Ministry of Housing and Urban Affairs
Government of India

स्वच्छ भारत
एक कदम स्वच्छता की ओर









Waste To Wealth

A READY RECKONER FOR SELECTION OF TECHNOLOGIES
FOR MANAGEMENT OF MUNICIPAL WASTE

Released - 2nd October 2017

FOREWORD

Hardeep S Puri

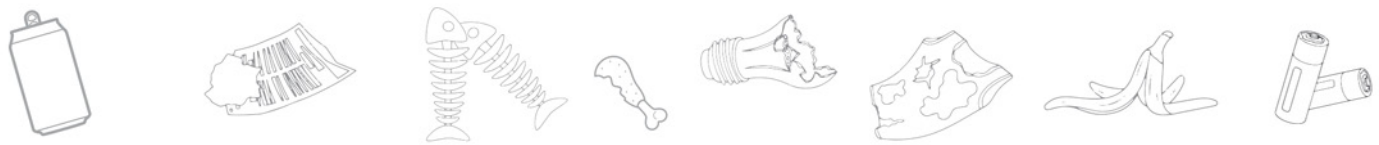
Hon'ble Minister of State (Independent Charge)
Ministry of Housing & Urban Affairs

The Swachh Bharat Mission, which aims to make India a clean and open defecation free nation by October 2019, needs to become a 'Jan Andolan' with participation from every stakeholder.

We have taken up a multi-pronged strategy for making the Mission a people's movement. As the mission is completing 3 years, it is heartening to note that the Swachh Bharat Mission has caught the imagination of citizens.

The increased participation from citizens, be it as part of our thematic drives, or voluntary 'Swachhata' activities from inspired individuals and organizations, is slowly but surely pushing the Mission towards becoming a 'people's movement'.

I am pleased to see the ready reckoner on technologies in Waste to Wealth being released by my Ministry. This compendium will lay out various technology options available in converting waste to wealth resource. The compendium also has a collection of case studies from all over the country which can be effectively replicated. It is my firm belief that this will go a long way in making waste managers active participants in our collective journey towards a "Swachh Bharat" by 2nd October 2019 by turning waste into a wealth resource.



FOREWORD

Durga Shanker Mishra

Secretary

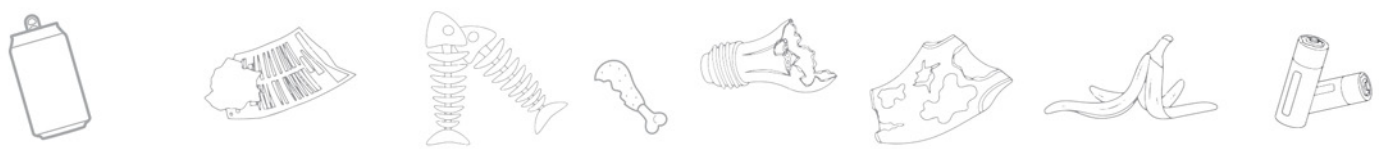
Ministry of Housing & Urban Affairs

With Swachh Bharat Mission (Urban) approaching its 3-year mark, it becomes imperative for us to expedite efforts towards making our urban areas clean, healthy and liveable.

For Swachh Bharat Mission to be a continuing success, it is important that we look at waste as a resource and not as garbage that should be discarded at the landfill site. Overflowing landfill sites are leading to air, land and water pollution in addition to loss of valuable wealth that could have been extracted from the waste.

If we as households, shopkeepers, healthcare providers, students, teachers, priests, bulk waste generators, RWAs, visitors, customers, etc commit towards extracting wealth out of waste, I am positive that we will not only achieve a clean India but this cleanliness will be sustained even after the mission period.

In view of this, the Ministry of Housing and Urban Affairs is releasing a ready reckoner on technologies in Waste to wealth. This compendium will let one explore various technology options that are now available to generate wealth from waste.



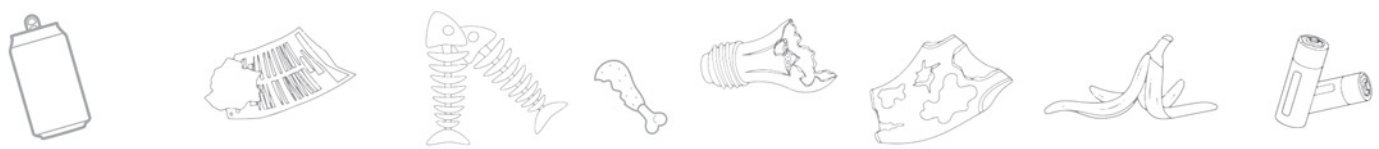
PREFACE

The Swachh Bharat Mission (SBM) has to achieve the objective of 100% municipal solid waste processing and disposal by 2019. The target is achievable once the ULBs start looking at waste as a renewable resource. The confidence of meeting the target emerges from the fact that all waste processing technologies, from the basic to sophisticated have been harnessed in India itself and can be replicated with minimal re-adjustments suiting to specific sites and ULBs.

This Ready Reckoner on Waste to Wealth is an effort under SBM to put together the available waste processing technologies in a simple way with working case studies for the ULB decision maker's awareness and in aiding them in identifying technologies suiting to their requirements. With the coming into force of SWM Rules 2016 provisions, all bulk generators also need to process waste by themselves and this Ready Reckoner is useful for them also. Once bulk generators carryout waste processing, the burden on the ULBs is likely to comedown by 15-20%.

Regarding collection and transportation of MSW, ULBs have achieved about 90% efficiency, but the gap in processing is substantial. Addressing these gaps in processing by suitably implementing the given models of generating revenues out of waste processing is the aim of this Ready Reckoner.

For other components of MSWM chain, reference may be made to the Municipal Solid Waste Management Manual 2016 published by CPHEEO, Ministry of Housing and Urban Affairs. In keeping with the improvements in waste processing, this Ready Reckoner will be regularly updated. Users are requested to refer to the latest version available on SBM's portal www.swachhbharaturban.in also.



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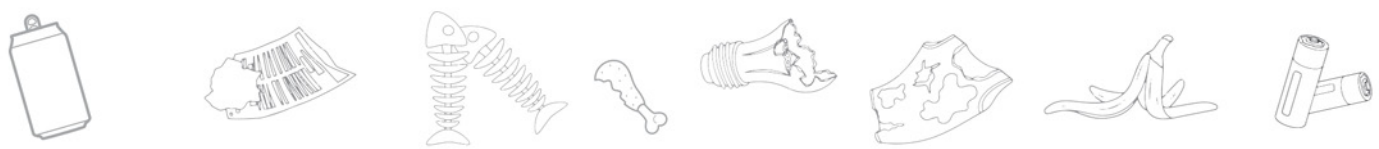
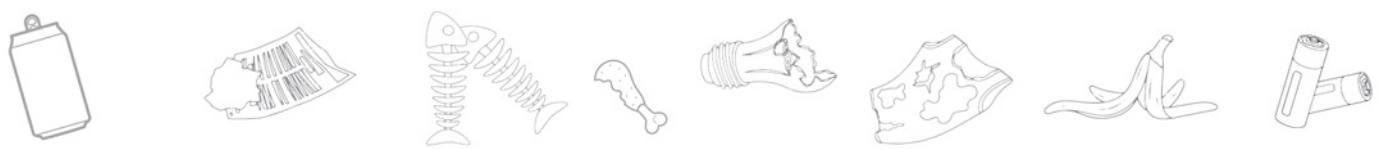


LIST OF ABBREVIATIONS

AMC	Ahmedabad Municipal Corporation
BBMP	Bruhat Bengaluru Mahanagara Palike
C/N	Carbon Nitrogen Ratio
CO_2	Carbon Dioxide
cm	Centimetre
CERC	Central Electricity Regulatory Commission
CPCB	Central Pollution Control Board
CPHEEO	Central Public Health and Environmental Engineering Organisation
C&D	Construction and Demolition
DBOO	Design Build Own and Operate
E-Waste	Electronic Waste
FCO	Fertilizer Control Order
GHG	Green House Gas(es)
H_2S	Hydrogen Sulphide
JMC	Jabalpur Municipal Corporation
kWh	Kilo Watt Hour
LA	Local Authority
LCV	Low Calorific Value
MSEDCL	Maharashtra State Electricity Distribution Company Limited
MDA	Market Development Assistance
MW	Megawatt
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
MSW	Municipal Solid Waste
MSWM	Municipal Solid Waste Management

NDMC	North Delhi Municipal Corporation
O&M	Operation and Maintenance
OWC	Organic Waste Composter
PPM	Parts Per Million
PA	Per Annum
PROM	Phosphate Rich Organic Manure
PCC	Pollution Control Committee
PPP	Public Private Partnership
PWD	Public Works Department
PMC	Pune Municipal Corporation
RDF	Refuse Derived Fuel
RCC	Reinforced Cement Concrete
RWA	Residents Welfare Association
SHG	Self Help Group
SWM	Solid Waste Management
SPV	Special Purpose Vehicle
SERC	State Electricity Regulatory Commission
SPCB	State Pollution Control Board
SDMC	South Delhi Municipal Corporation
TMC	Thrissur Municipal Corporation
TPD	Tonnes Per Day
ULB	Urban Local Body
WtE	Waste to Energy

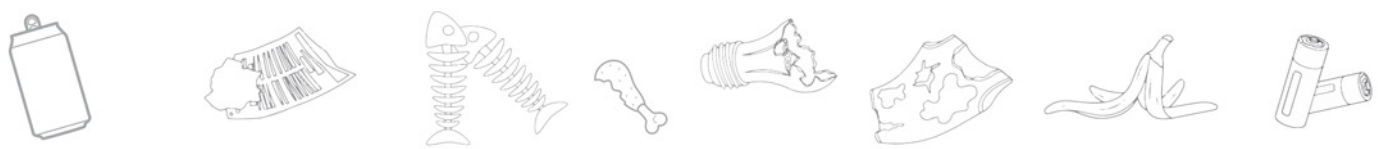


1 BACKGROUND

1.1 MUNICIPAL SOLID WASTE: AN OVERVIEW

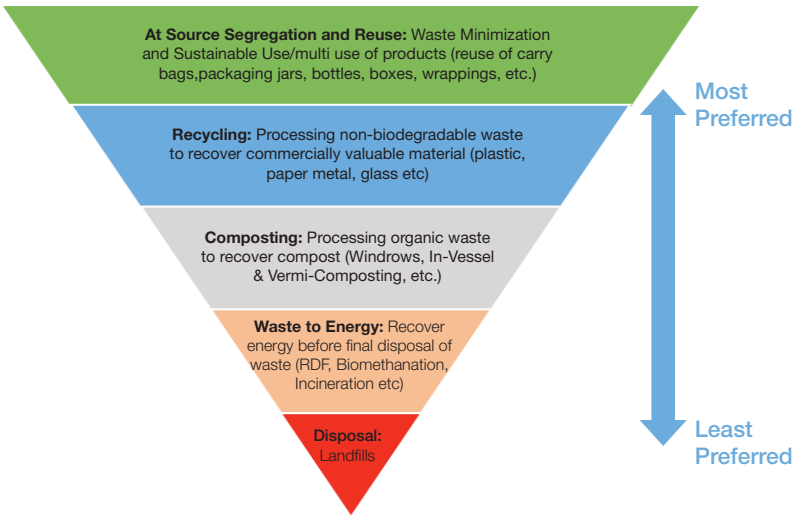
Municipal Solid Waste (MSW), commonly known as garbage or trash is a waste from everyday items that is discarded by us. Our daily activities give rise to a variety of solid wastes of different physico-chemical characteristics, which harm the surroundings unless properly managed and processed. Cleaning up of waste contamination is much more expensive compared to its prevention at every stage of possible contamination. We are facing a huge challenge to properly manage waste. Faced with huge volumes and heavy expenditure for management, efforts should be made to reduce waste volumes and generate earnings from treatment thereof.

The composition of municipal solid waste varies greatly from place to place and from time to time. It predominately includes food waste, household waste, market waste, packaging materials and products which are no longer useful. The sources can be residential, commercial, institutional and industrial. In the definition of municipal waste, the industrial waste, agricultural waste, medical waste, radioactive waste or sewage sludge is not included.



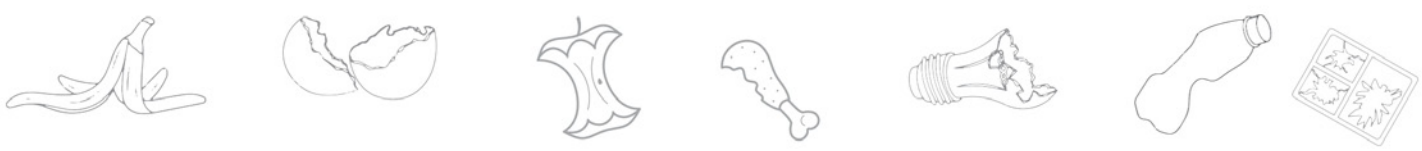
Source	Typical Waste Generator	Solid Waste Contents
Residential	Single and multiple households/ dwellings	Food wastes, paper, cardboard, plastics, textiles, leather, yard wastes, wood, glass, metals, ashes, special wastes (e.g., bulky items, consumer electronics, batteries, oil, tires), and household hazardous wastes.
Commercial	Shops, Stores, Hotels, Restaurants, Markets, Office, Malls etc.,	Paper, cardboard, plastics, wood, food wastes, glass, metals, special wastes, hazardous wastes
Institutional	Schools, Hostels, Hospitals, Government and Private Office Complexes	Paper, cardboard, plastics, wood, food wastes, glass, metals, special wastes, hazardous wastes.
Construction and Demolition Waste	Construction sites, road repairs, renovation sites, demolition of buildings	Wood, Steel, Concrete Debris, Glass, Sand, Tiles, Bituminous Concrete etc.
Municipal Services	Street Sweeping, landscaping, Cleaning of parks, beaches, other recreational areas	Street sweepings; drain silt; landscape and tree trimmings; wastes from parks, beaches, and other recreational areas

Waste collection and processing is performed by the Urban Local Body (ULB)/ Local Authority (LA) in the area under its jurisdiction. Waste disposal has to meet scientific standards otherwise it has serious detrimental effects on human health and environment. The Sustainable waste management hierarchy is given below:



Improper waste management is one of the main causes of environmental pollution. The World Health Organization (WHO) has observed that 22 types of diseases[1] are associated with improper management of municipal solid waste. Also, there are social implications of improper waste management which disproportionately affect the poorer communities living in slums and areas nearer to landfills and dumpsites. Millions of waste pickers are exposed to hazardous substances while collecting waste in the dumpsites seriously impacting their health and life expectancy. The improper waste management largely contributes to air, land and water contamination.

[1] Source: Waste and Human Health: Evidence and Needs: World Health Organisation, 2015

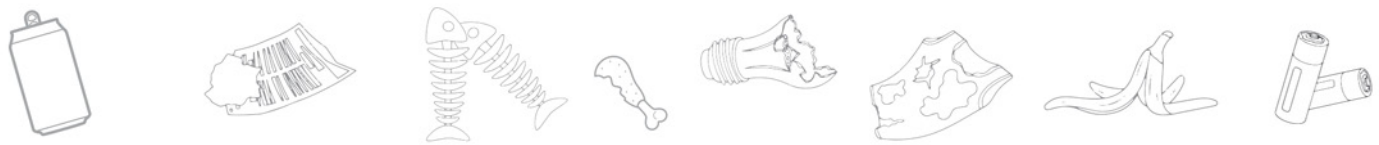


Municipal solid waste comprises of bio-degradable, recyclable and inert waste. The biodegradable waste stream is the bulk of MSW and most contaminating as it consists of discarded food, vegetables, fruits, meat and moisture, forming potent base for germs to multiply.

Next comes the recyclable waste which is most voluminous comprises of paper, plastics, metal, glass, fiber, cardboard, wood board etc. These if kept separately have lot of value but if mixed with biodegradable and inert waste, make a huge bulk of waste contaminated with germs and if crudely dumped together make for an environmental disaster. The inert waste is from swept dust, sand, ashes and materials of building construction & repair. If kept separate these are reusable and harmless but their indiscriminate disposal will form pockets for germs and pests to lodge and proliferate in the environment.

As generalized above, waste calls for proper scientific management from generation to final disposal. Along this trail of management, waste can be turned to a resource. Hence there exists a case for every ULB/LA and stakeholder in the waste chain to appropriate the slogan “Waste to Wealth”. This ready reckoner aims to provide information to every stakeholder to realize the potential of “waste to wealth”, involving the processing and treatment of waste to convert and recover from it financially valuable outputs. Considering the social and environmental benefits of waste processing, waste can truly be called a wealth resource. It is therefore the duty of everyone to handle waste as a resource, right from segregation at source to its scientific processing.

Apart from processing there are inseparable aspects of waste management in its proper storage, collection, transportation and final disposal which are not dealt within the ready reckoner. However, it is essential that all these associated aspects are also managed to preserve the resource potential of waste.



1.2. WASTE GENERATION AND MANAGEMENT SCENARIO

According to Report of Task Force on Waste to Energy, an estimated 62 Million tonnes[2] of MSW waste is generated annually by 377 Million people in India's urban areas, of which 80% is disposed of indiscriminately at dump yards in an unhygienic and unscientific manner by the municipal authorities leading to problems of health and environmental degradation. If the estimated 62 Million tonnes annual generation of MSW continues to be dumped without treatment, it would need 3, 40, 000 cubic metres (1240 hectares per year at 10 metre height and density of 500 kg/m^3) of landfill space every day. Considering the projected waste generation of 165 Million tonnes by 2031, the land consumed by landfills for 20 years could be as high as 45,400 hectares of precious land, which the country cannot afford. The task force report considers it imperative to minimize the waste going to landfills by at least 75% through processing of MSW using appropriate technologies.

The Central Public Health and Environmental Engineering Organization (CPHEEO) under Ministry of Housing and Urban Affairs has developed the Municipal Solid Waste Management Manual 2016, which provides detailed guidance to urban local bodies on the planning, design, implementation and monitoring of comprehensive municipal solid waste management systems.

As the Municipal Solid Waste Management Manual 2016 and the Report of the Task Force on Waste to Energy are in the nature of technical guidebooks, Ministry of Housing and Urban Affairs has prepared this Ready Reckoner for "Waste to Wealth" Management as a Swachh Bharat Mission initiative for the guidance of decision makers and all other stakeholders in simple and easily understandable format for waste processing and resource recovery thereof.

This report is a compendium of various recommendations provided by the above mentioned reports and other best practices on SWM to help ULBs/LAs to identify technically feasible, financially affordable and environmentally sound processing technologies for municipal solid waste.

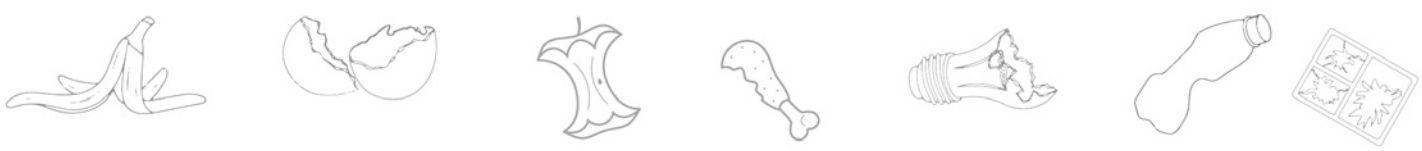
1.3. STATUTORY PROVISIONS FOR MANAGEMENT OF SOLID WASTE / WASTE IN GENERAL

1.3.1 Evolution of Laws

India has made constitutional safeguards for the protection and preservation of the environment and made several laws and acts. The laws concerning waste management in India are mentioned below:

Year	Laws	Areas of Application	Revised
1974	The Water (Prevention and Control of Pollution) Act	Industries, Landfills	1988
1975	The Water (Prevention and Control of Pollution) Rules	Industries, Landfills	-
1981	The Air (Prevention and Control of Pollution) Act	Industries	-

[2] As per 2011 census, 377 million people , generate 62 million tonnes of MSW per year which is based on an average per capita generation of 450 gm per person per day- Source: Report of the Task Force on Waste to Energy

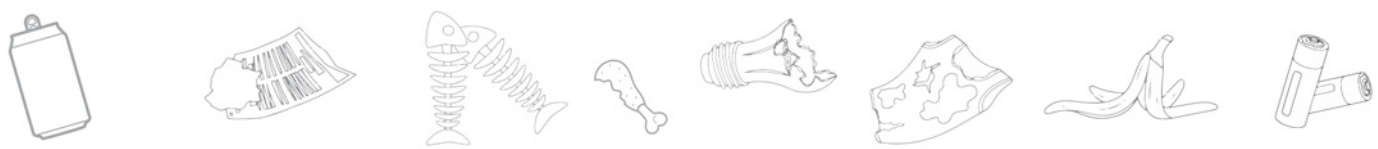


1986	The Environment (Protection) Act	Industries	-
1998	The Bio-Medical Waste (Management and Handling) Rules	Biomedical Waste from Health Care Facilities	2016
1998	Hazardous Waste (Management, Handling & Transboundary Movement) Notified 2008	Hazardous Waste from Industries	2016
2000	Solid waste (Management and Handling) Rules 2000	Waste Generation, Waste Collection& Transportation, Waste Processing, Waste Disposal	2016
2010	National Green Tribunal Act	Industries, Municipalities	-
2011	The Plastic Waste (Management and Handling) Rules	Plastic Waste	2016
2011	E-Waste (Management and Handling) Rules	E-Waste	2016
2016	Construction and Demolition Waste Management Rules	C&D Waste	2016

The Ministry of Environment & Forest had notified the Municipal Solid Wastes (Management and Handling) Rules in 2000, making it mandatory for municipal authorities to set up waste processing and disposal facilities, identify sanitary landfill sites, and improve existing dumpsites. The compliance did not happen, mainly because of the inability of municipalities to implement waste segregation, and lack of institutional and financial means to implement waste processing and disposal projects. Government of India has revised the Municipal Solid Waste (Management and Handling) Rules 2000 and notified the Solid Waste Management Rules 2016 on April 8, 2016. The salient features of the SWM Rules 2016 (hereafter called Rules) are as under:

1. Areas of Coverage:

a. Urban Local Bodies
b. Outgrowths in Urban Agglomerations
c. Census Towns as declared by the Registrar General and Census Commissioner of India
d. Notified Areas
e. Notified Industrial Townships
f. Areas under the control of Indian Railways
g. Airports / Airbases
h. Ports and Harbours
i. Defense Establishments
j. Special Economic Zones
k. State and Central Government Organizations
l. Places of Pilgrimage
m. Places of Religious and historical importance as may be notified by respective State Government from time to time



2. The Waste Generators are classified as:

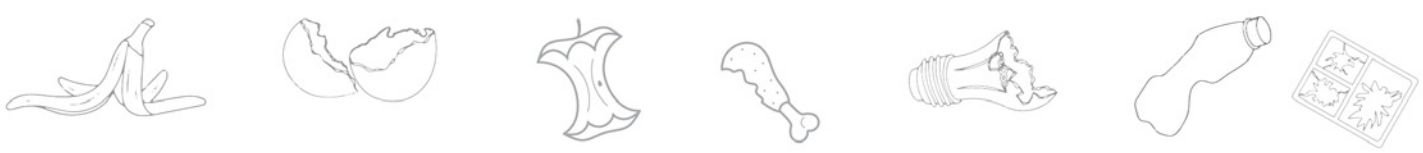
i. Every domestic, institutional, commercial and any other non-residential solid waste generator situated in any of the above areas.
ii. Event Organizers
iii. Street Vendors
iv. RWAs & Market Associations
v. Gated Communities having more than area 5000 sq. metres
vi. Hotels and Restaurants, etc.,

3. Duties of Waste Generators and Authorities

a. Every Waste Generator shall segregate waste and store separately and hand over to Municipal workers or authorized waste pickers
b. Local Authority / Panchayats shall prepare SWM plan with timeline and its implementation, segregate, adopt 3 R's, material recovery, processing/disposal of waste, user fee and levy spot fines
c. SPCBs / PCCs shall monitor, issue authorization and regulate.
d. Manufacturers/Brand Owners shall facilitate collect back wastes of their products and provide pouch for packaging sanitary wastes, etc.,
e. Industry (cement, power plant, etc.) shall use RDF from within 100 Km of their location
f. Operator of facilities shall follow guidelines/standards
g. Waste to Energy plants for waste with 1500 Kcal/kg and above and for co-incineration in cement and power plants.

