supplier.
Erection and commissioning	By Supplier
Transport, packaging, forwarding, insurance, etc.	By supplier
After sales service	One-year free service with parts for total machine after commissioning
Applicable taxes	As per GST

Annexure -2

MSW HANDLING TOOLS AND EQUIPMENT INCLUDING MECHANIZED TRANSFER STATION

S No.	Name of the Company	Contact Person Name & Address	Contact Number & Email Address
1	Hyva India Pvt. Ltd.	Mr. Haridas Gopalkrishnan EL 215, MIDC Mahape, Navi Mumbai Maharashtra-400710	Call +91-9677159207 Email: haridasg@hyvaindia.com; susheel@hyvaindia.com Phone.:+91 22 67618888 Customer Care: 1800 2121 528 Fax.:+91 22 27672182 www.hyva.com sales@hyvaindia.com
2	Zonta Infratech Pvt. Ltd.	Mr. Dennis Pulimittathu, 1st Floor, Reliable Phoenix Towers, #16 & 16/1, Museum Road, Bengaluru - 560001	Call+91-8067292100, 8086779855, 8965050732, dennis.puli@zontainfratech.com
3	Kam Avida Enviro Engineers Pvt. Ltd.	Mr. Krishna MD, Plot No. 2, Survey No. 255/1, Hinjewadi, Tal.: Mulshi, Dist.: Pune - 411057	Call 09822025166; 022-66756300; Tel.: +91 - 020 - 6675 6500 (BOARD) Fax: +91 - 020 - 6675 6400 E-Mail: query@kam-avida.com Email: mkrishna12@sify.com; salesnorth1@csd.kam-avida.in; mk@kam-avida.com
4	TPS Infrastructure Ltd.	Jaspreet Singh 84, M-Block, Commercial Complex, Greater Kailash Part-II, New Delhi 110 048, (INDIA).	Email : tps@tpsmfg.com, tps@tpsmfg.net; nehra.jaspreet@tpsmfg.com
5	Waste Management Corporation	Mr. Ajay Arora GG-1/1798, Vikaspuri, New Delhi-110018	Email: info@wastemanagementcorp.com; ajayarora@wastemanagementcorp. com +91-11-28543080 +91-9811169618
6	Precision Conveyor Systems	Mr. Santosh Jha (Director) B-26, Ist Floor, Hill Apptt., Plot No: 17, Sec-13, Rohini, Delhi-110085, INDIA	Call +91-9810014957, +91-9013445492, 91-11-27564654 91-11-27564654 info@precisionconveyors.com, precesion@gmail.com
7	Advance Equipment & Projects	E-18-B, Sector-8, Noida, Uttar Pradesh-201301	+91 9873384443 advance_equipment@yahoo.com
8	AVK Technologies Private Limited	Plot No. 440, Udyog Vihar-3, Udyog Vihar, Gurugram, Haryana-122016	0124-4002426 bbchaudhry@rediffmail.com

9	Genesis Waste Handling Private Limited	I12-16, Gajraulla Indl. Area, (UPSIDC), Gajraulla II, J.P Nagar, Uttar Pradesh-244235	+919818190759 gwh.equip@gmail.com
10	Green Tech Life	Level II, Prestige Omega, 104 EPIP Zone, Whitefield, Bangalore-560066	+91 9820086532 support@greentechlife.in
11	JCB (JC Bamford Excavators Ltd.)	23/7, Mathura Road, Ballabgarh, Faridabad, Haryana-121004	0129-4299000 delhi.marketing@jcb.com
12	Marvel Globes Industries	Plot No. 954, Gali No. 2, Luxman Vihar, Phase 1, railway Road, Gurgaon, Haryana-122001	+91 9810688683 marvelgloves@gmail.com
13	Navdeep Engineering Private Limited	732, Near Bus Stand Babyal, Ambala cant, Haryana	+91 8071802590 meenakshibajaj33@rediffmail.com
14	SRG International Private Limited	Plot No 13 A, Sector 4, Industrial Area, Faridabad, Haryana-121004	+91 8071803487 srgprefab@gmail.com
15	Usha Engineering	S-70/71, Lodhi Road Industrial Area Mohan nagar, Ghaziabad-201005	0120-2658299 rakesh.sales@ushaengineerings.com

Annexure -3

Safety Photo Illustration for MRF

The following photos provide specific comment on safety issues related to those operations.