4. Time Frame for Implementation of SWM Rules 2016 notified on 8th April 2016

i. Identifying a suitable site for setting up SWM facility & regional sanitary landfill : By April, 2017 (1 year from the date of notification)
ii. Procurement of the identified sites for setting up the SWM facility and Sanitary landfill : By April, 2018 (2years from the date of notification)
iii. Enforcing waste generators to practice segregation of waste at source : By April, 2018 (2 years from the date of notification)
iv. Ensure door-to-door collection of segregated waste and its transportation in scientific manner : By April, 2018 (2years from the date of notification)
v. Ensure separate management of Construction and Demolition (C&D) wastes : By April, 2018 (2 years from the date of notification)
vi. ULBs with 1,00,000 Plus population should have entire SWM system in place : By April, 2019 (3 years from date of notification)
vii. ULBs with less than 1,00,000 population should have entire SWM system in place : By April, 2019 (3 years from date of notification)
viii. Bio-remediation or capping of existing dumpsites: By April, 2021 (5 years from date of notification).



1.4. BEST SOLID WASTE MANAGEMENT PRACTICE

The best practices of municipal solid waste management are the 3Rs- Reduce, Reuse and Recycle

1. Reduce-

- Reduce waste generation in the first place
- Consume less=Waste less
- Decline plastics and disposals
- Decline plastic shopping bags
- Decline packaging
- Return packaging/dead product to manufacturers.

2. Reuse-

- Find safe usage for leftover foods, vegetables, fruits, etc.,
- Reuse disposables safely at personal level
- Reuse packaging and wrapping
- Reuse Items as much as possible

3. Recycle-

Return waste materials back into consumption cycle and for resource recovery.

Key: Segregation is the key for Recycling and for Realising "Waste to Wealth"

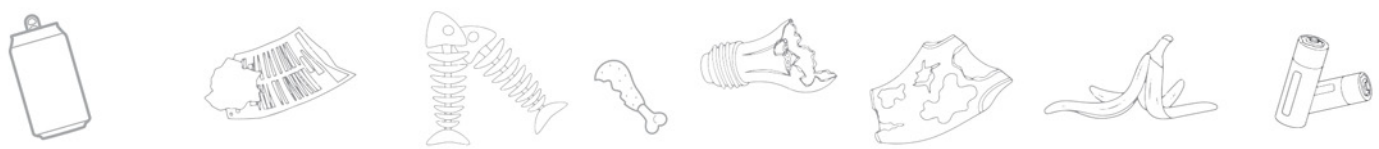
Resource Recovery from Wastes:

Bio-degradable Waste	Inert	Recyclables
Composting Biomethanation	As building materials	Revert to manufacturing process for • Paper • Plastics • Glass • Metal • Rubber If not, convert into RDF and use as a fuel for Heat and Energy

1.5. NEED FOR A READY RECKONER FOR WASTE TREATMENT & PROCESSING TECHNOLOGIES

To manage the current challenges of urban waste management, an integrated approach to waste management involving planning, financing, construction and operation of facilities for the segregation, collection, transportation, recycling, treatment and final disposal of the waste could be considered. The challenge has many elements-

1. Source segregation needs to be encouraged and mandated
2. Efficiency has to be bought to collection of waste,
3. Scientific treatment/processing of waste mandated along with final disposal.



Source segregation into dry and wet waste is vital for proper treatment of waste. It allows for cleaner streets and roads, effective waste treatment promoting recycling & reuse and safer disposal of waste.

This ready reckoner focuses on the treatment/processing of municipal solid waste (MSW) and stresses upon the importance of waste segregation at source and has been prepared based on the Solid Waste (Management & Municipal Handling) Rules 2016; the Municipal Solid Waste Management Manual 2016 by the Central Public Health & Environmental Engineering Organization (CPHEEO) and the recommendations of Report of Task Force on Waste to Energy, Planning Commission, May 2014.

The rules stipulate that all urban local bodies are responsible for proper collection, storage, transportation, processing and disposal of the municipal wastes. Only the residual inert after due processing of waste is to be disposed into a sanitary landfill in accordance with the rules. The rules direct the use of composting, vermi composting, anaerobic digestion or biomethanation for treatment of biodegradable waste. Incineration with or without energy recovery including pelletization and other thermal processes can also be used for processing of municipal wastes.

All the technologies/ processes being used in India are brought together in this simplified guide for enabling the decision maker's awareness and guide them in making appropriate decisions suiting to their requirements and restraining conditions. The ready reckoner gives the simple description, range of application, requirements, benefits, outputs and examples of case studies of the process/ technology concerned. All other aspects of MSW management are outside the ambit of this ready reckoner.

2

GOVERNMENT INITIATIVES FOR PROMOTING WASTE TO WEALTH

Under the Swachh Bharat Mission, Ministry has taken several initiatives along with sister Ministries and Departments to promote "Waste to Wealth" and for enabling implementation of Solid Waste (Management and Handling) Rules, 2016. The same are detailed below:

The list of initiatives undertaken by the Central Government are as under:

2.1 WASTE TO COMPOST

The Union Cabinet has approved for a Policy on Promotion of City Compost. Under the policy, a provision has been made for market development assistance of Rs. 1500 per tonne of city compost for scaling up production and consumption of the product. Market development assistance would lower purchase cost of city compost to farmers. Compost from city garbage would not only provide carbon and primary/ secondary nutrients to soil but will also help in keeping the city clean. Eco-Mark standard for City Compost would ensure that environment friendly quality product reaches the farmers.

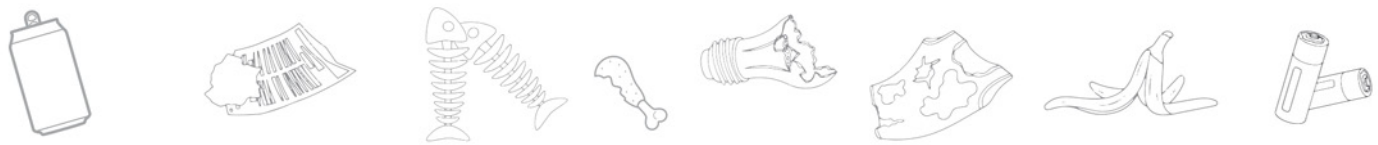
Apart from this, the Ministry has also eased some of the FCO's norms and conditions that would encourage the compost producers to sale the compost in bulk (without packing) for the benefit of farmers.

2.1.1 Compost Policy: Market Development Assistance Policy under Swachh Bharat Mission Initiative

1. Market Development Assistance (MDA) of Rs. 1500 per metric tonne of city compost to be paid to fertilizer marketing companies.
2. Fertilizer Marketing Companies obligated to purchase all city compost manufactured by respective cities to which they have been tagged.
3. Amendment on 28th September 2016: ULBs / Compost Manufacturers can also market compost directly to farmers (in bulk) and claim MDA of Rs. 1500 per tonne. DAC&FW Notification in this regard released for 43 plants and Notification for 47 plants is underway.

2.2 WASTE TO ENERGY

The Union Cabinet has approved the proposal of the Ministry of Power for amendments in the Tariff Policy. For the first time a holistic view of the power sector has been taken and comprehensive amendments have been made in the Tariff Policy 2006. Swachh Bharat Mission to get a big boost with procurement of 100% power produced from Waste-to-Energy plants.



The provision in the Electricity Tariff Policy 2006 is to "Mandatorily Purchase All Power Generated from Municipal Solid Waste at the Rate Determined by Appropriate Authority" by State Electricity DISCOMs.

2.2.1 Guidelines by Task Force Constituted by Planning Commission on Waste to Energy

The guidelines by the Task Force constituted by the Planning Commission (2014) for establishing Waste to Energy plants include the following:

1. appropriateness of WtE for a community must be evaluated on a case-by-case basis and should only be considered after waste reduction and responsible recycling programs are implemented.
2. Minimum eligibility criteria for getting financial support to set up WtE plants are the following:

- Municipal authority must select a suitable concessionaire through a competitive bidding to set up, operate and maintain the waste processing facility for a long term not below 20 years (DBOOT).
- The applicant must be a developer or technology provider who will actually construct, operate and maintain the plant;
- The developer must have critical staffing on board on full time basis or on long term contract;
- The developer must have past experience of operation and maintenance (O&M) of at least one such plant.

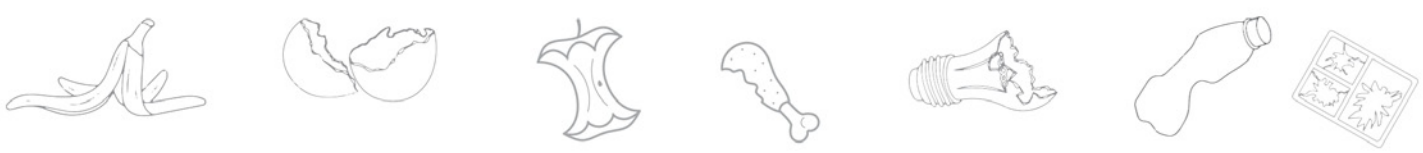
The Task Force Report clearly mentions the suitability of WtE plants when total waste generated is more than 550 TPD, along with composting for biodegradables as well as making RDF. This is suitable for ULBs having population of 10 Lakhs and above.

Considering the high costs of transportation of waste as well as the processed waste products and existence of extensive urban sprawl in large ULBs, coupled with the obligation of renewable energy on Electricity Discoms mandated to procure 100% power for WtE plants under Tariff Policy Dt. 28.01.2016, setting up WtE Plants is ideal for large ULBs.

2.2.2 Policy Initiatives for WtE under Swachh Bharat Mission

CERC Tariff for RDF based MSW Projects and MSW Projects

Technology	Levellised Fixed Cost	Variable Cost	Applicable Tarff Rate	Benefit of Accelerated Depreciation	Net Levellised Tariff
		FY 2015-16	FY 2015-16	(if availed)	(upon adjusting for Accelerated Depreciation benefit) (if availed)
	(Rs/kWh)	(Rs/kWh)	(Rs/kWh)	(Rs/kWh)	(Rs/kWh)
MSW	7.04	0.00	7.04	0.54	6.50
RDF based MSW	4.34	3.56	7.90	0.31	7.59



The above tariff will be applicable for entire useful life of 20 years for the MSW/RDF based MSW projects commissioned during FY 2015-16. However, in case of RDF based MSW projects, the variable component of tariff will change each year based on the escalation factor of 5%.

Based on this guidance of CERC, the appropriate State Electricity Regulatory Commission (SERC) can determine the tariff for the particular Waste to Energy plant set up under the area of its jurisdiction OR SERC can have its own analysis.

Tariff Policy under Central Electricity Act, 2003 as amended

The policy as notified on 28.01.2016 mentions at 6.4 (1) (ii) that Distribution Licensee (s) shall compulsory procure 100% power produced from all waste-to-energy plant in the State, in the ratio of their procurement of power from all sources including their own, at the tariff determined by the appropriate Commission under Section-62 of the Act (Ministry of Power Resolution, New Delhi, 28 January, 2016 regarding TARIFF POLICY).

2.3 CONSTRUCTION AND DEMOLITION WASTE

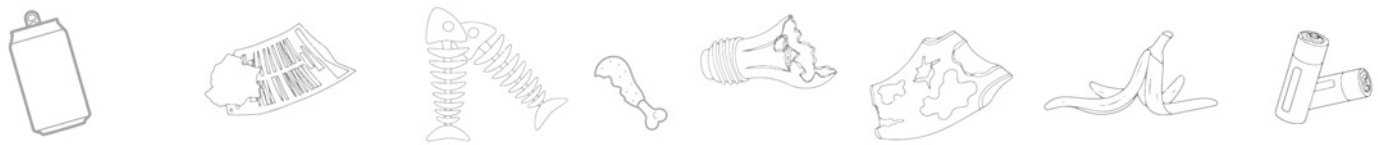
To minimize the quantity of inert reaching to landfill and to promote reuse/ recycle of construction & demolition waste (C&D waste), the Bureau of India Standards (BIS) has amended the specification for coarse and fine aggregate for concrete (Third Revision) (IS: 383-2016). The products from C&D waste could also be used for non-structural purposes like kerb stone, paver block and road construction, etc. as well as for structural purposes.

In March 2015, BIS has issued proposed revisions in IS: 383, which will allow use of coarse and fine aggregate derived from processing of recycled concrete as part replacement of natural sand (18). The amounts permitted, for both coarse and fine aggregate, are;

- 100 percent in lean concrete (up to M15 grade),
- 25 percent in plain concrete, and
- 20 percent in RCC (up to M20 grade).

CPWD issued guidelines on Reuse & Recycling of Construction & Demolition Waste through a book titled CPWD Guidelines for Sustainable Habitat.
http://cpwd.gov.in/Publication/Guideleines_Sustainable_Habitat.pdf

CPCB has launched a “GUIDELINES ON ENVIRONMENTAL MANAGEMENT OF C & D WASTES” which they have prepared in compliance with the Rule 10 sub-rule 1(a) of C & D Waste Management Rules, 2016, which was released in March, 2017. The reference link is provided as under to read and understand more about its management:
http://cpcb.nic.in/upload/Latest/Latest_171_Final_C&D_March_2017.pdf



2.4 PLASTIC WASTES DISPOSAL MECHANISM

2.4.1 Plastic Waste in Road Construction

A Government order in November 2015 has made it mandatory for all road developers in the country to use. Same amount of waste plastic, along with bituminous mixes, for road construction. Road developers will now have to use waste plastic along with hot mixes for constructing bitumen roads within 50 km of periphery of any city that has a population of over five lakh. In recently released guidelines for developers, the government has made it mandatory that in case of non-availability of waste plastic, the developer has to seek the road transport & highways ministry's approval for constructing only bitumen roads.

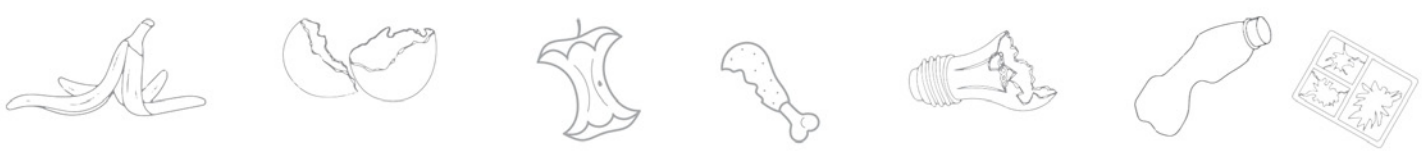
MORTH has also issued a direction to all states to use bituminous mixes with the waste plastic in at least a 10 km stretch as a pilot project. It further state that in order to study the performance of these roads, Central Road Research Institute (CRRI) reputed engineering colleges like IITs/ NITs/ Government Engineering colleges may also be engaged so that the efficiency of the system can be confirmed before making it mandatory in the contracts.

The Ministry has further directed that all the agencies have to take measures for implementation of the same and send the details identified stretches to be constructed with waste plastic and the feedback on the performance of the stretches constructed with waste plastic may be sent to the Chief Engineer with a 6-month interval. State agencies have been asked to send an action taken report to the ministry.

Advantages of Plastic Tar Road:

A well-constructed Plastic Tar Road will result in the following advantages.

- Strength of the road increased (Increased Marshall Stability Value)
- Better resistance to water and water stagnation



- No stripping and have no potholes.
- Increased binding and better bonding of the mix.
- Increased load withstanding property(Withstanding increased load transport)
- Overall consumption of bitumen decreases.
- Reduction in pores in aggregate and hence less rutting and raveling.
- Better soundness property.
- Maintenance cost of the road is almost nil.
- The Road life period is substantially increased.
- No leaching of plastics.
- No effect of radiation like UV.

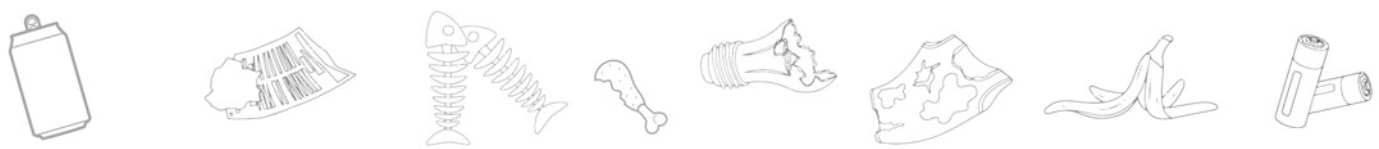
It has been found that modification of bitumen with shredded waste plastic marginally increases the cost by about Rs. 2500 per tonne. However this marginal increase in the cost is compensated by increase in the volume of the total mix, thereby resulting in less overall bitumen content, better performance and environmental conservation with usage of waste plastic.

2.5 E-PROCUREMENT THROUGH "GEM"

The Government has facilitate a portal by name of "GeM" which means "Government e Marketplace". All Central government and State Government Ministries/ Departments including its attached/ subordinate offices, Central and State autonomous bodies, Central and State Public Sector Units and local bodies etc. are directed to make procurement through GeM portal. Its salient features and benefits are as under:

- Direct access to all Govt. departments registered
- One stop marketing place with minimal marketing efforts.
- No need to watch for tenders of different Govt. departments.
- Freedom from Product registration: No need to run for product and model registration etc.
- Products accepted against supplier's guarantee/warrantee and generally free from pre-dispatch inspection testing and evaluation procedures.
- Freedom from fixed specifications: No need to customize to given specifications. Market your product with all features defined by you. Update and upgrade products as soon and as many times as you find it necessary.
- Dynamic pricing – price can be changed based on market conditions – no fixed price for whole year – no fear of fluctuation of raw material prices or exchange rate variations.
- Dynamic product listing – no need to run for model up-gradation/changes. List your latest products and market them based on features and your competitive prices.
- Get complete information of all Govt. requirements through Annual Procurement Plans.
- Timely payment.
- Consistent and uniform purchase procedures.

For more reference the below link can be visited:
https://gem.gov.in/



3

TECHNOLOGY OPTIONS FOR PROCESSING OF WASTE

The Municipal Solid Waste contains organic fraction (biodegradable waste) and inorganic fraction (dry waste including recyclable and combustible materials) and the inert & C&D fractions. There are various technologies by which different fractions of waste can be processed. The several methods of processing and treatment of municipal solid waste can be grouped together as:

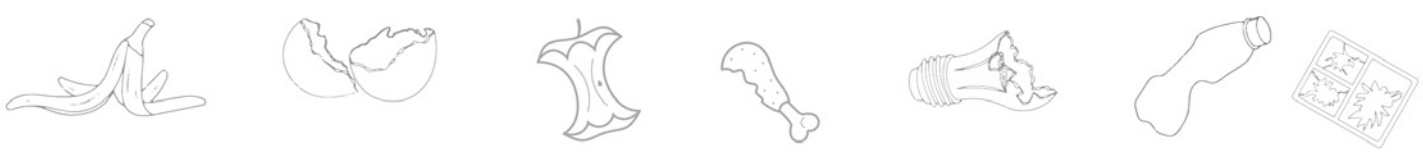
1. Biological Processing (Composting and Biomethanation)
2. Thermal Processing or Waste to Energy Processing
3. Processing for Reuse (especially for C&D Waste, Plastics in Roads)

The bio-degradable waste can be processed using biological (bio-chemical) conversion by Composting or biomethanation. Composting will yield bio-fertilizer commonly known as city compost useful as a soil conditioner, whereas Biomethanation will yield biogas as its output which can be used for production of electricity and heat/ light.

Dry/Combustible waste can be processed through thermal processing (waste to energy) which includes Incineration, Gasification and Pyrolysis. The output could be electricity which can be sold to electricity distribution companies at a set tariff.

Inerts shall be sent to scientific landfills. Construction and Demolition (C&D) Waste although not part of municipal waste, is a huge problem due to mixing of C&D waste with the municipal waste.

The classification/ characterization of the waste and the technology options for its treatment have been clearly depicted in the Report of Task Force on Waste to Energy and the same is shown in the figure below. The figure gives the pathways as to the waste processing technology to be opted for a given type of waste. The various processing technologies are briefly described in the subsequent sections.



Source: Report of the Task Force on Waste to Energy, Planning Commission, May 2014

3.1 BIOLOGICAL (BIOCHEMICAL) PROCESSING TECHNOLOGIES

Bio-chemical conversion of biodegradable MSW can be categorized into composting and biomethanation. Composting is an aerobic process in which biologically degradable wastes are converted through biochemical transformation to yield stable granular material commonly called City Compost - which could be used as soil conditioner and nutrient provider.

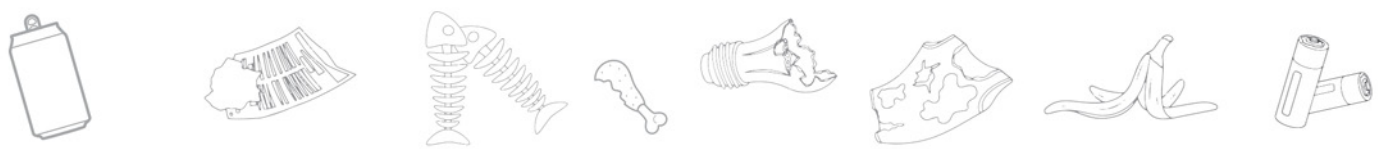
Biomethanation is an anaerobic slurry-phase process that can be used to recover nutrients and energy contained in biodegradable waste. Biogas can be used either as a source of thermal energy or to generate electricity by using gas engines or for gas lighting.

3.1.1 Understanding Biodegradable Waste

Biodegradable waste includes any organic matter in waste which can be broken down into carbon dioxide, water, methane or simple organic molecules by micro-organisms and other living organisms, using aerobic digestion, anaerobic digestion or similar processes.

3.1.2 Sources of Biodegradable Waste

Biodegradable waste is commonly found in municipal solid waste as green waste, food waste, paper waste, and biodegradable plastics. Other biodegradable wastes include human waste, manure,



sewage, sewage sludge and slaughterhouse waste, which however are to be kept out of the municipal waste. The sources of the biodegradable waste are mentioned below:

Figure: Components of bio-degradable waste

3.1.3 Composting

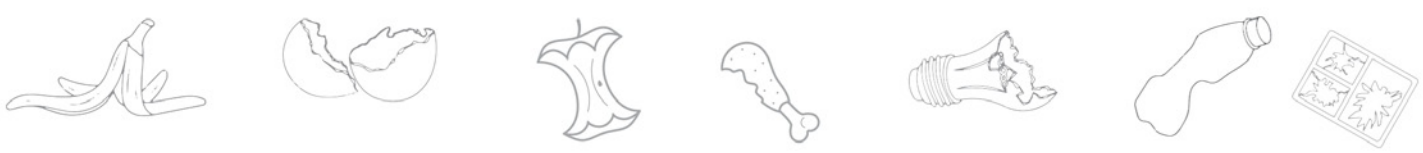
Composting involves the breakdown of organic waste by microorganisms in the presence of air, heat and moisture. This can be carried out on a small scale in households or on a large scale depending upon the quantity of waste to be processed and space available. Bacteria, fungi and actinomycetes act upon the waste to convert it into sugars, starch, and organic acids which in turn, are acted upon by high-temperature loving bacteria, resulting in a stable product called City Compost.

3.1.3.1 SWM Rules 2016: Provision on Composting

- Clause 4 Duties of Waste Generators (Section 6, 7, 8)
- Clause 15 Duties and Responsibilities of Local Authorities (section m, q, u, v)

3.1.3.2 Benefits of Composting

1. The economic benefits of compost use include improved soil condition, enhanced water retention capacity of soil, increased biological activity, micronutrient content, and improved pest resistance of crops.
2. Composting minimizes or avoids GHG emissions from waste.
3. Compost is useful as organic manure; it contains macronutrients (nitrogen, phosphorous, and potassium) as well as micronutrients. When used in conjunction with chemical fertilizers, optimum results are obtained.



4. Reduces dependency on chemical fertilizers
5. Compost can be used to revitalize impoverished soils and waste lands.
6. Compost may also be used as a bio matrix in remediation of chemical contaminants and as a remediated soil in contaminated sites where it helps in binding heavy metals and other contaminants, reducing leachate and bio-absorption.

3.1.3.3 Composting Process

Process Biology

Different organisms already present in MSW are known to play a predominant role in breaking down biodegradable constituents of 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.

1. Thermophilic Stage- Heat Generation (Sanitization)

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 (garbage heap for composting), a temperature rise from 35°C to 55°C–65°C is achieved within 2–3 days.

Windrows are turned at regular intervals to expose inner material to air so that temperature in these fresh sections rises again, and gradually the whole windrow is sanitized from pathogens.

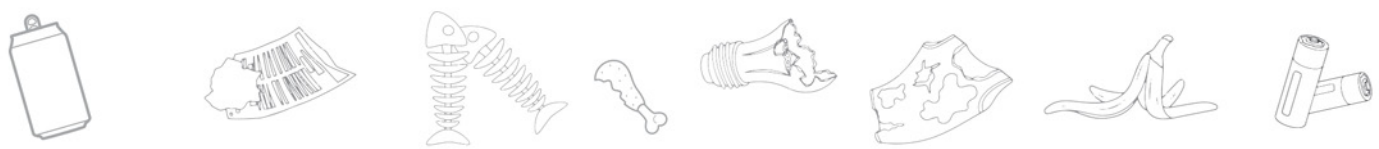
2. Mesophilic Stage

In the second stage, due to reduction in available food and nutrients, the microbial activity reduces, causing a decline in the temperature of the heap. There is a shift in the type of microbial species. The composted material becomes dark brown during this stage due to humus synthesis and starts to stabilize

3. Curing Stage

Curing of compost is done after the material from the windrow is screened. The screened material is then allowed to mature by curing stage. This is a very important phase in the composting process. Microbial species degrading complex polymers such as cellulose, lignin, etc., increase drastically during this phase.

Bacteria represent 80% of composting microbes. Free living nitrogen fixing bacteria, de-nitrifiers, sulphate reducers and sulphur oxidizers are important constituents of the total microbial population.



3.1.3.4 Physical and Chemical Parameters

Moisture: Moisture is a critical factor in 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 too high, anaerobic conditions set in and composting is affected.

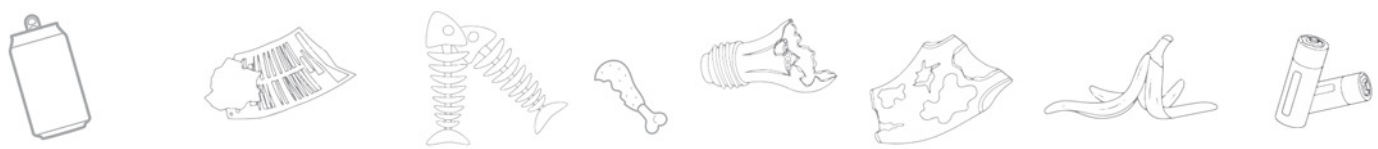
Aeration: The composting process requires adequate supply of oxygen for biodegradation by microorganisms. Under aerobic conditions, decomposition rate is 10–20 times faster than under limited oxygen supply or anaerobic conditions.

Carbon to Nitrogen Ratio: MSW in India has a general carbon-to-nitrogen (C/N) ratio of around 30:1, which is ideal for decomposition. The organisms involved in stabilization of organic matter utilize about 30 parts of carbon for each part of nitrogen. C/N ratio below 25:1 results in foul smell and a higher C/N ratio will impede the decomposition process

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.

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 and faster stabilization of the material. However, if the temperature becomes very high (>75°C), organisms and enzymes gets deactivated and the rate of activity may decrease.

Particle Size: The optimum particle size should have enough surface area for rapid microbial activity with 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.



3.1.3.5 Composting Technologies

3.1.3.5.1 Windrow Composting

Windrow Composting:

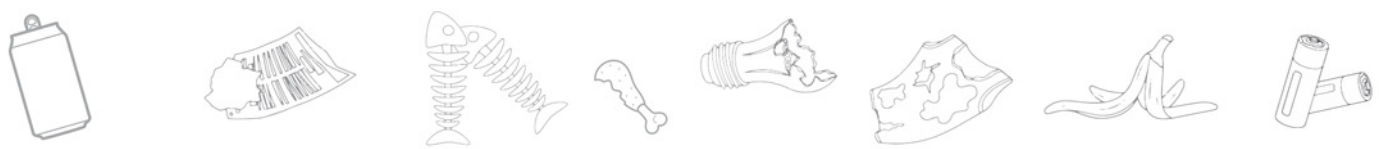
Windrow composting is the production of compost by piling biodegradable waste, in long rows (windrows). This method is suited to producing large volumes of compost. These rows are regularly turned over to improve porosity/voids and oxygen content, mix in or remove moisture, and redistribute cooler and hotter portions of the pile. Windrow composting is a commonly used composting method.

Environmental Concerns

Landfill (whether there is a need of landfill for the technology/process)	**Emissions** (Whether the technology/process is associated with emitting gases)	**Leachate** (Whether the technology /Process generates leachate
Yes for inert residue	Yes	Yes

Important Points on Windrow Composting

Parameters			
Type of waste	Organic Waste (All type of Wet-Biodegradable Waste)		
Suitability (Tons/day)	Min: 100 Tonnes		Max: 1000 Tonnes
Approx. Area Requirement (m^2)	Min: 12500 m^2		Max: 185000 m^2
Approx. Capital Investment (Rs.)	Min: 650 Lakhs		Max: 5500 Lakhs
Approx. Operational Costs (PA)	Min: 70 Lakhs		Max: 250 Lakhs
Compost Generation	Resource: Compost	Min: 15 TPD	Max: 175 TPD
Approx. Operational costs (Rs.)	750 INR per Tonne of Compost		
Processing Period	60Days		
Type of Labour Requirement	Skilled + Semi Skilled + Unskilled		
Suitability	Large Quantity of Waste Large piece of land Agriculture and Horticulture activity in surrounding		



Case Study on Windrow Composting-1

Windrow Composting:

Okhla Waste to Compost Plant

Processing Capacity: 200 TPD

Compost Production: 30 TPD

Company/Organization/Players: *South Delhi Municipal Corporation along with IL&FS Environmental Infrastructure & Services Limited*

Details on the Project:

The Okhla compost plant was set up on Public Private Partnership (PPP) in association with South Delhi Municipal Corporation of Delhi (SDMC). Today the plant processes 200 Tonnes of MSW each day and produces 30 TPD of organic compost.

The Process:

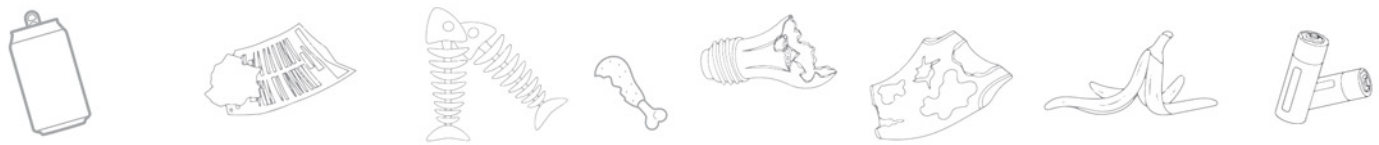
The production process of compost involves the following processes:

1. Windrow formation under the Monsoon Sheds
2. Coarse Segregation
3. Refinement
4. End Product
5. Packaging

Products:

The facility produces compost and is marketed in the brand name of two products:

1. Greenphos: Organically bound, value added Phosphate Compost which is enriched with beneficial microbe culture along with the presence of essential nutrients like Carbon, Nitrogen, Potassium, Calcium, Zinc, Iron etc.,
2. Harit Lehar: A humus rich organic compost, compliant to standards of Fertilizer Control Order (FCO)



Case Study on Windrow Composting-2

Windrow Composting:

Ahmedabad Municipal Corporation

Processing Capacity: 500 TPD

Compost Production: 55 TPD

Company/Organization/Players: *Ahmedabad Municipal Corporation along with Excel Industries Limited*

Details on the Project:

Model: PPP

Ahmedabad the capital of Gujarat covers 500 km^2 area in the heart of the state. Population of the city is around 7.5 million. City collects and transports approx. 4000 Tonnes of garbage every day.

Excel Industries Ltd has signed 30-year agreement with Ahmedabad Municipal Corporation (AMC) in 1997 for 500 TPD MSW processing for converting it into compost. AMC has given 25-acre land on 1 rupee/sq. mtr rent basis. This is the oldest & largest surviving MSW treatment compost plant in India.

As per the original agreement, Excel is giving 2.5% royalty to AMC on realization price of compost. The plant is one of the highest producers of good quality City Compost in India.

3.1.3.5.2 Vermi Composting

Vermi Composting

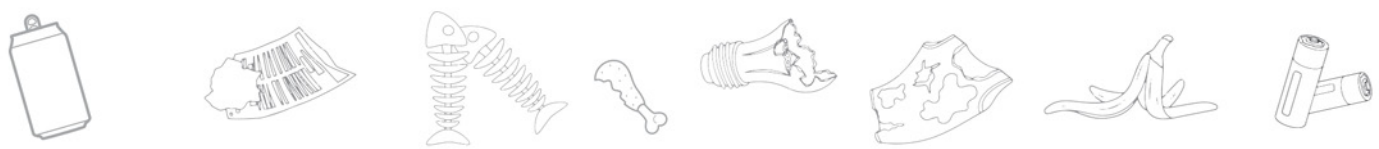
Vermi compost (or vermin-compost) is the product of the composting process using various species of worms, usually red wigglers, white worms, and other earthworms, which feed in mixture of decomposing vegetable or food waste, and release droppings called vermi cast (also called worm castings, worm humus or worm manure) is the end-product of the breakdown of organic matter by an earthworm.

Environmental Concerns

Landfill (whether there is a need of landfill for the technology/process)	**Emissions** (Whether the technology/process is associated with emitting gases)	**Leachate** (Whether the technology /Process generates leachate
No	No	No

Important Points on Windrow Composting

Parameters			
Type of waste	Only Organic Waste		
Suitability (Tons/day)	Min: 0.1 Tonnes		Max: 2 Tonnes
Approx. Area Requirement (m^2)	Min: 100 m^2		Max: 2500 m^2
Approx. Capital Investment (Rs.)	Min: 0.25 Lakhs		Max: 2.5 Lakhs
Approx. Operational Costs (PA)	Min: 1.80 Lakhs		Max: 16.80 Lakhs
Energy/ Resource Generation	Resource: Compost	Min: 0.04TPD	Max: 0.80TPD
Approx. Production costs (Rs.)	5000 INR per Tonne of Compost		
Type of Labour Requirement	Unskilled		



Case Study on Vermi Composting

Vermi Composting

Bruhat Bengaluru Mahanagara Palike (BBMP)

Processing capacity: 20 TPD

Company/Organization/Players: *Bruhat Bengaluru Mahanagara Palike (BBMP) along with MSGP Infratech Private Limited*

Project Details:

The waste is placed in vermi pits made from Granite Stone slabs or bricks and cement. The beds are 1 metre wide, 0.75 metre high and 10 metre long. Two beds are placed next to each other and in between each set of two beds there is a passage way of about 0.6 metre. The beds are covered.

The beds have a layer of coconut husk or similar bedding material at the bottom to facilitate drainage and movement of the worms. Worms of the species Eisenia foetida will be released on top of the waste. Approximately 30 kg of worms or about 100,000 worms is required for each of the vermi bed.

Maturation

After 30 to 40 days, the vermi compost is harvested manually and the harvested compost is stored for about two weeks to allow cocoons to hatch. At the end of this period the worms in the compost are again separated and the worms are placed back in the vermi beds.

Screening

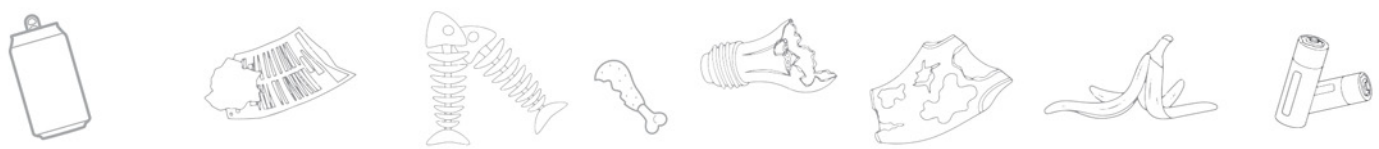
The compost is screened manually using inclined screens with mesh size of 8mm and 4mm.

Quality Control

In order to ensure that quality of the compost is tested in a lab to determine the nitrogen, phosphorus and potassium and organic content. The compost is also tested in the field by applying it in test plots.

Model:

PPP- DBOO (Design Build Own and Operate). Land and waste provided by BBMP whereas the private party made full investment for the plant and also for O&M Private party gets the revenues from sale of vermi-compost whereas BBMP's obligation to treat is also fulfilled.



3.1.3.5.3 Aerated Static Pile Composting

Aerated Static Pile Composting:

Aerated Static Pile (ASP) composting, refers to the system used to biodegrade organic material without physical manipulation (turning) during composting. The blended waste is usually placed on perforated piping, providing air circulation for controlled aeration. It may be in windrows, open or covered, or in closed containers. With regard to complexity and cost, aerated systems are most commonly used by larger, professionally managed composting facilities, although the technique may range from very small, simple systems to very large, capital intensive, industrial installations.

Aerated static piles offer process control for rapid biodegradation, and works well for processing saturated wet waste and large volumes. ASP facilities can be under roof or outdoor windrow composting operations, or totally enclosed in-vessel composting, sometimes referred to tunnel composting.

Environmental Concerns

Landfill (whether there is a need of landfill for the technology/process)	**Emissions** (Whether the technology/process is associated with emitting gases)	**Leachate** (Whether the technology /Process generates leachate
Yes, for inert residue	No	Yes

Important Points for Aerated Static Pile Composting

Parameters			
Type of waste	Pure Organic Waste		
Suitability (Tonnes/day)	Min: 0.10 Tonnes		Max: 10 Tonnes
Approx. Area Requirement (m2)	Min: 300 m^2		Max: 1000 m^2
Approx. Capital Investment (Rs.)	Min: 2.50 Lakhs		Max: 11.0 Lakhs
Approx. Operational Costs (PA)	Min: 1.80 Lakhs		Max: 5.50 Lakhs
Energy/Resource Generation	Resource: Compost	Min: 0.04 TPD	Max: 3.50 TPD
Approx. Production costs (Rs.)	1800 INR per Tonne of compost		
Type of Labour Requirement	Semi-Skilled + Unskilled		

3.1.3.5.4 In Vessel Composting

In Vessel Composting:

In-vessel composting generally is a method that confines the composting materials within a building, container, or vessel.

In-vessel composting systems can consist of metal or plastic tanks or concrete bunkers in which air flow and temperature can be controlled, using the principles of a “bioreactor”. Generally the air circulation is metered in via buried tubes that allow fresh air to be injected under pressure, with the exhaust being extracted through a bio-filter, with temperature and moisture conditions monitored using probes in the mass to allow maintenance of optimum aerobic decomposition conditions.

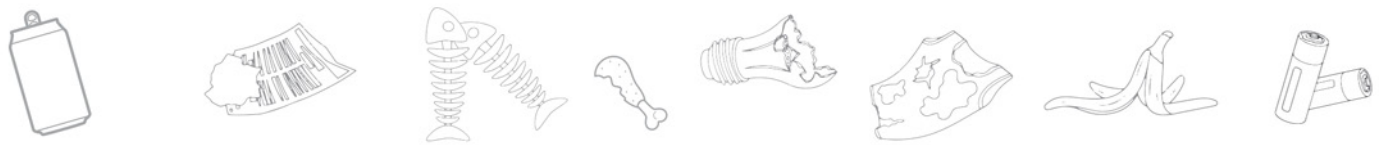
This technique is generally used for municipal scale organic waste processing, including final treatment of sewage bio-solids. It can also refer to aerated static pile composting with the addition of removable covers that enclose the piles.

Environmental Concerns

Landfill (whether there is a need of landfill for the technology/process)	**Emissions** (Whether the technology/process is associated with emitting gases)	**Leachate** (Whether the technology /Process generates leachate
Yes, for inert residue	No	Yes

Important Points for In Vessel Composting

Parameters		
Type of waste	Pure Organic Waste	
Suitability (Tonnes/day)	Min: 0.50 Tonnes	Max: 5 Tonnes
Approx. Area Requirement (m2)	Min: 200 m^2	Max: 500 m^2
Approx. Capital Investment (Rs.)	Min: 2.50 Lakhs	Max: 60 Lakhs
Approx. Operational Costs (PA)	Min: 2.16Lakhs	Max: 9.00 Lakhs
Energy/ Resource Generation	Resource: Compost Min: 0.15 TPD	Max: 1.5 TPD
Approx. Production costs (Rs.)	1700 INR per Tonne of Compost	
Type of Labour Requirement	Semiskilled + Unskilled	



3.1.3.5.5 Pit Composting

Pit Composting:

Pit or trench Composting is the process of burying organic waste directly into soil. Trenching is an excellent method to use in combination with growing annual plants, especially plants like cabbage, corn etc. It also encourages the development of deep, water conserving root systems. Trenching utilizes anaerobic (without oxygen) decomposition to create an underground band of nutrient-rich humus for plants. This is a slower composting process than that occurs in a well-managed windrow, but the trenched materials will retain more nitrogen during the process.

Dig a hole or trench deep and as wide and long as is practical . Pile the soil up beside the trench. Fill the bottom 15 cm (6") of trench with nutrient-rich food and organic waste and fill in the hole with the excavated soil. Make sure the materials are quite moist before burying them.

Environmental Concerns

Landfill (whether there is a need of landfill for the technology/process)	**Emissions** (Whether the technology/process is associated with emitting gases)	**Leachate** (Whether the technology /Process generates leachate
Yes, for inert residue	No	No

Important Points on Pit Composting

Parameters		
Type of waste	Pure Organic Waste	
Suitability (Tonnes/day)	Min: 0.10 Tonnes	Max: 2 Tonnes
Approx. Area Requirement (m2)	Min: 100 m^2	Max: 2500 m^2
Approx. Capital Investment (Rs.)	Min: 0.25 Lakhs	Max: 3.00 Lakhs
Approx. Operational Costs (PA)	Min: 1.86 Lakhs	Max: 3.00 Lakhs
Energy/ Resource Generation	Resource: Compost Min: 0.04 TPD	Max: 0.80 TPD
Approx. Production costs (Rs.)	1050 INR per Tonne of Compost	
Type of Labour Requirement	Unskilled	

3.1.3.5.6 Mechanized Organic Waste Composter

Pit Composting:

Mechanized Organic Waste Composter:

Mechanized Organic Waste Composter are designed to make composting easy and convenient. Mechanized OWC's are fully automatic and have very compact and aesthetic design.

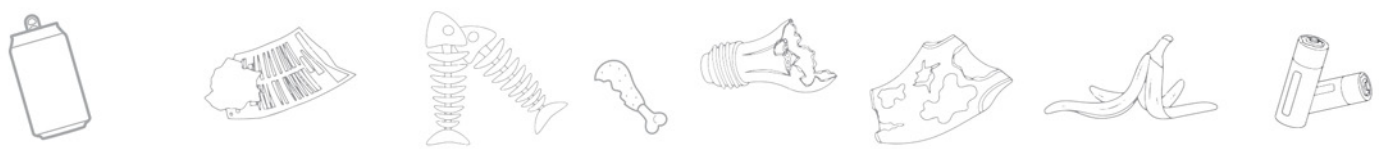
OWCs are equipped with intuitive technology which maintains the right temperature, air flow and moisture. A special bacteria which is heat, salt and acid resistant is used. Once the bacteria are introduce in machine they reproduce at a rapid pace under ideal internal conditions.

Environmental Concerns

Landfill (whether there is a need of landfill for the technology/process)	**Emissions** (Whether the technology/process is associated with emitting gases)	**Leachate** (Whether the technology /Process generates leachate
Yes, for inert residue	No	Yes

Important Points on Mechanized Organic Waste Composter

Parameters			
Type of waste	Mixed Wet Waste		
Suitability (Tonnes/day)	Min: 100Kgs		Max: 5Tonnes
Approx. Area Requirement (m2)	Min: 100m^2		Max: 1000 m^2
Approx. Capital Investment (Rs.)	Min: 3.0 Lakhs		Max: 90 Lakhs
Approx. Operational Costs (PA)	Min: 2.0 Lakhs		Max: 18.00 Lakhs
Energy/ Resource Generation	Resource: Compost	Min: 30Kgs/ day	Max: 1.50 Tonnes/ day
Approx. Production costs (Rs.)	1500 INR per tonne		
Approx. Life Duration	7 Years		
Type of Labour Requirement	Skilled + Unskilled		
Reduction in Waste Volume	30%		



Case Study on Mechanized Organic Waste Converter- 1

Mechanized Organic Waste Converter

Thrissur Municipal Corporation Kerala

Capacity: 4 Tonnes per day

Compost Production: 1 Tonne per day

Company/Organization/Players: *Thrissur Municipal Corporation of Kerala along with Essel Industries Limited*

Project Details:

Owned by: Thrissur Municipal Corporation (TMC)
Technology, Installation and Commissioning by: Excel Industries Limited
Operated by: M-Way Consultants Kerala (fully outsourced)

Details of the Project: The Organic Waste Converter plant is located in the heart of Thrissur right behind the bus station. It was commissioned in the year 2012.