Photo 1

Hand sorting operations may require additional safety attention to include high visibility clothing, training on ergonomics and possibly job rotation.

Photo 2

An example of safety signage indicating required personal protective equipment.

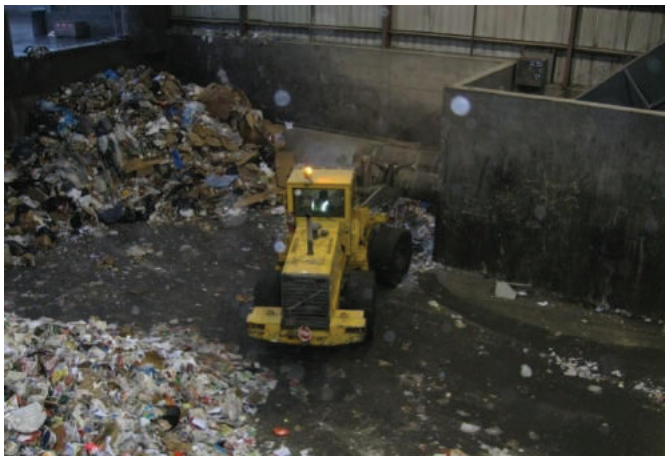


Photo 3

Safe operation of heavy equipment requires constant attention to avoid contact with fixed objects and minimizing personnel foot traffic.

Photo 4

An illustration of labeling on an electrical disconnect identifying the affected equipment.

Photo 5

An example of machine guarding. Machine guarding should be a high visibility color to communicate potential hazards.

Photo 6

Fire extinguishers should be located throughout the facility with clear access paths maintained.
The proper type of fire extinguisher should be evaluated based on fire exposures.

Photo 7

An example of appropriate safety and hand railings on an access stair way.

High visibility colors for safety equipment is recommended and required in certain applications.

Photo 8

An example of an elevated work platform. Work platforms must be safe to work from and should contain no holes that can lead to tripping.

Work platforms must also be sturdy and not subject to tipping over.

Photo 9

All personnel who may walk in areas where heavy equipment is in operation are required to wear high visibility clothing.

Photo 10

Only trained and authorized personnel may operate forklift trucks.

Training is required initially and at least every 3 years.

Photo 11

Other equipment that is used in a MRF location will require appropriate safety training for employees.

Photo 12

An example of a lock out procedure utilizing multiple locks.

Photo 13

An example of a warning sign to prevent foot traffic beneath a conveyor sorting line.

Photo 14

Any moving parts that are below 2m from the ground level or walking and working platforms must be protected with machine guarding.

Photo 15

An example of a safe work practice of using the handrails when walking down a platform stairway.

Swachhata Pledge

Mahatma Gandhi dreamt of an India which was not only free but also clean and developed.

Mahatma Gandhi secured freedom for Mother India.

Now it is our duty to serve Mother India by keeping the country neat and clean.

I take this pledge that I will remain committed towards cleanliness and devote time for this.

I will devote 100 hours per year that is two hours per week to voluntary work for cleanliness. I will neither litter nor let others litter.

I will initiate the quest for cleanliness with myself, my family, my locality, my village and my work place.

I believe that the countries of the world that appear clean are so because their citizens don't indulge in littering nor do they allow it to happen.

With this firm belief, I will propagate the message of Swachh Bharat Mission in villages and towns.

I will encourage 100 other persons to take this pledge which I am taking today.

I will endeavour to make them devote their 100 hours for cleanliness.

I am confident that every step I take towards cleanliness will help in making my country clean.

Ministry of Housing and Urban Affairs

Government of India