Built in a compact 500 sq. metre covered shed, the plant treats segregated organic waste coming from the vegetable market nearby and converts it into good quality city compost. This compost is being used in the city parks and also supplied to nearby farmers from nearby areas.

Process: The 'Excel OWC Process' of de-centralized composting consists of:

a. Manual Segregation on Segregation Tables
b. Shredding of large sized waste materials in a slow speed shredder
c. Fine homogenizing and inoculation using Excel Bioculum in the OWC Machine
d. 10-day curing in Curing Systems consisting of racks, crates and automated moisture control system

Cost of the Plant: 40 lakhs for 4 Tonne Plant
Model: Fully owned and operated by TMC

Case Study on Mechanized Organic Waste Converter- 2

Mechanized Organic Waste Converter

Infosys Bangalore

Capacity: 1.5 Tonnes per day

Compost Production: 0.3 Tonne per day

Company/Organization/Players: *Infosys Bangalore with Essel Industries Limited*

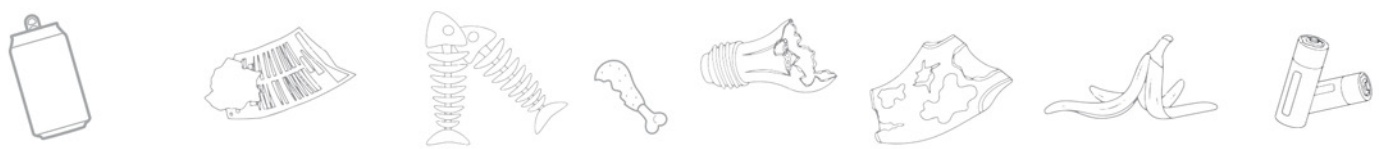
Project Details:

Owned by: Infosys, Bangalore
Technology, Installation and Commissioning by: Excel Industries Limited
Operated by: Vennar Organic, Bangalore (fully outsourced)

The sustainability team at Infosys decided to transport the organic waste generated from all its campuses in Bangalore to a dedicated plant owned by them at the outskirts of the city. The plant is operational since 2015. Built over 100 sq. metres, this plant treats all the cooked and uncooked food waste from their canteens of all Infosys campuses in Bangalore and converts it into good quality city compost. This compost is then used for landscaping in its own campuses.

Process: The 'Excel Process' of de-centralized composting consists of:
a. Manual Segregation on Segregation Tables
b. Shredding of large sized waste materials in a slow speed shredder
c. Fine homogenizing and inoculation using Excel Bioculum in the OWC Machine
d. 10-day curing in Curing Systems consisting of racks, crates and automated moisture system

Cost of the Plant: 18 lakhs for 1 Tonne Plant
Model: An example for Bulk Generators obligation. It is a private-private partnership entered by Infosys.



3.1.3.5.7 Hybrid Composting

Hybrid Composting Based on Segregation Model Infosys Bangalore

Tirruchirapalli City Corporation, Tamil Nadu

Company/Organization/Players: *Tirruchirapalli City Corporation, Tamil Nadu*

Project Details:

To ease the pressure on central compost yard Tirruchirapalli City Corporation (TCC) has initiated 29 Nos of Micro compost centres (MCC) to process the wet waste to manure. These 29 MCC would cover to 58 wards and each MCC could handle 3 - 5 MT.

Cost – Buildings and machinery: Rs. 20 Lakhs to Rs. 80 Lakhs depending volume of waste and space available for construction.

O& M: SHG Members selected trained and engaged in door to door collection and processing of the wet waste in MCC.

The produced manure is given free of costs to farmers.
Model: O&M Model, Infrastructure provided by ULB.

Case Study on Heritage School, Sector 62

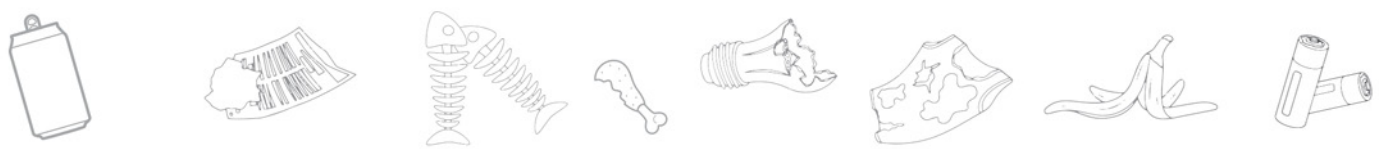
Hybrid Composting Based on Segregation Model

Heritage School
Sector 62, Gurgaon

Company/Organization/Players: *Heritage School, Sector 62, Gurgaon*

Project Details:

The school has set up a hydrid-rapid composting technology system which converts biodegradable waste into organic manure in January 2016. The process involves three steps including crushing, de-watering and shredding systems. The machine capacity for horticulture as well as the food waste is 300 Kgs per day. The system produces 20-30 Kgs of manure per day which is used for gardening purposes.



3.1.3.6 Equipment required for composting: Windrow Method

1. **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.

2. **Windrow turner:** Loaders can be used to turn the compost windrows; however, specialized 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 specialized 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 metres in base width for plants receiving 100 tonnes per day (TPD) or more of waste.

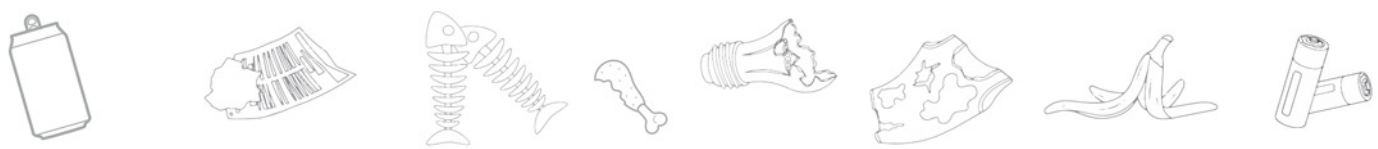
3. **Screener:** A trommel screen is desired at the end of the curing process to screen the finished compost for a suitable particle size. This will remove any larger undesirable items to ensure a suitable compost quality.

4. **Bagging:** Compost is usually packed in 50 kg bags.

3.1.3.7 Quality of Compost

The compost which is to be used as fertilizer for food crops should abide by the FCO, 2009, while compost used as a soil conditioner and for other purposes should at least meet the requirements of SWM Rules, 2016. The FCO, 2013 specified quality standards for PROM, while retaining the standards specified in FCO, 2009 for organic compost.

Parameters	Organic Compost	Phosphate Rich Organic Manure (PROM)
	FCO 2009	FCO (PROM) 2013
Arsenic (mg/kg)	10	10
Cadmium (mg/kg)	5	5
Chromium (mg/kg)	50	50
Copper (mg/kg)	300	300
Lead (mg/kg)	100	100
Mercury (mg/kg)	0.15	0.15
Nickel (mg/kg)	50	50
Zinc (mg/kg)	1000	1000
C/N ratio	<20	Less than 20:1
pH	6.5-7.5	Maximum 6.7
Moisture, % by weight, minimum	15-25	25
Bulk density (g/cm3)	<1	<1.6
Total Organic Carbon, % by weight, minimum	12	7.9
Total Nitrogen (N), % by weight, minimum	0.8	0.4
Total Phosphate P2O5,% by weight, minimum	0.4	10.4
Total potassium (K2O), % by weight, minimum	0.4	-
Color	Dark Brown to Black	-
Odor	Absence of Foul Odor	-
Particle Size	Minimum 90% material should pass through 4.0 mm IS sieve	Minimum 90% material should pass through 4.0 mm IS sieve
Conductivity (as dsm-1), not more than	4.0	8.2
Note: Tolerance limits as per FCO: i. For compost- The sum total of nitrogen, phosphorus and potassium nutrients shall not be less than 1.5% in compost. ii. For PROM- No such directive.		



3.1.4 Biomethanation

Biomethanation is the anaerobic (in the absence of free oxygen) fermentation of biodegradable matter in an enclosed space under controlled conditions of temperature, moisture, pH, etc. The waste mass undergoes decomposition due to microbial activity, thereby generating biogas comprising mainly of methane and carbon dioxide (CO_2), and also digested sludge, which is stabilized but may contain some pathogens. Due to the anaerobic environment, hydrogen sulfide (H_2S) is generated with varying percentage depending on the Sulphur content in the system (in the form of protein, sulphate, etc.). Like composting, biomethanation is one of the most technically viable options for Indian municipal solid waste (MSW) due to the presence of high organic and moisture content.

3.1.4.1 SWM Rules 2016: Provision on Biomethanation

- Clause 4 Duties of Waste Generators (Section 6, 7, 8)
- Clause 15 Duties and Responsibilities of Local Authorities (section m, q, u, v)

3.1.4.2 Benefits of Biomethanation Process

1. The produced biogas can be used for cooking or for the production of electricity and heat/light.
2. Biomethanation of biodegradable organic material would result in stabilized sludge which can be used as a soil conditioner and fertilizer.
3. Ideal for waste with high moisture content.

3.1.4.3 Biomethanation Process

Process Description: Generally the overall process can be divided into four stages:

1. Pre-treatment
2. Anaerobic Fermentation
3. Collection of biogas and its usage
4. Residue Treatment

1. Pre-treatment:

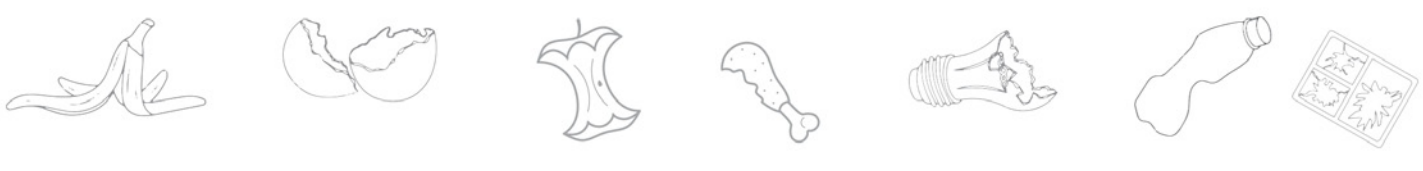
Pre-processing involves separation of non-digestible material either through source segregation or through mechanical sorting at the biogas plant facility to remove undesirable or recyclable material such as glass, metals, stones, etc. The waste is shredded before it is fed into the digester for better fermentation.

2. Anaerobic Fermentation (Digestion):

Anaerobic fermentation happens in three steps brought about by different groups of microbes: hydrolysis (hydrolytic bacteria), acidogenesis (acidogenic bacteria), and finally biomethanation (methanogenic bacteria).

3. Gas Recovery

The biogas obtained is stored and may be scrubbed to ensure automotive quality CNG-like gas (CO_2 less than 5% and H2S less than 10 ppm). Biogas may also be used for generating electricity.



4. Residue Treatment

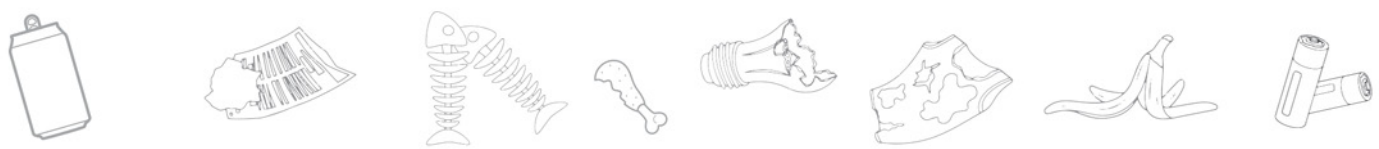
The digested sludge is dewatered and the liquid recycled for use in the dilution of incoming feed. The bio-solids are dewatered to 50%–55% total solids with a screw press, filter press, or other types of dewatering systems and aerobically cured to obtain a compost product.

3.1.4.4 Operating Parameters for Biomethanation

1. **Temperature:** Temperature affects bacterial growth and hence the amount of biogas produced. Treatment of waste in anaerobic reactors is normally carried out within two ranges: around 25°C–40°C (ideally 35°C–37°C) known as mesophilic range, and higher than 45°C (ideally 55°C–60°C) known as thermophilic range
2. **pH:** The anaerobic digestion process is limited to a relatively narrow pH band from 6.0 pH to 8.5 pH approximately, especially that the methanogenic bacteria are very sensitive to pH (close to neutral pH around 7.0)
3. **Toxicity:** A number of compounds are toxic to anaerobic microorganisms. Methanogens are commonly considered to be the most sensitive to toxicity
4. **Carbon-to-nitrogen ratio:** Optimum carbon-to-nitrogen (C/N) ratio in anaerobic digesters is 20:30. Optimum C/N ratios of the digester materials can be achieved by mixing material of high and low C/N ratios, such as organic solid waste (high in carbon) and sewage or animal manure (high in nitrogen).
5. **Organic loading rate:** Organic loading rate is the frequency and speed at which the substrate is added to the digester. For each plant of a particular size, there is an optimal rate at which the substrate should be loaded.
6. **Retention time:** The required retention time for completion of the reactions varies with differing technologies, process temperature, and waste composition. The retention time for waste treated in a mesophilic digester ranges from 20 to 30 days. A high solids reactor operating in the thermophilic range has a retention time of about 14 days.

3.1.4.5 Important Points for Biomethanation

Parameters			
Type of waste	Mixed Combustible Waste		
Suitability (Tonnes/day)	Min: 0.50Tonnes		Max: 300 Tonnes
Area Requirement	Min: 350 m^2		Max: 37,000 m^2
Capital Investment	Min: 15.0 Lakhs		Max: 9000 Lakhs
Operational Costs	Min: 1.5 Lakhs		Max: 90 Lakhs
Energy/Resource Generation	Power + Compost	Min: 0.2MW	Max: 3.0MW
Production costs	4.50 per unit electricity		
Life Duration	15 Years		
Handling Expertise	Skilled+ Semi Skilled+ Unskilled		
Reduction in Waste Volume	40%		



Case Study on Bio-Methanation Plant-1

Bio-Methanation Plant

Nisargruna Plant, Shatabdi Hospital Site at Govandi, Mumbai

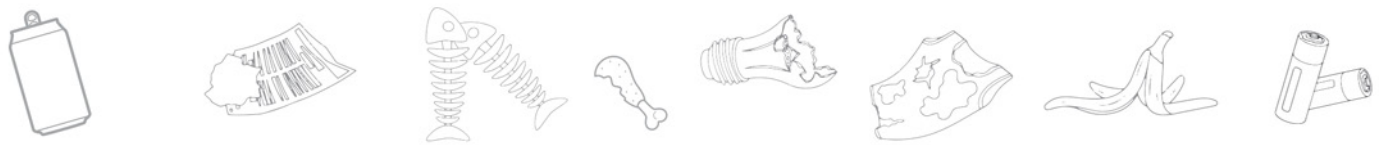
Processing capacity: 2 TPD

Company/Organization/Players: *Shatabdi Hospital Site at Govandi, Mumbai*

Project Details:

Technical details of the plant Major components of BARC's a Nisarguna plant include a mixture/pulper with 5 HP motor for crushing solid waste, a pre-mix tank, a pre-digester tank, an air compressor, a slow water heater or solar panels, a main digestion tank, a gas delivery system, manure pits, a tank for recycling water, a water pump, slurry pump and a gas utilization system. The waste is homogenized in a mixer using water. This slurry enters the pre-digester tank where aerobic thermophilic bacteria proliferate and convert part of this waste into organic acids like acetic acid, butyric acid, propionic acid and formic acid.

Total space required (storage and operational set up)	35 m x 25 m = 875 m^2
Actual space required for plant	Approx. 750 m^2
Technology	Aerobic and Anaerobic process Developed by BARC
How often the microbial culture has to be added	Only once at the time of plant commissioning
Number of days/weeks required for establishing the culture in the digester	Only one day (culture can be transferred or brought here from any similar running plant)
Does the establishment of culture vary from season to season (eg. In winter and summer)	Aerobic digester – varies therefore a constant temperature has to be maintained Anaerobic digester – NO
Initially how many days/weeks are required for obtaining the stable purity of Methane	Approximately one week
After how many days/weeks of actual operations, the first waste feeding to the plant begins	First feeding can start from day one but to reach the optimum capacity it will require some more days (for a 5 tonne plant it may require 3-4 months)
Working days of plant/yr	365 days (for Shatabdi Hospital)
Whether any special types of enzymes are used on regular basis	No
Retention time	Actually 12 days (4 pre-digester and 8 secondary digester) but to be on the safer side it is 19 days
Capacity of the Plant	5 tonnes
Quantity of gas produced	Average 150 m^3/tonne of input but depend on type of waste.
How many MW or KW of electricity produced per day	108 kwh in 12 hours
Owner of the End product	Gas – Municipal Corporation of Greater Mumbai Manure – Stree Mukti Sangathan
Total manpower required including security personnel	7
Total quantity of waste used every day	2 Tonnes
Types of waste used	All types of Biodegradable kitchen wet waste (cooked and pre cooked) and raw vegetable and fruit waste.
Maintenance cost of the plant /yr	2,40,000/- at present future projections are 3,60,000/-
Cost of the Plant: 5 Tonnes	25 Lakhs
Cost of the Plant: 2 Tonnes	12.50 lakhs



Case Study on Bio-Methanation Plant-2

Bio-Methanation Plant

Katraj Biogas Plant Based on 5 Tonne Per Day of MSW

Company/Organization/Players: *Pune Municipal Corporation along with Mailhem IKOS Environment Pvt. Ltd.*

Project Details:

Pune Municipal Corporation (PMC) has implemented waste segregation at source and has implemented various treatment schemes for the solid waste thus collected. Treatment of biodegradable municipal solid waste to generate combustible gases (which can be used either as fuel in Kitchen or as fuel for generating power) was one of the early initiatives taken by the Corporation. PMC has got 5 such biogas generation plants designed, supplied and installed by Mailhem Ikos Environment Private Limited.

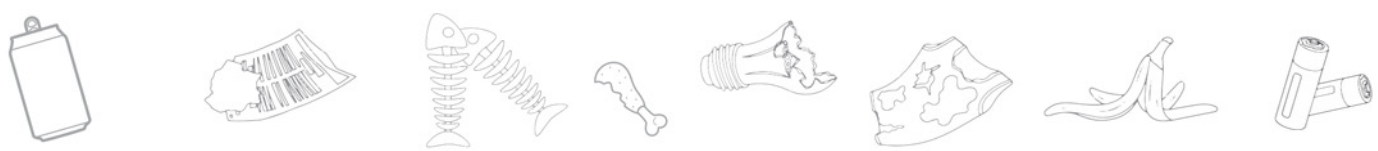
Sr. No	Details	Amount (INR)
A	Annual Income	
1	Saving in electricity per annum	8,71,200
2	Savings by use of good quality organic manure	4,95,000
3	Savings in transportation of 1650 ton per annum of waste	8,25,000
	TOTAL INCOME per annum (A)	21,91,200
	ANNUAL EXPENDITURE	
	Operation & Maintenance cost	5,42,000
	Captive electricity consumption	72,600
	TOTAL EXPENDITURE per annum (B)	6,14,600
	TOTAL INCOME – TOTAL EXPENDITURE (A - B)	15,76,600
	Total Investment including PMC Dept work (2009)	70,00,000
	Pack back period	4.5 years

1. ADDITIONAL FINANCIAL BENEFITS TO PMC:

a. 80% accelerated depreciation is available in the year of installation.
b. Environmental impact due to neat and clean means of disposal cannot be quantified in terms of money.
c. Impact of Subsidy by MNRE (GOI) and Carbon Credits has not been taken into account.

2. BENEFITS FOR PUNE MUNICIPAL CORPORATION

a. Generated wastes can be treated and disposed of locally and therefore increase operating life of Sanitary Land Fill site.
b. Reduces cost of transportation of wastes to the Landfill site, which is a normally located on the outskirt of the city.
c. Waste Management – collection & transportation of segregated wastes in a decentralized manner can be achieved and monitored more effectively.
d. The treatment of mixed wastes results in bi-products biogas and fertilizer.
e. Decentralized Biomethanation plants require less space and are aesthetically good looking.



Case Study on Bio-Methanation Plant-3

Bio-Methanation Plant

Pune Municipal Corporation
Biogas Generation Capacity: 300 m^3 /day

Company/Organization/Players: *Pune Municipal Corporation*

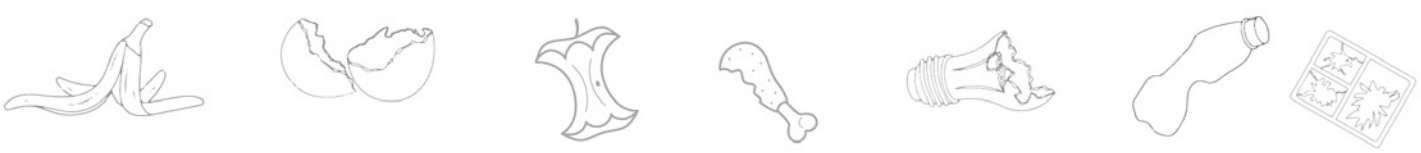
Project Details:

The project is an initiative by Pune Municipal Corporation to treat 100 TPD of waste in decentralized manner. The details of the plants are provided as under:

Biogas Generation	300 m3/day
Calorific Value	4800-5000 Kcal/cum
Engine Efficiency	25%
Electricity Generation	1.5 kWh/Cum of Biogas
Equivalent Electricity Generation	450 kWh/day
Auxiliary Power Consumption	50 kWh/day
Net Surplus Electricity for sale	400 kWh/day

Advantages for Pune Municipal Corporation:

1. **Disposal of waste at local level** Reduction in transportation cost @ Rs. 400 per tonne of waste, approximately Rs.1.43 Cr. annually (98 tonnes per day).
2. **Valuable Bi-Products** such as Biogas and Manure.
3. **Generated Electricity** will be utilized for street lighting.
4. **Space requirement** of 5000 sq. ft. for 5 TPD plant
5. **Reduced Greenhouse Gas Emissions** Stopping release of @ 180 cum of Methane in to the atmosphere per day per plant which is 22 times danger than CO2 for Global Warming.



Case Study on Bio-Methanation Plant-4

Bio-Methanation Plant

Sholapur Municipal Corporation
Processing Capacity: 300 TPD MSW
Installed Power Generation Capacity: 3 MW

Company/Organization/Players: *Sholapur Municipal Corporation with Organic Recycling Systems Private Limited*

Project Details:

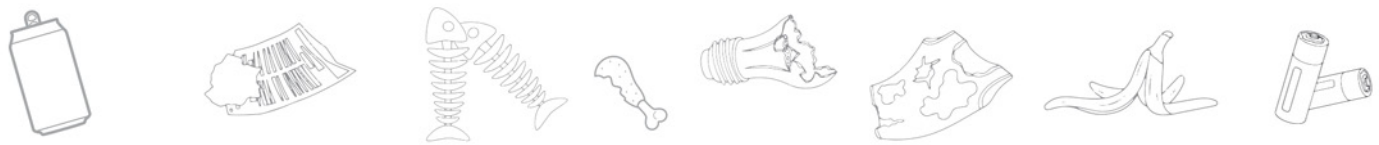
The anaerobic digestion of municipal solid waste is a process that has become a promising technology in waste management throughout the world. Biogas production from mixed municipal solid waste (MSW) was investigated under thermophilic dry anaerobic digestion operation (DRYADTM process).

The plant has installed DRYADTM process as a sustainable technology for minimizing the organic fraction of municipal solid waste going to landfill, to provide the renewable source of energy as well as to reduce the potential greenhouse gases emission from landfill. The process established for 400 TPD MSW processing capacity plant at Solapur Bio-energy System Pvt. Ltd, Solapur. Installed power generation capacity is 3 MW and plant is planning for additional 1 MW, and 60- 70 TPD of good quality compost/soil enricher will also be produced at full capacity.

The operation/process involved is Separation, Sizing, Homogenizing and Mixing to right consistency and temperature for feeding the DRYADTM digester. This plant is successfully commissioned and in operation, thus generating power from produced biogas. The electricity generated from the project is being wheeled to the grid for off take by MSEDCL since July 2013 onward.

The compost generated from the plant is as per FCO norms and being sold to leading fertilizer companies. Recyclable materials are being sold to recycling agencies. The process remnants that are less in quantity and are not more than 15%, are being sent to Landfill. Solapur WTE plant is country's first WTE plant based on Biomethanation technology on a large scale which is developed indigenously, and is successfully operational in the sector since last two year

Model: PPP Model with self-funded private party.
Land requirement is 9 acres which is provided by ULB. Investment: Rs. 90 Crores
Revenue: Selling of Power and Compost.



3.2 WASTE TO ENERGY TECHNOLOGIES

Waste-to-Energy (WtE) technology utilizes Municipal Solid Waste (MSW) to produce electric and heat energy through complex conversion methods. WtE technology provides an alternative source of renewable energy in a world with limited or challenged fossil reserves.

3.2.1 SWM Rules 2016: Provision on Incineration

- Clause 15 Duties and Responsibilities of Local Authorities: (section V)
- Clause 18
- Clause 21. Criteria for Waste to Energy process

3.2.2 Guidelines by Task Force on Waste to Energy Constituted by Planning Commission

The guidelines by the Task Force constituted by the Planning Commission (2014) for establishing Waste to Energy plants include the following:

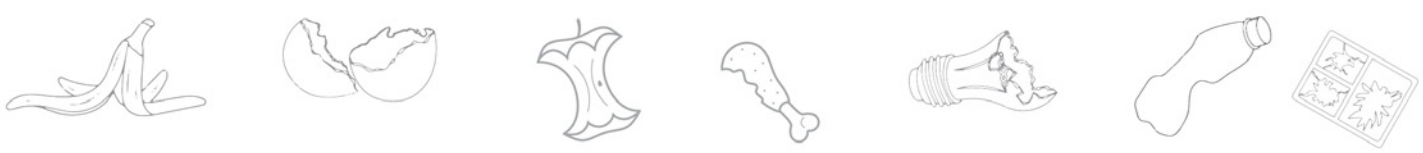
1. The appropriateness of WtE for a community must be evaluated on a case-by-case basis and should only be considered after waste reduction and responsible recycling programs are implemented.

2. Minimum eligibility criteria for getting financial support to set up WtE plants are the following:

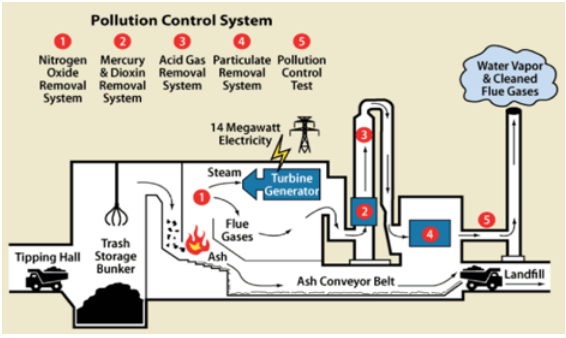
- Municipal authority must select a suitable concessionaire through a competitive bidding to set up, operate and maintain the waste processing facility for a long term not below 20 years (DBOOT).
- The applicant must be a developer or technology provider who will actually construct, operate and maintain the plant;
- The developer must have critical staffing on board on full time basis or on long term contract;
- The developer must have past experience of operation and maintenance (O&M) of at least one such plant.

The Report of Task Force on waste to energy clearly mentions the suitability of WtE plants when total waste generated is more than 550 TPD, along with composting for biodegradables as well as making RDF. This is suitable for ULBs having population of 10 Lakhs and above.

Considering the high costs of transportation of waste, the processed waste products and existence of extensive urban sprawl in large ULBs, as compared with the obligation of renewable energy on Electricity Discoms mandated to procure 100% power for WtE plants under Tariff Policy Dated 28.01.2016, the setting up WtE Plants is ideal for large ULBs.



3.2.3 Direct Combustion (Incineration)



Incineration:

Incineration is a waste treatment process that involves combustion of waste at very high temperatures in the presence of oxygen and results in the production of ash, flue gas, and heat. Incineration is a feasible technology for combustion of unprocessed or minimum processed refuse and for the segregated fraction of high calorific value waste.

Key Criteria:

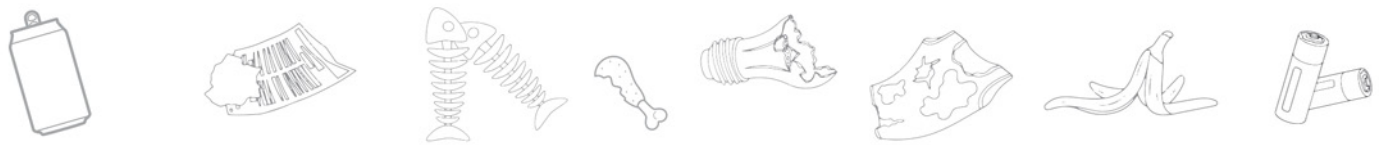
MSW incineration projects are appropriate only if the following overall criteria are fulfilled:

- a mature and well-functioning waste management system has been in place for a number of years;
- Incineration is especially relevant for the dry bin content in a two-bin system. For unsegregated waste, pre-treatment is necessary;
- The lower calorific value (LCV) of waste must be at least 1,500 kcal/kg.
- The furnace must be designed in line with best available technologies to ensure stable and continuous operation and complete burnout of the waste and flue gases. MSW is usually incinerated in a grate incinerator. Uniform combustion of waste is dependent on the grate design.
- Produced electricity or steam can be sold on a sustainable basis (e.g., feeding into the general grid at adequate tariffs).
- Since the capital investment is very high, the planning framework of the community should be stable enough to allow a planning horizon of 25 years or more.
- Pre-feasibility study for the technology leads to positive conclusions for the respective community.
- Strict monitoring systems are to be proposed and to be followed.

Brief Overview of Incineration Process:

The following general description of an incineration plant includes the crucial processing steps and aspects:

- Siting of an incineration plant;
- Waste reception and handling (storage, on-site pre-treatment facilities);
- Combustion and steam generation system;
- Flue gas cleaning system;
- Energy generation system (steam turbine and generator in case the unit is equipped for WTE recovery);
- Residual hauling and disposal system; and
- Monitoring and controlling incineration conditions.



Environmental Concerns

Landfill (whether there is a need of landfill for the technology/process)	**Emissions** (Whether the technology/process is associated with emitting gases)	**Effluent** (Whether the technology /Process generates effluents)
Yes	Yes	Yes

Important Points for Direct Combustion (Incineration)

Parameters		
Type of waste	Mixed Combustible Waste	
Suitability (Tonnes/day)	Min: 300 Tonnes	Max: 2000 Tonnes
Area Requirement	Min: 90,000 m^2	Max: 600,000 m^2
Capital Investment	Min: 4350 Lakhs	Max: 29000 Lakhs
Operational Costs	Min: 261 Lakhs	Max: 1740 Lakhs
Energy/Resource Generation	Resource: Syngas/ Power Min: 3.06MW	Max: 20.41MW
Production costs	4.50 per unit electricity	
Life Duration	15 Years	
Handling Expertise	Skilled+ Semi Skilled+ Unskilled	
Reduction in Waste Volume	90%	

Case Study on Direct Incineration-1

Narela-Bawana Plant

North Delhi Municipal Corporation

Processing Capacity: 2000 MT

Power Generation: 24 MW

Year of Start: 2017

Company/Organization/Players: *North Delhi Municipal Corporation*

Project Details:

Considered as the country's biggest such plant, it can process 2,000 MT of waste and generate up to 24MW energy. The capacity of Narela-Bawana plant would be expanded to process about 3,000 MT waste in future. Narela-Bawana plant, has come up on a private-public partnership model with Ramky Group at a cost of Rs. 458 crore, is the biggest such facility in the country.

Model: PPP Model

Land and partly CAPEX funding provided by the Government on revenue sharing basis.

Case Study on Direct Incineration-2

Jabalpur Waste to Energy Plant

Jabalpur Municipal Corporation

Processing Capacity: 600 MT

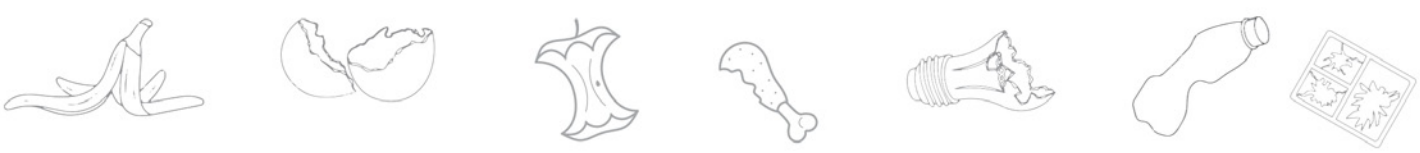
Power Generation: 11.5 MW

Company/Organization/Players: *Jabalpur Municipal Corporation along with Essel Infra*

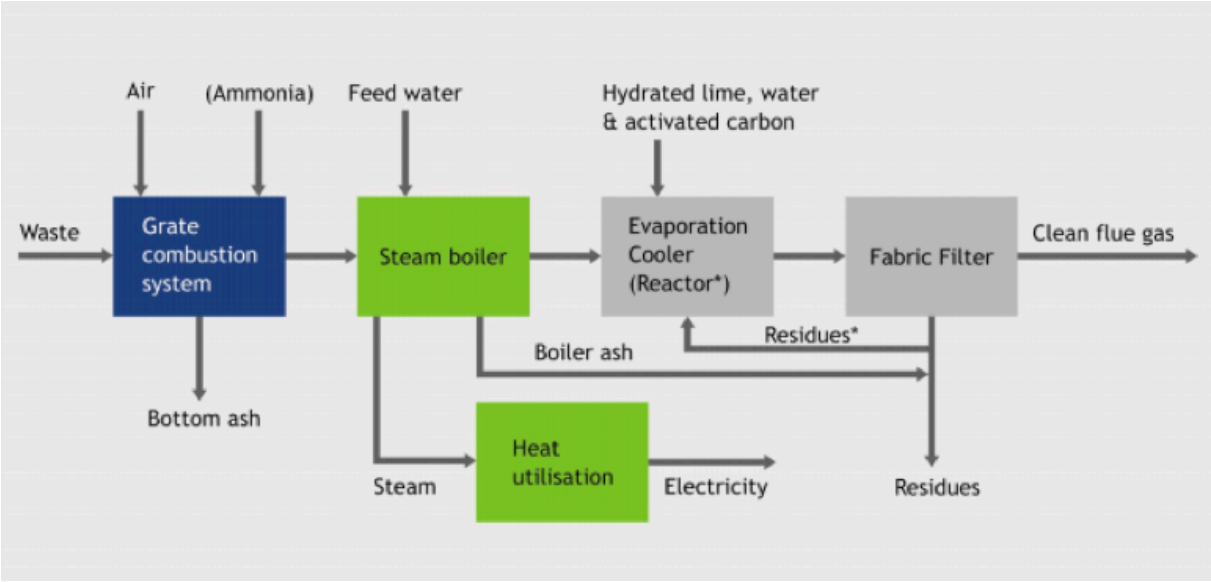
Project Details:

Municipal Corporation of Jabalpur Madhya Pradesh has signed Concession Agreement for 20 years with M/s Essel Jabalpur MSW Pvt. Ltd. (SPV of M/s Essel Infra Projects Mumbai) as Design Build Operate and Transfer (DBOT) Model on 5th February 2013 to process the 600 MT Municipal Solid Waste Generated from Jabalpur City on Mass Burning (Waste to Energy Technology) with technology partner by M/s Hitachi Zosen. As per Concession Agreement, Municipal Corporation Jabalpur will get Rs. 20.70 / MT Royalty from Concessionaire. The generation of electricity from 600 MT will be proposed 11.5 MW out of which 9.2 MWe electricity will be exported to MPEB Grid with Power Purchase Agreement (PPA) Rate Rs. 6.39 /unit

S. No	Items	Details
1	Name of the Plant Location	Kathonda, Jabalpur, Madhya Pradesh
2	Month/Year of Commissioning	May 2016
3	Total anticipated cost	Rs. 178 Crores
4	Solid Waste Intake Capacity	600 TPD
5	Power generation, MWh	Designed: 11.5 MW Rated: 9.2 MW to grid
6	Power tariff by State	Rs. 6.39
7	Type of waste used	Mixed
8	Technology adopted	Mass Burning
9	Date of Commissioning	May 2016, generation started

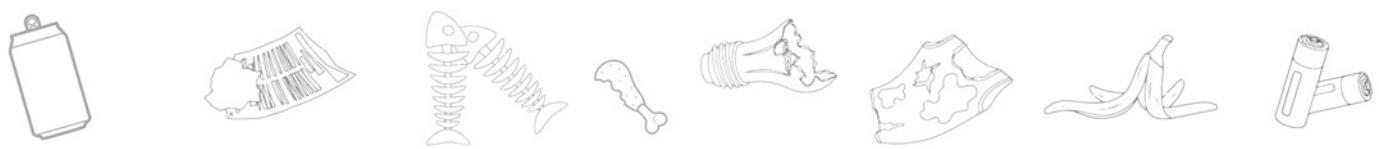


The Process:



Some Technological Highlights:

- Grate based system
- The optimized secondary combustion chamber with tangential secondary air-injection and specifically chosen refractory which results in low emission
- DeNOx SNCR system ensuring minimum emissions and simultaneously guarantees maximum efficiency as well as the lowest amount of residues
- The combustion control system (CCS) ensuring operations a requested thermal load. Constant steam production, flue gas oxygen content and flue gas flow are achieved even at varying waste quality.



Case Study on Direct Incineration-3

Timarpur Okhla Waste Incineration Plant

North Delhi Municipal Corporation

Processing Capacity: 1600 MT

Power Generation: 12 MW

Company/Organization/Players: *South Delhi Municipal Corporation along with JITF*

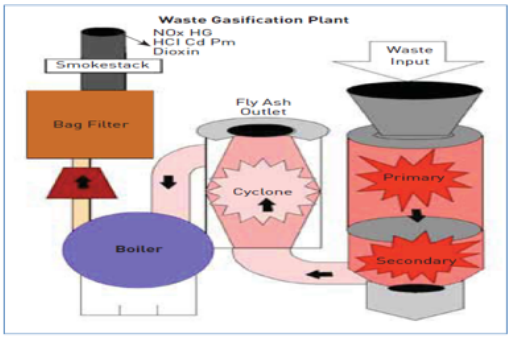
Project Details:

Timarpur-Okhla Waste Management Co Pvt Ltd is an initiative of M/s Jindal ITF Ecopolis. JITF Urban Infrastructure Ltd won the bid to develop the project on a Built Own Operate and Transfer (BOOT) basis, in a Public private partnership with the Delhi Government as legal Entity: Timarpur Okhla Waste Management Co Pvt Ltd. The incineration plant was commissioned in January 2012 and is processing 2,000 tons per day (TPD) and generating 16 MW. No tipping fee but waste is to be provided by MCD at plant site.

The project is the first and largest integrated waste management project ever being set up in the country. The project is CDM registered with United Nations Framework Convention on Climate Change (UNFCCC) for earning carbon credits.

Model: PPP, Land Provided by Government

3.2.4 Gasification



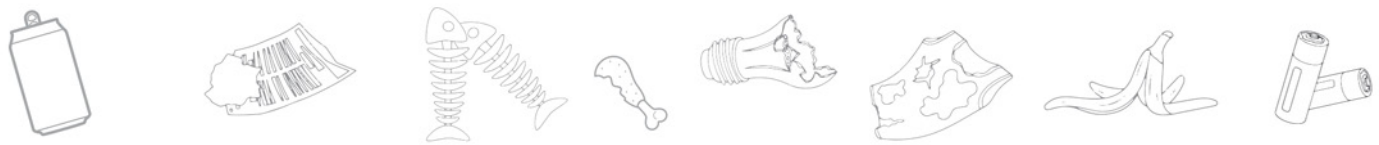
Gasification:

Gasification is the partial combustion of organic or fossil based carbonaceous material, plastics, etc. into carbon monoxide, hydrogen, carbon dioxide, and methane. This is achieved at high temperature (650°C and above), with controlled amount of air, oxygen, or steam.

The process is largely exothermic, and the main product is syngas, which contains carbon monoxide, hydrogen, and methane. Typically, the gas generated from gasification will have an NCV of 4–10 MJ/Nm3. The other main product is a solid residue of non-combustible material (ash).

Environmental Concerns

Landfill (whether there is a need of landfill for the technology/process)	**Emissions** (Whether the technology/process is associated with emitting gases)	**Effluent** (Whether the technology /Process generates effluents)
Yes	Yes	Yes



Process Description:

MSW should be pre-processed before it can be fed into the gasification process. The pre-processing comprises of manual and mechanical sorting, grinding, blending with other material, drying, and pelletization, is to produce a feed material with consistent physical characteristics and chemical properties. Carbonaceous material of municipal waste stream is the most important feedstock for gasification.

Gasification of MSW in the waste gasification plant is accomplished in two chambers:
(i) The primary chamber is operated with less air than required for combustion and
(ii) The secondary chamber is operated with excess air conditions.

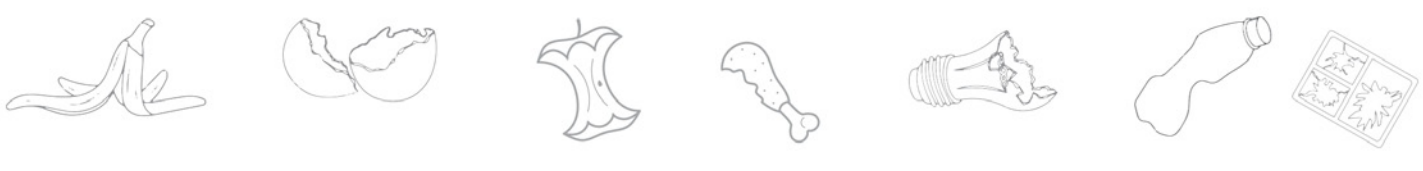
The waste is fed into the primary chamber and semi-pyrolyzed, releasing moisture and volatile components. The heat is provided by the controlled combustion of fixed carbon within the waste. The syngas that is driven off has a high calorific value becomes feedstock for the secondary chamber. Combustion air is then added to the syngas, and the combined gases are combusted in the secondary chamber.

Types:

Gasification technology is selected on the basis of available waste quality, capacity range, and gas quality conditions. The main reactors used for gasification of MSW are fixed beds and fluidized beds. Larger capacity gasifiers are preferable for treatment of MSW because they allow for variable fuel feed, uniform process temperatures due to highly turbulent flow through the bed, good interaction between gases and solids, and high levels of carbon conversion.

Important points on Gasification

Parameters		
Type of waste	Mixed Combustible Waste	
Suitability (Tonnes/day)	Min: 500 Tonnes	Max: 1000 Tonnes
Area Requirement	Min: 1,50,000 m^2	Max: 3,00,000 m^2
Capital Investment	Min: 7750 Lakhs	Max: 15100 Lakhs
Operational Costs	Min: 465 Lakhs	Max: 906 Lakhs
Energy/Resource Generation	Resource: Syngas/ Power Min: 8.33 MW	Max: 16.67 MW
Production costs	7.20 per unit electricity	
Life Duration	15 Years	
Handling Expertise	Skilled+ Semi Skilled+ Unskilled	
Reduction in Waste Volume	95%	



Case Study on Gasification

Gasification

Pune Municipal Corporation

Processing Capacity: 700 TPD

Electricity Generation: 10 MW per day

Company/Organization/Players: *Pune Municipal Corporation along with ROCHEM Technologies*

Project Details:

The technology is based on Gasification which has a processing capacity of 700 tonnes of MSW per day. The plant is capable of producing 10 MW electricity per day. The plant is set up on DBOOT basis between Pune Municipal Corporation and ROCHEM Technologies Private Limited.

The space requirement for the plant is about 10,000 Sq. metres Currently the plant is producing 0.78 MW to 1 MW of power per day by processing around 250 metric tonne of waste per day. It is consumed within plant. Commercialization is proposed.

3.2.5 Refuse Derived Fuel

Refuse Derived Fuel (RDF)

RDF typically consists of the residual dry combustible fraction of the MSW including paper, textile, rags, leather, rubber, non-recyclable plastic, jute, multilayered packaging and other compound packaging, cellophane, thermocol, melamine, coconut shells, and other high calorific fractions of MSW.

The suitability of RDF for use as a fuel or resource is dependent on certain parameters of the constituent waste:

- Calorific value;
- Water content;
- Ash content;
- Sulphur content; and
- Chlorine content.

The required specific composition and characteristics of RDF for fuel or co-processing will be determined by the kind of boiler/furnace, temperatures achieved in the furnace, and the associated flue gas management systems.

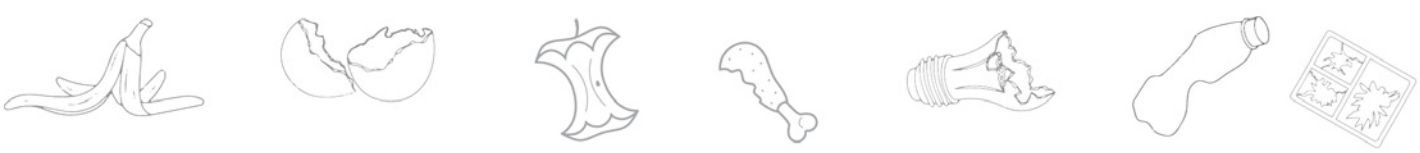
Environmental Concerns

Landfill (whether there is a need of landfill for the technology/process)	**Emissions** (Whether the technology/process is associated with emitting gases)	**Effluent** (Whether the technology /Process generates effluents)
Yes	No	No

Process Description:

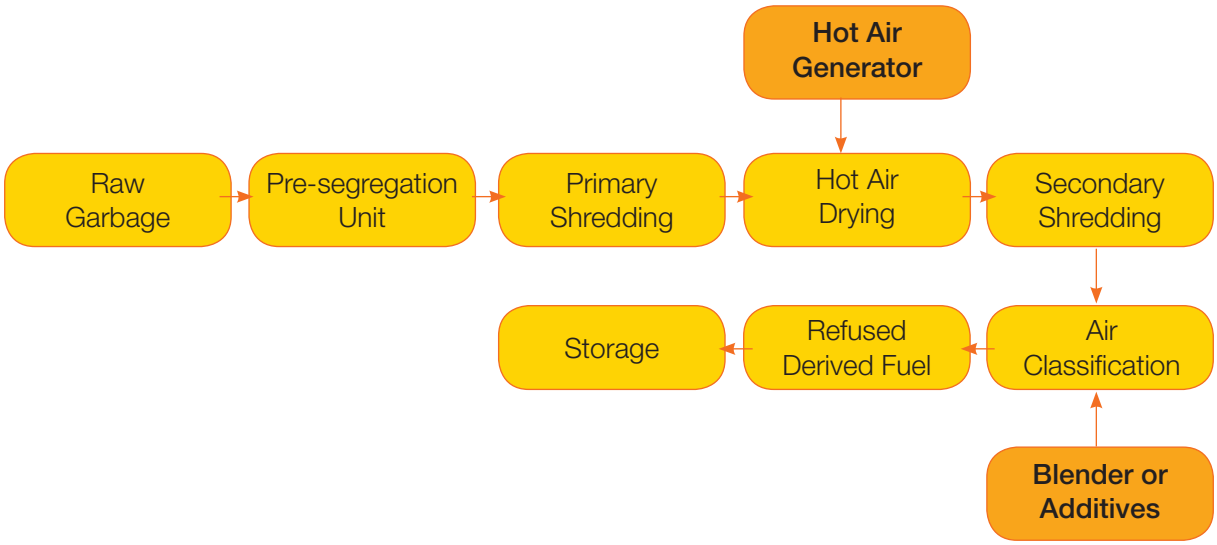
The RDF production line consists of several unit operations in series to separate unwanted components and condition the combustible matter to obtain required RDF characteristics. In general, segregation and processing may include:

1. Sorting or mechanical separation
2. Size reduction (shredding, chipping, and milling);
3. Drying (where required);
4. Separation;
5. Screening;



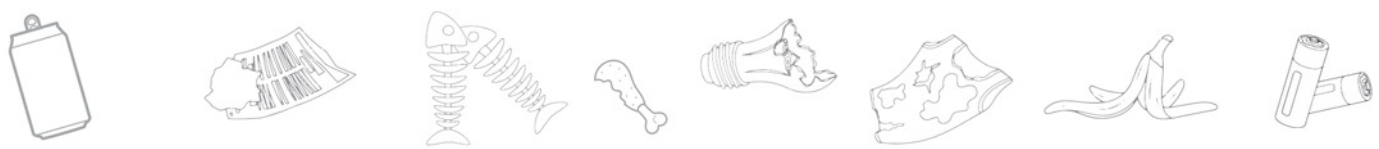
6. Air density separation (for removing fine inert material);
7. Blending;
8. Packaging; and
9. Storage

The type and configuration of unit operations required depend on the end use of the RDF determines the necessary characteristics of RDF (size, moisture, ash content, calorific value, chloride, heavy metals, etc.)



Important Points for RDF

Parameters			
Type of waste	Mixed Combustible Waste		
Suitability (Tonnes/day)	Min: 0.50		Max: 150.00
Area Requirement	Min: 100m^2		Max: 1000m^2
Capital Investment	Min: 15.0Lac		Max: 15.0Cr
Operational Costs	Min: 3.50Lac PA		Max: 18.0Lac PA
Energy/Resource Generation	Resource: RDF	Min: 0.25 MTPD	Max: 75.0 MTPD
Production costs	Rs. 2000 TPD		
Life Duration	15 Years		
Handling Expertise	Skilled + Semi Skilled + Unskilled		
Reduction in Waste Volume	50 %		



Case Study on Refuse Derived Fuel

Refuse Derived Fuel

Co-processing of Segregated Plastic Waste An Initiative of Jabalpur Municipal Corporation and ACC–Holcim

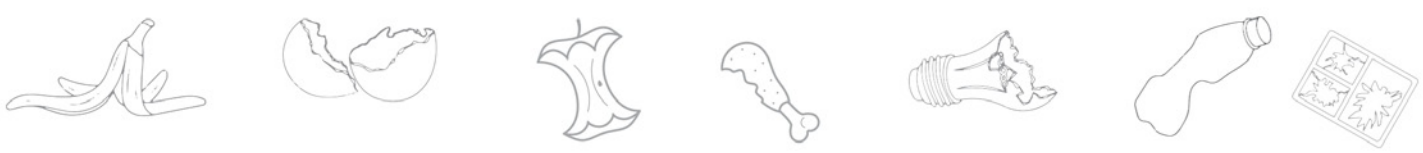
Company/Organization/Players: *Jabalpur Municipal Corporation along with ACC Holcim*

Project Details:

1. Out of 340 tonnes of MSW generated in Jabalpur Municipal limits, 5% was plastic and other combustible fractions (approximately 15–20 tonnes of waste per day), which was sent to the cement plant.
2. JMC introduced door-to-door waste collection service from households in 6–7 colonies as a pilot service wherein waste pickers collect the waste.
3. Self-help groups (SHGs) of over 200 waste pickers were formed for collection and segregation of waste.
4. JMC initiated a process of issuing identification numbers followed by issuing identification cards to the waste collectors or waste pickers to formally integrate them into the system.
5. Non-recyclable fractions of waste—e.g., double coated plastic, torn paper, jute, tetra-packs, thermocol, waste tyres, etc.—were segregated and transported to cement plants.
6. Until 2013, ACC–Kymore Cement Works had successfully co-processed 1,622 tonnes of segregated waste, and the initiative is being replicated in other locations as well.

To demonstrate the co-processing methodology, ACC had conducted co-processing trial of plastic waste at Kymore Cement Works plant, with support from CPCB and MPPCB. The results of the trial run demonstrated that there are no negative influences of the stack emissions on product quality. The presence of high temperature and long residence time of the kiln ensures complete destruction, thus making co-processing in cement kiln a safer and greener way of management of segregated plastic waste.

Considering the importance and benefits of the co-processing technology and based on the experience of various successful trial runs for hazardous and non-hazardous waste across the country, CPCB formulated the “Guidelines on Co-processing in Cement or Power or Steel Industry.” In these guidelines, CPCB has included plastic as a nonhazardous fraction that can be co-processed.



3.3 PLASTICS WASTE MANAGEMENT

3.3.1 Environmental Issues and Challenges

The quantum of solid waste is ever increasing due to increase in population, developmental activities, changes in life style, and socio-economic conditions. Plastic garbage is seen littered all over the country and has started causing several problems. Plastic waste clogs drains, causing floods. It chokes animals which eat plastic bags, etc. Plastics found in fields blocks germination and prevents rainwater absorption

Plastics waste is a significant portion of the total municipal solid waste (MSW). It is estimated that approximately 14 thousand tonnes per day (TPD) of plastics waste is generated i.e. approx. 9% of about 1.50 lacs TPD of MSW in the country.

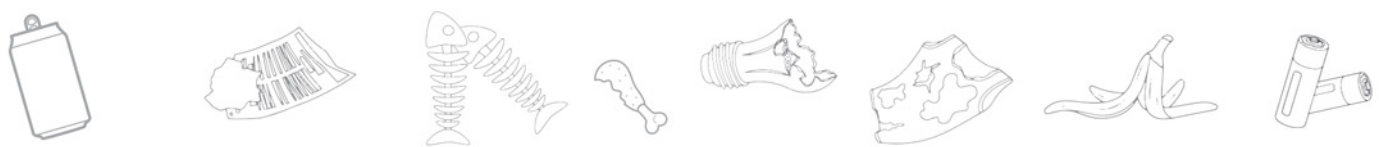
The plastics waste constitutes two major categories of plastics; (i) Thermoplastics and (ii) Thermoset plastics. Thermoplastics, constitutes 80% and thermoset constitutes approximately 20% of total post-consumer plastics waste generated in India. Thin plastic waste is the biggest problem and its economic use needs to be explored to reduce the menace.

3.3.2 Processing Disposal Pattern of Plastics Wastes

1) As Refuse Derived Fuel (RDF) for co-processing along with coal in Thermal and Cement Industries and
2) As a limited substitute for Bitumen in road construction

Plastic garbage that litters the country like carry bags, chip bags, chocolate bar wrappers, plastic bags, bottles, lids, etc. can be shredded and added as a limited substitute for bitumen in road construction. This method makes plastic waste a useful substitute in construction, simple and cost effective.

A Government order in November 2015 has made it mandatory for all road developers in the country to use. Same amount of waste plastic, along with bituminous mixes, for road construction. This is to help overcome the growing problem of plastic waste disposal in India.



3.3.3 Process of using Plastic Waste in Road Construction

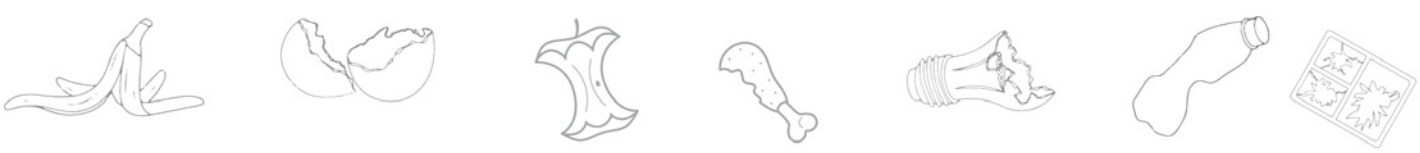
The process is to first shred the plastic wastes to a particular size using a shredding machine. The aggregate mix is heated at 165°c and transferred to the mixing chamber and the bitumen is heated to 160°c to result in good binding. It is important to monitor the temperature during heating.

The process is easy and does not need any new machinery. For every kilo of stone, 50gms of bitumen is used and 1/10th of this can be plastic waste reducing the amount of bitumen being used. Plastic increases the aggregate impact value and improves the wear and tear quality of flexible pavements. These roads have better resistance towards rain water and cold weather. Apart from this process, additional job for rag pickers can be generated.

“Constructing roads from polythene” is a new project that the Himachal Pradesh government has embarked on to rid the state of polythene menace. After the use of polythene was banned in the state last year, there have been huge stocks in the state, which the government decided to utilize for metaling the roads. The proposal envisages metaling more than 250 km long roads in six zones of the state. After a successful experiment in Nurpur district, the task is in progress in Shimla for the road connecting the city to the airport, a distance of 15 km.

The state under the scheme would purchase plastic waste at Rs3/- per kg with an additional rupee as handling charges. The State Government would extend fiscal incentives to panchayats, urban bodies and individuals for contributing towards proper collection of waste plastic in their respective areas. Out of 1200 to 1500 tonnes of solid waste collected during the first phase of campaign, 50 to 60 tonnes contained plastic waste which would be used in the metaling of roads.

The use of plastic in roads has also become a source of earning for rag pickers: Rs. 12/- per kg per day. This can go up to Rs. 14/- per kg for 5-10 kg and Rs.16/- per kg for quantity exceeding Rs. 10/- kg of plastic. The PWD would bill Rs. 2/- extra, Re. 1/- as handling charges and another rupee to be utilized for the welfare of rag pickers and waste workers by providing them boots, masks, gloves, free medicines and an insurance cover of Rs. 2 lakh in case of any eventuality.



Case Study on Plastics to Construction

Use of plastic waste in bituminous mixes in construction of National Highways and Roads

Company/Organization/Players: *Shimla, Himachal Pradesh*

Project Details:

Plastic waste is cut into a size between 2.36 mm and 4.75mm using shredding machine. Bitumen is heated to 160°C , to prevent weak bonding. At the mixing chamber the shredded plastic waste is added to the hot aggregate. It gets coated uniformly within 30 seconds. Hot bitumen is then added over the plastic-coated aggregate and the resulting mix is used for road construction. The road-laying temperature is between 110°C and 120 °C

The Himachal Pradesh State Pollution Control Board in collaboration with the Public Works Department (PWD) has built three road stretches on a pilot basis by using shredded plastic waste on the outskirts of Shimla.

“The results have been good in the past four months as there has been no stripping or any other major damage to the roads laid by using plastic-asphalt mix. Of course, the plastic blend not only helps lowering the cost of tarring but also enhances the durability of roads because of higher binding strength of plastic,” PWD Superintending Engineer said. “The plastic waste replaces 10 to 15 per cent of the bitumen and thus saves approximately Rs. 35,000 to Rs. 45,000 per km of a road stretch,” he added.

3.4 CONSTRUCTION AND DEMOLITION WASTE

With the growing generation of construction and demolition waste, the Government of India has deemed it appropriate to formulate a separate regulation for construction and demolition waste namely Construction and Demolition Waste Rules 2016 describing the roles and responsibilities of the different stakeholders as well as the compliance criteria for the management of the construction and demolition waste.

Construction and demolition waste means "the waste comprising of building materials, debris and rubble resulting from construction, remodeling, repair and demolition of any civil structure".
C&D waste includes bricks, tiles, stone, soil, rubble, plaster, drywall or gypsum board, wood, plumbing fixtures, non-hazardous insulating material, plastics, wall paper, glass, metal (e.g., steel, aluminum), asphalt, etc. However, C&D waste does not include any hazardous waste as defined under the Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016.

3.4.1 SWM Rules 2016: Provision on Construction and Demolition Waste

Clause 4: Duties of waste generators:-

(c) Store separately construction and demolition waste, as and when generated, in his own premises and shall dispose of as per the Construction and Demolition Waste Management Rules, 2016;

Clause 15: Duties and responsibilities of local authorities:-

(s) Transport construction and demolition waste as per the provisions of the Construction and Demolition Waste management Rules, 2016;

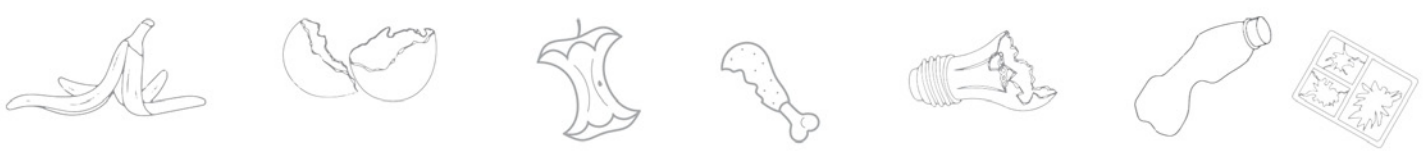
3.4.2 Benefits of Processing of C&D Waste

- C&D waste can be put to profitable use, given the scarcity of sand and stone for construction, thereby saving natural resources.
- It prevents public nuisance and traffic congestion issues arising from indiscriminate dumping of C&D waste.
- It saves valuable space at landfill sites.
- It reduces cost of bulk transportation if recycled near to source of generation.

3.4.3 Uses of Processed Construction and Demolition Waste

The use of the processed construction and demolition waste has been described below, primarily as mixed aggregates or recycled aggregates (RA) and as recycled concrete aggregates (RCA):

(i) Recycled aggregate (RA) may be used in making concrete for nonstructural purposes. The extent of use would be limited to non-load bearing structures only, provided the conditions mentioned below at point no.(ii) is complied with. Examples of use – wall between two RCC load bearing members, filling walls between RCC frame, non-industrial flooring, etc.



(ii) The RA shall be free from deleterious material, such as, organic content, vegetable matter, coal, clay lumps, external substances and soft fragments like pieces of plastics, paper etc. RA shall also be free from chemicals detrimental for the strength or durability of concrete or steel reinforcement such as chlorides, etc.

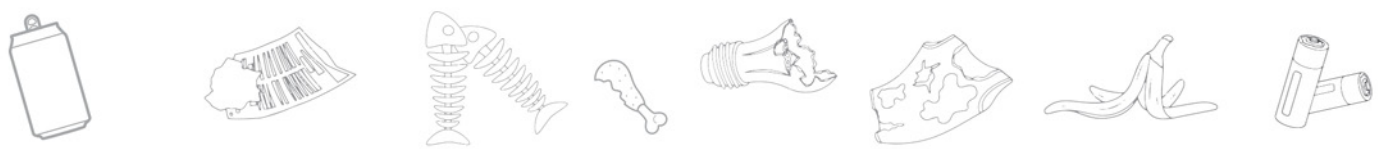
(iii) Percentage of replacement of natural aggregates by RA can be up to 20% for any type of plain concrete work. The percentage can be increased up to 30% for road sub-base / base / other road related applications except wearing course. However, this shall be backed up by laboratory test reports.

(iv) RA of appropriate quality (as mentioned above) can be used for various purposes, such as, in making kerb stones, paving blocks, concrete blocks and bricks, road sub-base, pathways for pedestrian use, rural roads (used for walking and bicycles) etc. However, it has to be ensured that the existing norms for strength (such as, M20, M25 etc.) are complied with for desired application.

(v) Recycled concrete aggregate (RCA) can be used in all grades of PCC (non-structural and structural).

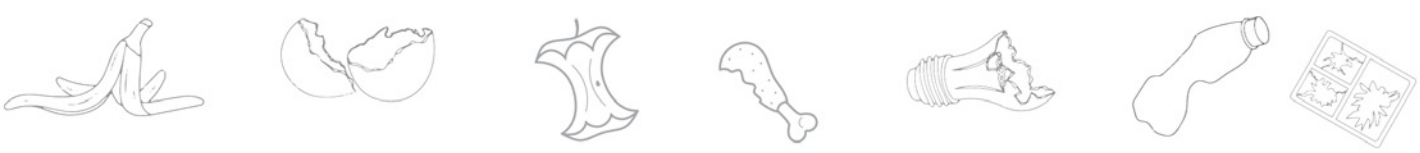
(vi) Recycled concrete aggregates have to be pre-wetted near to SSD (saturated surface dry) conditions before use to avoid rapid slump loss due to its high water absorption rate. Admixtures with better slump retention effect would be useful.

(vii) Fine washed aggregates in the range of 4.75 mm to 0.075 mm (75 μ) separated from C&D waste using 'wet' process may be used as 'manufactured sand' for non-load bearing structures.



3.4.4 Construction and Demolition Waste and Their Reuse Potential

Material	Process	End Use
Demolition Waste	Crushed and sorted	Recycled Aggregate
Construction Waste	Washed to remove cement and recover aggregate	Recycled Aggregate
Reinforced Concrete	Crushed sorted and steel bar removed Steel recycled	Crushed, sorted aggregate For recycling
Clay bricks and roof tiles	Cleaned Crushed and Sorted Pulverized	Reused for masonry Aggregate Mixed with lime to produce mortar
Calcium silicate bricks	Cleaned Crushed Pulverized	Reused for masonry Aggregate Recycled into new calcium silicate bricks
Natural stone masonry	Cleaned Crushed	Reused for masonry Aggregate
Natural stone slabs	Clean Crushed	Flooring, cladding Aggregate
Ceramic tiles	Cleaned Crushed	Flooring, cladding Aggregate
Asphalt Paving	Crushed and Cold Mixed Crushed and hot mixed	Road construction excluding wearing course
Mixed Demolition waste	Crushed	Fill material
Steel	Cleaned Recycled	Reused Steel Components New Steel Components
Aluminum	Cleaned Recycled	Aluminum recycling streams
Timber beams, doors	Cleaned	Reused as beams, doors etc
Timber boards	Cleaned	Reused as shuttering and other products Feedback for engineered woods
Plastics	Recycled	Plastic Recycling systems
Gypsum Plasterboard	Cleaned Crushed Recycled	Reuse as boards Soil Conditioner New Gypsum Products
Glass	Cleaned Crushed Recycled	Glass Recycling Streams



Case Study on Plastics to Construction

Construction and Demolition Waste Processing

Crushing units at Burari C&D waste recycling plant

Company/Organization/Players: *North Delhi Municipal Corporation along with IL&FS*

Project Details:

North Delhi Municipal Corporation's (NDMC) Standing Committee approved the waste collection contract with IL&FS till 2019 and sanctioned Rs. 23 crore for the expenditure on transporting the materials to the plant. Though the plant was set up with 500 tonnes per day (TPD) capacity, it has since been expanded to 2,000 TPD.

The unit gets mixed waste from 28 designated points in three zones of the North Delhi Municipal Corporation.

Process:

The waste is segregated into big concrete pieces, mixed C&D waste as per size and unrecyclable materials like plastic and wood, which are sent to a waste-to-energy plant in Okhla. The plant uses manual segregation for bigger plastic pieces as well as a magnetic separator for metallic objects.
The waste is crushed, washed and used to make ready-mix concrete, kerb stones, cement bricks, pavement blocks, hollow bricks and manufactured sand. A committee set up to look into BIS regulations is likely to include C&D aggregate in its policy within a few months. Once the aggregate is allowed, the end-products will be used by government departments and larger builders.

3.5 LANDFILL

3.5.1 SWM 2016 Provision on Landfills

- Clause 15: Duties and responsibilities of local authorities:- (section zh, zi, zj, zk)
- Clause 20: Criteria and actions to be taken for solid waste management in hilly areas: (Section a, b)

3.5.2 Types of Municipal Solid Waste to be accepted at landfills

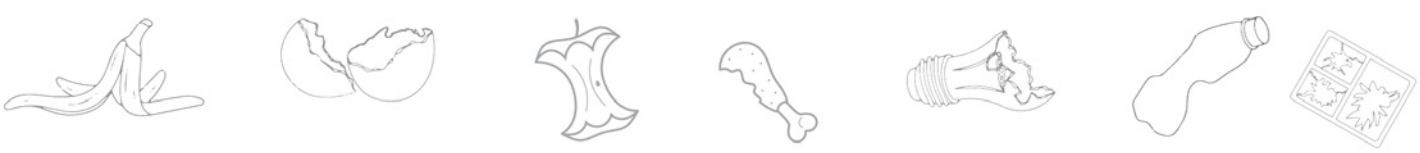
Waste categories suitable for sanitary landfills are the following:
i) Non-biodegradable and inert waste by nature or through pretreatment;
ii. Commingled waste (mixed waste) not found suitable for waste processing;
iii. Pre-processing and post-processing rejects from waste processing sites; and
iv. Non-hazardous waste not being processed or recycled.

Sanitary landfilling is banned for the following waste streams in the municipal solid waste (MSW):

(i) Biodegradable waste or garden waste,
(ii) Dry recyclables, and
(iii) Hazardous waste or industrial waste (to be disposed in hazardous waste sites with special containment).

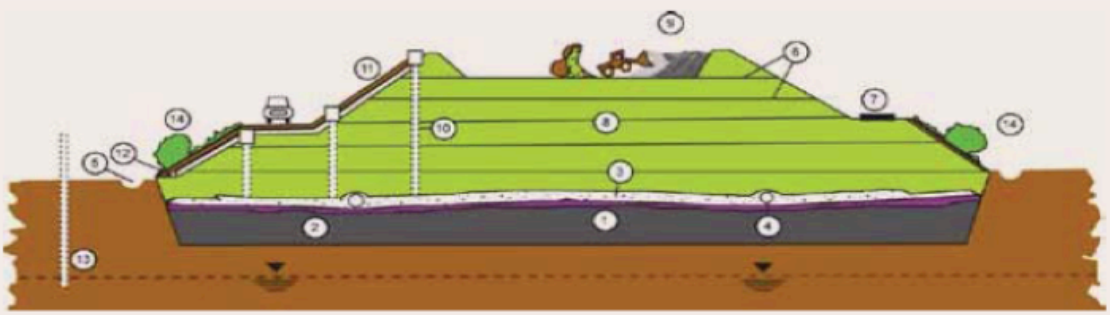
Ideally, nothing should go to a landfill. However after treating and processing waste, process rejects and inerts will need final disposal unless reused. Only about 10-20% of waste which is inert in nature should be landfilled.

For ensuring such efficiency, the sanitary landfill should be operated as a separate economic entity, operating on a fee for landfilling otherwise crude landfilling/dumping will continue.



3.5.3 Essential Components of Municipal Sanitary Landfill

The figure below illustrated the essential components of municipal sanitary landfill which includes:



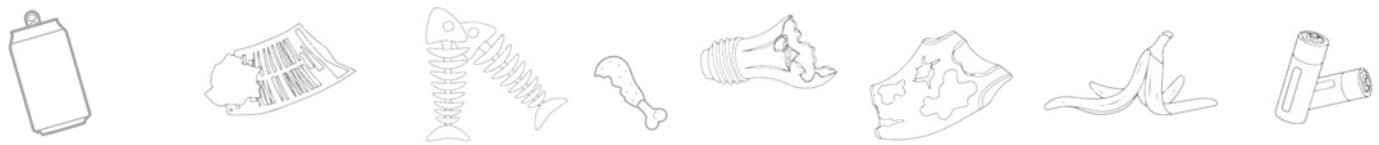
1. Geological barrier
2. Impermeable base liner
3. Drainage layer
4. Leachate collection system
5. Storm - water drain ditch
6. Bordering dams
7. Circulation roads
8. Landfill body
9. Filling and compacting in layers
10. Gas venting system
11. Protective cover system
12. Gas collectors
13. Groundwater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

- a liner system at the base and sides which prevents migration of leachate or gas to the surrounding soil;
- a leachate collection and treatment facility which collects leachate from within and from the base of the sanitary landfill and then treats the leachate;
- a gas collection and control facility (optional for small sanitary landfills) which collects and extracts gas from within and from the top of the sanitary landfill and then treats it or uses it for energy recovery;
- a final cover system at the top of the sanitary landfill which enhances surface drainage, prevents infiltrating water, and supports surface vegetation;
- a surface water drainage system which collects and removes all surface runoff from the sanitary landfill site;
- an environmental monitoring system which periodically collects and analyses air, surface water, soil, gas, and groundwater samples around the sanitary landfill site; and
- Closure and post-closure plan which lists the steps that must be taken to close and secure a sanitary landfill site once the filling operation has been completed and the activities for long-term monitoring and operation and maintenance (O&M) of the completed sanitary landfill are functional.

3.5.4 Planning and Design of a Landfill

Steps for designing, implementation and operation of a Sanitary Landfill are:

1. Site selection,
2. Sanitary landfill design,
3. Construction of a sanitary landfill,
4. Sanitary landfill operation, and
5. Closure and post-closure plan.



3.5.5 Criteria for Identifying Suitable Land for Sanitary Landfill Sites

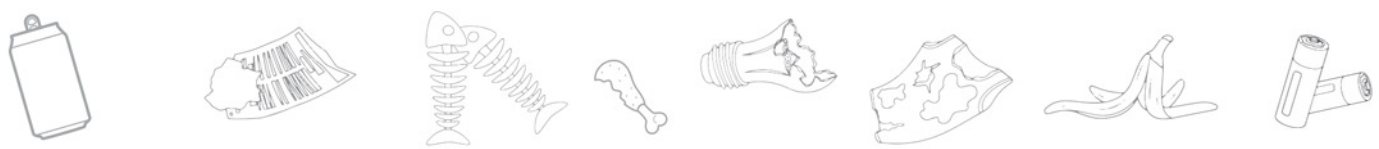
S. No	Place	Minimum Siting Distance
1	Coastal regulation, wetland, critical habitat areas, sensitive eco-fragile areas, and flood plains as recorded for the last 100 years	Sanitary landfill site not permitted within these identified areas
2	Rivers	100 meters (m) away from flood plain
3	Ponds, lakes, water bodies	200 m
4	Non-meandering water channel (Canal, drainage, etc.,)	30 m
5	Highway or railway line, water supply wells	500 m from center line
6	Habitation	All landfill facilities; 500 m
7	Earthquake zone	500 m from fault line fracture
8	Flood prone area	Sanitary landfill site is not permitted
9	Water table (highest level)	The bottom liner of the landfill should be above 2 m from the highest water table
10	Airport	20 Km

3.5.6 Preliminary guidance for Sanitary Landfill Sizes

Waste Quantity (tonnes per design life of landfill)		Required Site Area (HA)
In million	In lakhs	
< 1.0	< 10	15-20
1.0-2.0	10-20	20-30
2.0-3.0	20-30	30-40
3.0	>30	>40

3.5.7 Staff Requirement for Landfill Operations

Functions	Responsibilities	Experience	Nos
Landfill Manager	• Waste Filling • Compliance with operation manual and filling plans • Daily personnel training • Supervision of weighbridge operator or controller • Keeping of customers contact • Adherence of safety rules	Civil Engineering Technician Training in safety matters Training in Environmental issues Knowledge of environmental legislation	1
Weighbridge operator and controller	• Control and record of incoming waste • Operating the weighbridge • Directing vehicles towards disposal area • Visual monitoring of delivered waste other than municipal waste	Administration competencies Training in environmental issues Knowledge of environmental legislation	2
Night Watchman	• Site security especially during night time	Training in safety matters	3
Foreman	• Waste filling procedures • Daily personnel and equipment planning • Control of landfill compaction • Cell construction • Road construction and condition of roads	Training foreman with long time experience in construction works Training in safety matters	4
Spotter	• Traffic regulations in the filling area and organization of waste disposal • Checking of unloaded waste	Special training in filling procedures Training in distinction of different waste and of acceptable or unacceptable waste Basic Training in safety	5



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CRITERIA FOR SELECTION OF TECHNOLOGIES

TREATMENT OPTIONS BASED ON POPULATION

Population	Waste Quantity (TPD)	Treatment Option	Cost in Rs. Lakhs	Products
15,000-50,000	3-10	Bio-Methanation & Conventional Composting	Rs. 20 Lakhs/ Tonne	Bio-gas & manure
		Vermi Composting	Rs. 8 Lakhs/ Tonne	Compost
		Conventional Composting	Rs. 10 Lakhs/ Tonne	Compost
50,000-1,00,000	10-20	Bio-Methanation & Conventional Composting/ Vermi Composting	Rs. 10 Lakhs/ Tonne	Bio-Gas & Compost
1,00,000-10,00,000	20-350	Integrated waste processing – Bio-methanation/ Compost/RDF	Rs. 400 Lakhs/ 100 Tonne	Bio-Gas Compost & RDF
10,00,000-2,00,00,000	350- 8,000	Integrated waste processing – Bio-methanation/ compost/ RDF/ WtE	-Rs1500-2000 Lakhs/100 MT	Bio-Gas, Compost, RDF & Electricity

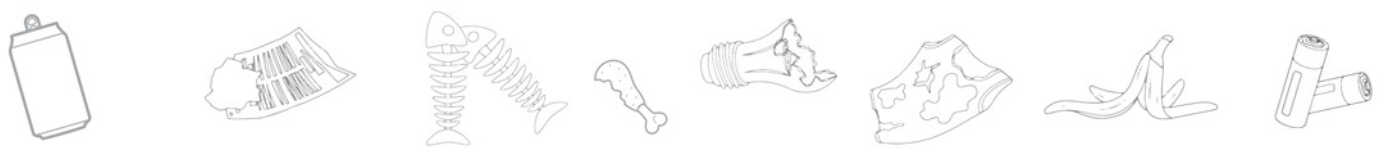
Source: The Report of Task Force on Waste to Energy, Planning Commission, 2014

SUMMARY FOR DIFFERENT COMPOSTING TECHNOLOGIES

Parameters	Windrow	Aerated Static Pile	In-Vessel	Vermi-Composting
Applicable Population Size (PE)	Above 1 Lakhs-10 Lakhs	Above 1 Lakhs-10 Lakhs	Above 1 Lakhs-5 Lakhs	Less than 1 Lakhs
General	Simple Technology	Simple Technology	For commercial use	Suitable for quantities less than 25 TPD generation of mixed MSW
Time	8 Weeks	5 Weeks	3 weeks	8 Weeks
Financial Implication	Moderate	Costly	Very Costly	Moderate

INDICATIVE CRITERIA FOR SELECTION OF APPROPRIATE TECHNOLOGY FOR TREATING WET WASTE

Criteria	Windrow Composting	Vermi Composting	Biomethanation
Applicable with Population Size	Above 1 Lakh	Between 5,000 to 1 Lakh	Small scale – between 5,000 to 25,000 PE Can be extended to Large scale
Facility Location	Plant should be located at least one km away from habitation, if it is open windrow composting. The distance could be 500m in case of covered plants.	Within the residential area (with appropriate environmental safe guards)	Plant should be located at least 500 m away from residential areas, for plant sizes upto 500 TPD.
Land Requirement	High	High	Moderate
Requirement for Segregation prior to technology	High	Very High	Very High
Rejects	About 30% including inert if only composting is done	About 30% including inert	About 30% from mixed Waste
Technology Maturity	well established	Community scale projects are successful	Not suitable for mixed waste
Market for Byproduct/ End Product	Quality compost compliant with FCO 2009 has a good market.	Good market potential for compost in Urban and Rural areas.	The technology is not fully explored, though it has a potential to generate energy as well as digested sludge manure.
Labour Requirement	Labour intensive	Labour intensive	Less Labour intensive

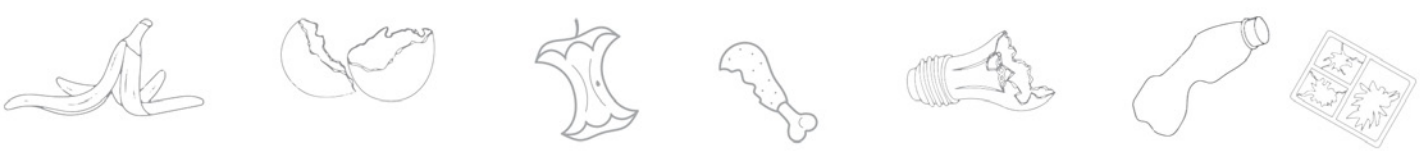


INDICATIVE CRITERIA FOR SELECTION OF RDF TECHNOLOGY

Applicable with Population Size	Above 5 Lakhs, ULB can go for Cluster approach
Facility Location	Plant should be located at least 500 m away from residential areas.
Land Requirement	Low to Moderate (For 300 TPD of MSW: 2 ha of land is required)
Requirement for Segregation	High
Rejects	Around 30% from mixed waste
Technology Maturity	Quality of RDF should be based on end use. Rules regulating characteristics of RDF and guidelines for appropriate use not prescribed by concerned authority.
Market for Byproduct/ End Product	Good market potential for RDF. In small cities, RDF plants only become feeders of RDF to large RDF based power plants and cement plants.
Labour Requirement	Labour intensive (based on current practice)

INDICATIVE CRITERIA FOR SELECTION OF SELECTING WTE TECHNOLOGY

Applicable with Population Size	More than 10 Lakh
Facility Location	Plant should be located at least 1 Km away from residential areas.
Land Requirement	Low
Requirement for Segregation	High – Feed stock should be free from inert and low on moisture Content
Rejects	Around 10-15%
Technology Maturity	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
Market for Byproduct/ End Product	Good potential of energy generation if power purchase agreements are made reflecting true cost of production including O&M costs
Indicative Capital Requirement	Very High capital, operating and maintenance costs.
Labour Requirement	not labour intensive but Requires considerable technical capacity,



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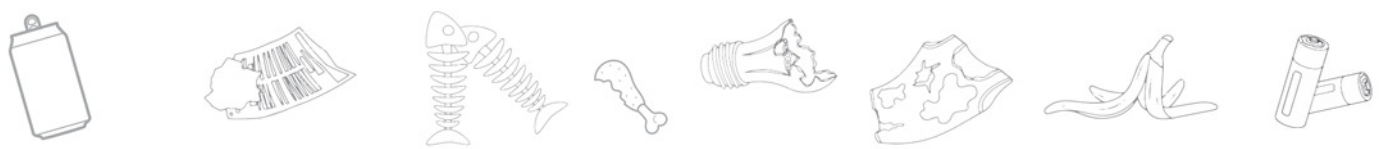
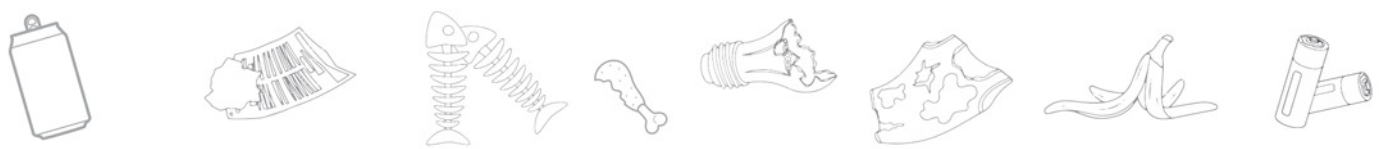
COMPARATIVE ANALYSIS OF THE FINANCIAL FEASIBILITY OF ALL PROCESSES

Sr.	Name of the Technologies	Comparison							
		Suitability (Tonnes/day)		Area (m2)		CAPEX (Rs.in Lacs)		OPEX (Rs.in Lacs)	
1)	Bio-chemical Waste to Compost	Min.	Max.	Min.	Max.	Min.	Max.	Min. (PA)	Max. (PA)
1.1	Vermi Composting	0.10	2.00	100	2500	0.25	2.50	1.80	16.80
1.2	In-vessel Composting (drum)	0.50	5.00	200	500	2.50	60.00	2.16	9.00
1.3	Mechanized Composting (Organic Composter)	0.10	5.00	100	1000	3.00	90.00	2.00	18.00
1.4	Windrow Composting	50.00	1000.00	12141	60705	650.00	5500.00	70.00	250.00
1.5	Pit Composting	0.10	2.00	100	2500	0.25	3.00	1.86	3.00
1.6	Bio-Slurry Compost (Bio-fertilizer)	0.50	10.00	300	1500	12.00	250.00	5.40	12.60
1.7	Stack Composting	0.10	10.00	300	1000	2.50	11.00	1.80	5.50
2)	Waste to Energy (Thermal Technologies)	Min.	Max.	Min.	Max.	Min.	Max.	Min. (PA)	Max. (PA)
2.1	Direct Combustion (Mass Burn and RDF)	300.00	2000.00	90000	600000	4350.00	29000.00	261.00	1740.00
2.2	Pyrolysis	Under development for Municipal Waste							
2.3	Conventional Gasification	Under development for Municipal Waste							
2.4	Biomethanation / Biogas	0.50	300.00	350	37000	15.00	9000.00	1.50	90.00



Sr.	Name of the Technologies	Comparison				
		Type of Waste	Energy/ Resource Generation (Tonne or MW Per Day)			Production Cost (Per Tonne or Kwh)
1)	Bio-chemical Waste to Compost	Intake/ Process	Resource Output	Min.	Max.	Per Unit
1.1	Vermi Composting	Organic Waste	Compost	0.04	0.80	5000.00
1.2	In-vessel Composting (drum)	Organic Waste	Compost	0.15	1.50	1700.00
1.3	Mechanized Composting (Organic Composter)	Organic Waste	Compost	0.15	1.50	1500.00
1.4	Windrow Composting	Organic Waste	Compost	7.50	175.00	1500.00
1.5	Pit Composting	Organic Waste	Compost	0.04	0.80	1050.00
1.6	Bio-Slurry Compost (Bio-fertilizer)	Organic Waste	Compost	0.10	2.00	1750.00
1.7	Stack Composting	Organic Waste	Compost	0.04	3.50	1800.00
2)	Waste to Energy (Thermal Technologies)	Intake/ Process	Resource Output	Min.	Max.	Per Unit
2.1	Direct Combustion (Mass Burn and RDF)	Mixed Combustible Waste	Syn. Gas/ Power	3.06	20.41	4.50
2.2	Pyrolysis	Under development for Municipal Waste				
2.3	Conventional Gasification	Under development for Municipal Waste				
2.4	Biomethanation / Biogas	Organic Waste	Biofuel/ Power	0.02	3.00	4.50

S.No	Name of the Technologies	Comparison					
		Life Duration	Handling Expertize	Reduction in Waste Volume	Environmental Concerns		
		Years	Skill Level	Residue %	Landfill	Emission	Effluent
1)	Biological (bio-chemical) Technology	Years	Skill Level	Residue %	Landfill	Emission	Effluent
1.1	Vermi Composting	15years	Unskilled	40%	N	N	N
1.2	In-vessel Composting	7years	Semi + Unskilled	30%	Y	N	Y
1.3	Mechanized Composting (Organic Waste Convertor)	7years	Semi + Unskilled	30%	Y	N	Y
1.4	Windrow Composting	10years	Skilled + Semi + unskilled	50%	Y	Y	Y
1.5	Pit Composting	15years	Unskilled	40%	Y	N	N
1.6	Bio-Slurry Compost (Bio-fertilizer)	5years	Semi + Unskilled	30%	Y	N	Y
1.7	Stack Composting	10years	Unskilled	40%	Y	N	N
2)	Waste to Energy (Thermal Technologies)	Years	Skill Level	Residue %	Landfill	Emission	Effluent
2.1	Biomethanation / Biogas	10years	Skilled + Semi + unskilled	40%	Y	Y	Y
2.2	Direct Combustion (Mass Burn and RDF)	15years	Skilled + Semi + unskilled	90%	Y	Y	Y
2.3	Conventional Gasification	15years	Skilled + Semi + unskilled	95%	Y	Y	Y
2.4	Pyrolysis	15years	Skilled + Semi + unskilled	95%	Y	Y	Y



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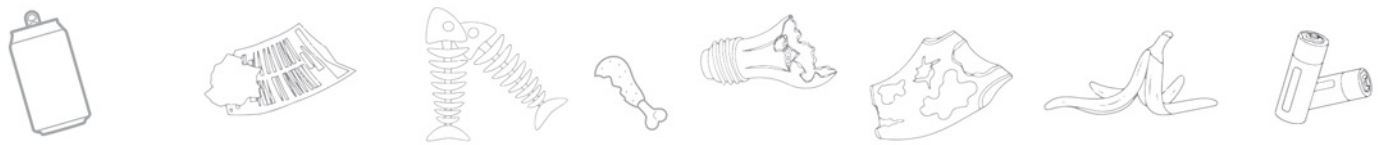
VENDORS FOR MSW MANAGEMENT

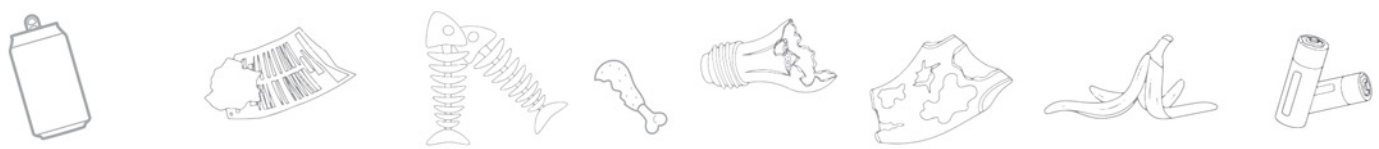
A	DOOR TO DOOR WASTE COLLECTION SERVICES		
S No.	Name of the Company	Contact Person Name & Address	Contact Number & Email Address
1	Antony Waste Handling Cell Pvt. Ltd.	Mr. Jose Jacob, MD Navi Mumbai	Call 9821021475, 27551629 Email: josejacob@antonyasia.com
2	National Cleaning Company	Mr. Mohan Pandey, Country Manager Kuwait	Call 96524767540; 044-42303285 Email: mohan@ncc-kw.com
3	Waste Management Corporation	Mr. Ajay Arora GG-1/1798, Vikaspuri, New Delhi-110018	info@wastemanagementcorp.com; www.wastemanagementcorp.com; +91-11-28543080 +91-9811169618
4	Ramky Enviro Engineers Ltd.	A Ayodhya Ram Reddy, Ramky Grandiose – 12th & 13th Floors, Ramky Towers Complex, Gachibowli, Hyderabad-500 032. Telangana, India.	Phone No. 040-2301 5000 (60 - Lines) 9515104390 E-mail: waste@ramky.com Web: www.ramkyenviroengineers.com arr@ramky.com;
5	A2Z Infraservices Limited	28/142, Ground Floor, West Patel Nagar, New Delhi - 110008 Cosmos Building, B-38, Sector 32, Jharsa Chowk, Gurgaon-122001	Tel: +91-124-4517600 Fax: +91-124-4380014 Email: amit@a2zemail.com; http://a2zgroup.co.in
6	SPML Infra Limited	Mr. Deepak Sethi PML House, Plot No. 65, Sector-32, Gurugram	Email: info@spml.co.in; +91-1243944555; +91124-3983201; deepak@spml.co.in
7	IL&FS Environment	Mr. Shajahan Ali Core 4B, 4th Floor, India Habitat Centre, Lodhi Road, New Delhi – 110 003	Tel No: (011) 2468 2060/81 Fax: (011) 2468 2070/ 71

B	WASTE COLLECTION BINS		
S No.	Name of the Company	Contact Person Name & Address	Contact Number & Email Address
1	Sintex Industries Limited	Sintex Plastics Technology Ltd. Kalol (N. Gujarat) 382 721. India	Phone : +91 – 2764-253000 Fax : +91 – 2764-253100 Phone : +91 – 2764-253500 Fax : +91 – 2764-253800 Email: CC@sintex.co.in
2	Genesis Waste Handling Pvt. Ltd.	Contact Person: Mrs. Priya Tyagi (Manager) Mobile No: 09818190759 Contact Person: Mr. Tippin Tyagi (G. M Sales & Marketing) Mobile No: 09818199759 Manufacturing Address: I 12-16, Gajraula Indl. Area, (U.P.S.I.D.C.), Gajraula II, J.P. Nagar, U.P. 244235	gwh.equip@gmail.com; tippin@genesis-india.co.in; priya@genesis-india.co.in
3	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
4	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
5	Sotkon (Portugal) Indian Recycle & Waste Management Co	Mr. Albert Khan, 35, 1st Floor, Zamrudpur, New Delhi	Call +91-1146565890/ 95/ 9871397147 Email: albert@irwm.in
6	Otto Waste Systems (India) Pvt. Ltd.	No. 201, New India Industrial Estate Off Mahakali Caves Road, Mumbai - 400093, Maharashtra, India	Call+91-9819049947; 022-56754170; 56754171 nitin@ottoasiapac.com



C	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

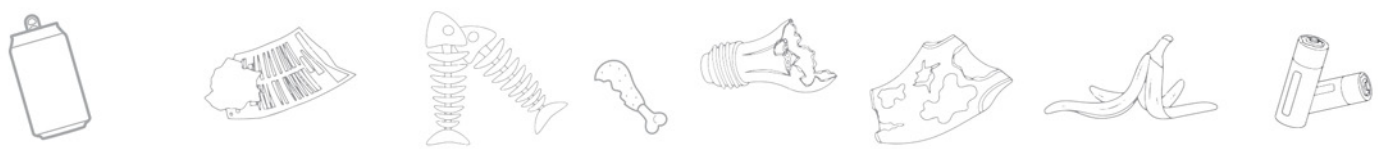
9	Genesis Waste Handling Private Limited	I12-16, Gajraulla Indl. Area, (UPSIDC), Gajraulla II, J.P Nagar, Uttar Pradesh-244235	+919818190759 gwh.equip@gmail.com
10	Green Tech Life	Level II, Prestige Omega, 104 EPIP Zone, Whitefield, Bangalore-560066	+91 9820086532 support@greentechlife.in
11	GSE Lining	223, Gemsstar Commercial Complex, Ramachandran Lane, Extn. Kanchpada, Malad West, Mumbai-400064	022-28440841/42 sudhirr@gseworld.com
12	JCB (JC Bamford Excavators Ltd.)	23/7, Mathura Road, Ballabgarh, Faridabad, Haryana-121004	0129-4299000 delhi.marketing@jcb.com
13	Marvel Globes Industries	Plot No. 954, Gali No. 2, Luxman Vihar, Phase 1, railway Road, Gurgaon, Haryana-122001	+91 9810688683 marvelgloves@gmail.com
14	Navdeep Engineering Private Limited	732, Near Bus Stand Babyal, Ambala cant, Haryana	+91 8071802590 meenakshibajaj33@rediffmail.com
15	SRG International Private Limited	Plot No 13 A, Sector 4, Industrial Area, Faridabad, Haryana-121004	+91 8071803487 srgprefab@gmail.com
16	Usha Engineering	S-70/71, Lodhi Road Industrial Area Mohan nagar, Ghaziabad-201005	0120-2658299 rakesh.sales@ushaengineerings.com



D	WASTE RECYCLING AND SOLID WASTE MANAGEMENT SOLUTION PROVIDERS		
S No.	Name of the Company	Contact Person Name & Address	Contact Number & Email Address
1	Waste Management Corporation	Mr. Ajay Arora GG-1/1798, Vikaspuri, New Delhi-110018	info@wastemanagementcorp.com; www.wastemanagementcorp.com; +91-11-28543080 +91-9811169618
2	Exigo Recycling Private Limited	338, Paras Trade Centre, Gurgaon-Faridabad Road, Gurugram-122002	0124-4046076 sourcing@exigorecycling.com
3	Green Planet Waste	506, 5th Floor, Nipun Tower, Karkardooma Community centre, Vikas Marg Extn, Delhi-110092	011-22375415 info@gpwm.in
4	Jusco Ltd	Sakchi Boulevard Road Northern Town, Jamshedpur-831001	0657-6646000 rajesh.rajan@tatasteel.com
5	Larsen&Toubro	Mount Poonamallee Road, Manapakkam Chennai-89 9th Floor, Ambadeep Building, 14 KG Marg Delhi-110001	044-22526000 ttrs@intecc.com
6	Shivalik Solid Waste management Ltd	Village Majra, Post Office Dabhota, tehsil nalagarh, Distt. Solan, Himachal Pradesh-17401	01795-260427 infosswmlmkt@gmail.com
7	Antony Waste	Flat No.1403, 14th Floor, Dev Corpora Building, Opp. Cadbury Co., Eastern Express Highway, Thane, Maharastra	022-41009295 aaysonpaul@antonyasia.com
8	Bhavani Bioorganics Limited	Manjeera Heights, Phase-1, 401-B, BlockChitra Layout, saroor nagar, Hyderabad, Andhra Pradesh-50074	040-65159369 bhavanibio@gmail.com
9	Eco Wise Waste Management Private Limited	Plot No 14F, Ecotech 3, Greater Noida, Uttar Pradesh-201308	9811177864 naina@ecowise.net.in
10	Go Green Services	Plot No. 54, Sector 40, Gurgaon-122002	+91 8527493144 citizengurgaon1@gmail.com
11	Kanak Resources	4th Floor, Dr. Gopaldas Bhawan, Barakhamba Road, new Delhi-110001	011-49691000 info@kanakresources.com
12	Proton Enviro	F93, DLF Park Place, Golf Cource Road, DLF Phase V, Gurgaon-122001	8800779003 rahul@protonenviro.com

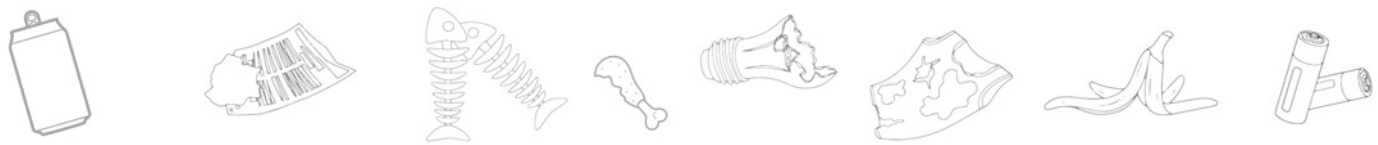
13	Sulabh International	Sulabh Gram, mahavir Enclave, Palam-Dabri Road, New Delhi-110045	011-25031518 info@sulabhinternational.org
14	Daily Dump	1163, 1st Cross, Off 12th Main, Near Sony Centre, HAL 2nd Stage, Bangalore-560008	080-41175311 hello@dailydump.org
15	Extra Carbon	Mr. Gaurav 615, ILD Trade Centre, Sohna Gurgaon Road, Malibu Town, Sector-47, Gurugram-122001	1800-3070-1065 info@extracarbon.com www.extracarbon.com
16	Arise	309, Narain Manzil, 23, Barakhamba Road, Connaught Place, New Delhi	011-45047166/67 corporate@ariseindialtd.com

E	PROVIDERS OF COMPOST PLANT (CENTRALIZED/ DECENTRALIZED) EPC AND O&M		
S No.	**Name of the Company**	**Contact Person Name & Address**	**Contact Number & Email Address**
1	Hyquip Equipment & Services	1-1-564/1/A, Hyquip House, Near Golconda X Roads, Gandhi Nagar, Hyderabad, Telangana 500020	Email: sales@hyquip.com Phone: +91 40 3028 7213
2	Alfa Therm Limited	Mr. Harjot Chadha 6, Community Centre, Mayapuri Industrial Area Phase - I, New Delhi-110064 (INDIA),	Tel : +91-11-28115222, 28116222, 28114748 Fax : +91-11-28115396 Email : alfatherm@vsnl.com
3	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
4	Organic Recycling Systems Pvt. Ltd.	Mr. Suhas Bhand Chairman 501, 5th floor, Lakhani's Centrium, Plot no.27, Sector 15,CBD Belapur Navi Mumbai, 400614	Call 022-41702222; 41702200; +91-7738362733 Email: suhas.bhand@organicrecycling.co.in
5	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



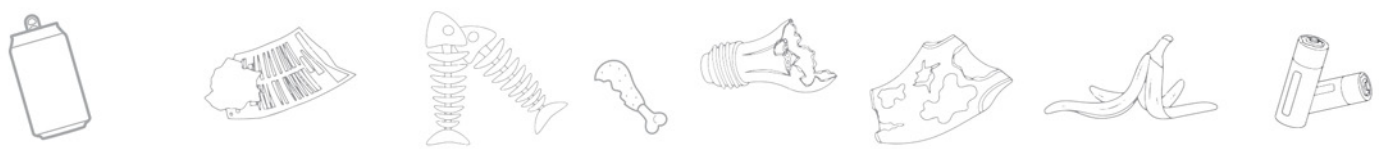
6	Excel Industries Limited	Saurabh Shah, 184-87, S.V. Road, Jogeshwari (West), Mumbai - 400 102, Maharashtra, India.	Email: excel.mumbai@excelind.com Tel.: 91 - 22 - 66464200 Fax: 91 - 22 - 26783657
7	Sisco Projects Private Limited	Mr. S. Santhosh Velmurugan, Manager - Projects 377, Rajaram Salai, K.K.Nagar, Tiruchirappalli - 620 021.	Tele Phone: 431-4044900 (30 lines) Fax: 00-91-431-2456148 Website: www.siscoprojects.com Mobile : 093667 99909 Email:projects@siscoprojects.com
8	Monica Processing Plants	44/D-2 Sanwer Road, Industrial Estate, Indore -452015 INDIA	Phone/Fax: 91-731-2720337 91-731-4023323 E-Mail : info@monicaprocessing.com
9	ZUCI ENERGY PRIVATE LIMITED	GOVINDARAJU SUJEET KUMAR 2-2-185/40/2, Sri Satya Sai Nilayam Apt 202, RK Nagar, Amberpet, Hyderabad TG 500013	Email ID: sujeet.g@zucienergy.in; contact@zucienergy.in; +91-40 65551204
10	HYDROAIR TECTONICS (PCD) LTD,	116, Raheja Arcade, Sector-11, Plot No.61, CBD Belapur, Navi Mumbai, Maharashtra 400 614, India	Phone +91-22-2756 43 47/ 43 48/ 4777, 91-022 27566865 / 41568181 Fax - 91-22-2756 43 64 E-mail : hydroenviro@vsnl.net
11	Daily Dump	1163, 1st Cross, Off 12th Main, Near Sony Centre, HAL 2nd Stage, Bangalore-560008	080-41175311 hello@dailydump.org
12	Green Tech Life	Level II, Prestige Omega, 104 EPIP Zone, Whitefield, Bangalore-560066	09820086532 support@greentechlife.in
13	Earth Care Solutions	Room No. 12/453-7, Deshasneham Buildings, Vadakke Kamath Lane, MG Road, Poothole PO, Trissur, Kerala-680004	+91 8592053562 earthcaresolutions@gmail.com
14	Eco Care Technologies	22/23, Thiyagaraya Road, 11GF-rainbow Arcade, T.Nagar, Chennai-600017	044-26253705 sales@garbodrain.com

15	Green Bandhu Environmental Solutions and Services	H-25/7, DLF Phase 1, Haryana, Gurugram-122002	+91 9818167932 greenbandhu@gmail.com
16	Ecoman Enviro Solutions	Flat No. 19, 4th Floor, Kinadn park, Behind Hardikar Hospital, Shivaji Nagar, Pune-411005	020-32535122 feedback@ecomanenviro.com
17	Orbin	701, Brigade Rubix, 20, HMT Main Road, Yeswanthpur, Bangalore-560013	+91 7259404888 contact@orbin.in
18	Myco Compost	Shivam-149/3, House No. 894/1, Ganesh nagar, Opposite Solapur, Janata Sahkari bank, Dhyari Pune, Maharastra-411041	+91 9604046983 koustubhyadre@yahoo.com
19	Reddo Natura	No. 3555, 2nd Floor, 13th H Main, 3rd Cross, Doopanahalli, Indiranagar, Bengaluru-560038	+91 8892973952 tvsbhat23@gmail.com
20	Scope Unlimited	Kunal Kapre (Founder) G-72, Sector 6, Noida, Uttar Pradesh-201301	+91 8071807128 scopeunlimited@live.in
21	Vivesty Green	F-6, 49/1380, N.M Complex, C.H Cross Road, West Nadakkavu, Calicut-673011	green@vivesty.com



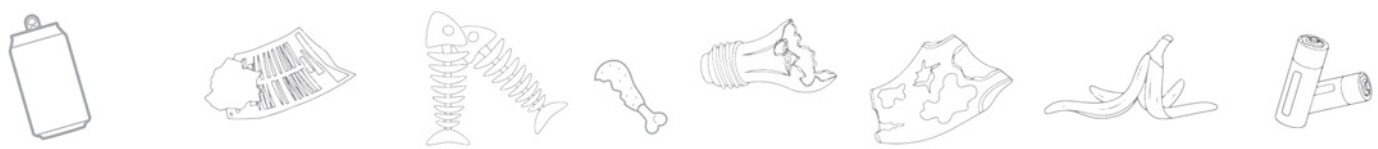
F	PROVIDERS OF WASTE TO BIO-GAS		
S No.	Name of the Company	Contact Person Name & Address	Contact Number & Email Address
1	Waste Management Corporation	Mr. Ajay Arora GG-1/1798, Vikaspuri, New Delhi-110018	info@wastemanagementcorp.com; www.wastemanagementcorp.com; +91-11-28543080 +91-9811169618
2	Aruna Green Ventures Pvt. Ltd.	581, 30th Main, Survey No.17, Kathriguppe, Banashankari III Stage, Near Devagowda Petrol Bunk, Bengaluru-560085	+91-8861035555, 8861075555; Email: greeneria@arunagreen.com; www.arunagreen.com
3	FRD Biomec Private Limited	Building No. 12/503, Opp. Sakthi Automobiles, Nadathara Mannuthy Bypass Road, Near Petrol Bunk, Nadathara, Kerala-680751	+91 8129366300 caajith@yahoo.com
4	Clarke Energy	Plot No. 160 CTS No. 632 Lane No. 4 Dahanukar Colony Kothrud Pune-411038	020-25397167 india@clarke-energy.com
5	Alliance Thermal Engineers	Sector 10, MIDC, Bhosari, Pimpri-Chinchwad, Maharastra-411026	+91 9822430891 alliance.thermal@gmail.com
6	GPS Renewables	22nd B Main Rd, Parangi Palya, Sector 2, HSR layout, Bengaluru, Karnataka-560102	08065690586 info@greenpowersystems.co.in
7	Envitec Biogas India Private Limited	63B, 13th Cross, J.P Nagar, IIIrd Phase, Bangalore-560078	080-26580466 nsmohan@envitec.in
8	Lars Enviro	168, South Ambazari Road, Nelco Society, Subhash Nagar, Bajaj Nagar, Nagpur, Maharastra-440010	0712-2224130 sales@larsenviro.com
9	GGE Power Private Limited	26/24 East Patel Nagar, New Delhi-110008	+91 9311035656 sales@ggepower.com

10	Green Elephant Engineering	13, Kotbagi Hospital Road, Harmony Society, Ward No.8, Wireless Colony, Aundh, Pune, Maharastra-411007	irina@greenelephant.in +91 9845372120
11	Spectrum Bioenergy	Banjara Hills, Hyderabad-500034	040-23281918 drrao@srel.in
12	Perfect Bio-Waste & Power Management Private Limited	B-301, Okhla Industrial Area, Phase-1, New Delhi, Delhi-110020	+91 9311160471 perfectgasgenerators@gmail.com
13	SP Renewable Energy Sources Private Limited	1st Luv-Kush Complex, Dist. Anand, Gujarat-388001	+91 9978764099 cmd@spre.co.in
14	S&S Biofuels Consultants	Plot No-298, K-2, A Ward, F5 Dnyanraj Park, margay Galli, Shivaji Peth, Near Gandhi maidan, Kolhapu, Maharastra-416012	+91 9422046664 ssbiofuels@gmail.com
15	Organic Recycling Systems Pvt. Ltd.	Mr. Suhas Bhand Chairman	Call 022-41702222; 41702200; +91-7738362733 Email: suhas.bhand@organicrecycling.co.in
16	Mailhem Engineers Private Limited	14, Vishranbaug Society, 2nd Floor, Senapati Bapat Road, Opp. International Convention Centre, Pune, Maharastra-411016	020-25532228 info@mailhem-ikos.com
17	Biotech-Renewable Energy	MP Appan Road, Vazhthacaud, Dist. Thiruvananthapuram, Thycaud, Kerala-695014	04712331909 mailtobiotech@gmail.com



G	PROVIDERS OF WASTE TO ENERGY/ FUEL PLANT SETTINGUP AND O&M		
S No.	Name of the Company	Contact Person Name & Address	Contact Number & Email Address
1	Jiangxi Jianglian International Eng. Co. Ltd.	Mr. Andy Huang (Director of Mktg.) Floor 12, CATIC International Square, No. 1, North Ganjiang Rd, Nanchang, Jiangxi-330000	Tel: 86-791-86665899-803; FAX 86-791-86665799 Email: yd6188@126.com; hsq2018@sina.com
2	Hitachi Zosen India Pvt. Ltd.	Mr. K. Sreenivasa Rao, Head Business # 8-2-685/ 1/ 1/ A, 4th Floor, Near Jagannath Temple Road No.12, Banjara Hills, Hyderabad-500034	Mobile: +91-8501009992; 40-23334241; Email: sreenivasarao.k@hz-india.com; s.sankaranarayanan@hz-india.com
3	Concord Blue Technology Ltd.	Mr. Paras Goyal, Group Head	cb@concordblueenergy.com
4	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
5	Neway Engineers MSW Private Limited	Dr. Shiv Kumar A-2, CEEBROS TIRUMALA APARTMENTS, NO:23/36, VENKATRAMAN STREET, T. NAGAR, CHENNAI-600017.	91-44-24571254/ 2254; 7358204888; 7358707333 newaymsw@gmail.com
6	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
7	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
8	BSR Green & New Center Energy	Mr. Sreenivas Reddy B H E L, MIG - 852 RAMACHANDRAPURAM HYDERABAD Telangana - 502032	Call +91-9393925959; 9494925959 ajayarora@bsgreenpower.com; bsrgreenpower@gmail.com
10	JITF Urban Infrastructure, New Delhi	MV Chary Jindal ITF Centre, 28, Shivaji Marg, New Delhi-110015	Deepak.Pandey@jindalecopolis.com; neelesh.gupta@jindalecopolis.com; 9873930842; 9000866626 011-45021983 Info.jindalitf@jindalitf.com
11	Elephant Energy Private Ltd. (EEPL)	Sh. Neeraj Bharati, Director A-1/136, 3rd Floor Safdarjung Enclave NEW DELHI, 110029	Email: info@ElephantEnergy.in; +91 11 404 69801

12	A2Z Waste Management	O-116, First Floor, Shopping Mall, Arjun Marg DLF Phase-1, Gurgaon-122002	0124-4300426 amit@a2zemail.com
13	Abil	Abil House, Plot No. 2. Ganesh Khind Road, Range Hills Corner Pune, Maharastra-411007	020-25578888 info@abilgroup.com
14	GPS Renewable Private Limited	619, 22nd B Main, 21st Cross, Sector 2, HSR Layout, Bengaluru-560102	080-65690586 info@greenpowersystems.co.in
15	Hydroair Tectonics Ltd.	116, Raheja Arcade, Sector-11, Plot No.61, CBD Belapur, Navi Mumbai, Maharastra-400614	022-27564347 hydroenviro@vsnl.net
16	IL&FS India Limited	Plot C22, G Block, Bandra Kurla Complex, Bandra East, Mumbai-400051	022-26533333 info@ilfsindia.com
17	Jain Irrigation Systems	B-30, Shivalik Malviya Nagar, New Delhi-110017	011-26691569 jainnewdelhi@jains.com
18	Ramky Enviro Engineers	Ramki Grandiose-13th Floor, Ramky Tower Complex, Gachibowli, Hyderabad-500032	040-23015000 sksanjiv@ramky.com
19	Selco International	House No. 1-1-336/49, Chikkadpali, Hyderabad-500020	selco@satyam.net.in
20	Zanders Engineers Limited	D-98, Phase 8B, Phase 7, Industrial Area, Sector 74, Sahibzada Ajit Singh Nagar, Punjab-140308	0172-6610661 mohalica@zanders.in

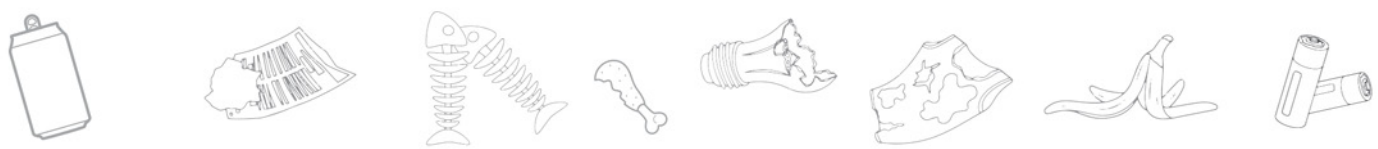


H	LANDFILL EPC VENDORS AND O&M SERVICE PROVIDERS		
S No.	Name of the Company	Contact Person Name & Address	Contact Number & Email Address
1	Detox Corporation	Hiral Desai & Ankit Jani Business Development Detox House, Opp. Gujarat Samachar Press, Udhana Darwaja, Ring Road, Surat-395002	Call +91-261-2351248, 2346181; +91-9924440695; info@detoxcorp.com; info@sepplindia.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	IL&FS Env. Infra & Service Ltd.	Mr. Rabjot Isher Core 4B, 4th Floor, India Habitat Centre, Lodhi Road, New Delhi – 110 003	Call +91-9599106726 rabjot.isher@ilfsindia.com
4	Chennai MSW Private Limited	Mr. RM Rao (National Head)	Call +91-9515114539; 7331175459 Email: cmswpl@gmail.com
5	UPL Environmental Engineers	Mr. Kamlesh Parikh, CEO	info@upeel.com
6	Khilari Infrastructure Private Limited	Mr. Sahebrao Khilari, MD	9820289341; sshillari@yahoo.co.in; ssk.kipl2005@gmail.com

I	DUMPSITE REMEDIATION EPC AND O&M VENDORS		
S No.	Name of the Company	Contact Person Name & Address	Contact Number & Email Address
1	Neway Engineers MSW Private Limited	Dr. Shiv Kumar A-2, CEEBROS TIRUMALA APARTMENTS, NO:23/36, VENKATRAMAN STREET, T. NAGAR, CHENNAI-600017.	91-44-24571254/ 2254; 7358204888; 7358707333 newaymsw@gmail.com
2	Detox Corporation	Hiral Desai & Ankit Jani Business Development Detox House, Opp. Gujarat Samachar Press, Udhana Darwaja, Ring Road, Surat-395002	Call +91-261-2351248, 2346181; +91-9924440695; info@detoxcorp.com; info@sepplindia.com

3	Zigma Global Environ Solutions Pvt. Ltd.	Nagesh Prabhu C, Director & Ajay Arora (Vice President)	Call +91-8220005157; +91-9811169618; nagesh@zigma.in
4	Chennai MSW Private Limited	Mr. RM Rao (National Head)	Call +91-9515114539; 7331175459 Email: cmswpl@gmail.com
5	Ecogreen Energy Private Limited	Ankit Aggarwal, Chief Executive Officer	Call +91-9911181517 & +91-9899660676 ankit@ecogreenenergy.co.in; rupesh@ecogreenenergy.co.in
6	IL&FS Env. Infra & Service Ltd.	Mr. Arun Kr. Sharma Core 4B, 4th Floor, India Habitat Centre, Lodhi Road, New Delhi – 110 003	Call +91-9650410505 rabjot.isher@ilfsindia.com
7	Abellon Clean Energy Ltd.	Aatrey Pandya	Call +91-9099964346; aatrey.pandya@abelloncleanenergy.com
8	De-Syecan Waste Mgmt Pvt. Ltd	Mehul Mistry 507, AURUM, Makrand Desai Road, Bh. Vasna Petrol Pump, Vadodara-390007	Call +91-9067002496; mehul.mistry@desyecan.com

J	CONSTRUCTION & DEMOLITION DEBRIS MANAGEMENT AND DISPOSAL		
S No.	**Name of the Company**	**Contact Person Name & Address**	**Contact Number & Email Address**
1	IL&FS Env. Infra & Service Ltd.	Mr. Rabjot Isher	Call +91-9599106726 rabjot.isher@ilfsindia.com
2	Neway Engineers MSW Private Limited	Dr. Shiv Kumar A-2, CEEBROS TIRUMALA APARTMENTS, NO:23/36, VENKATRAMAN STREET, T. NAGAR, CHENNAI-600017.	91-44-24571254/ 2254; 7358204888; 7358707333 newaymsw@gmail.com
3	Detox Corporation	Hiral Desai & Ankit Jani Business Development Detox House, Opp. Gujarat Samachar Press, Udhana Darwaja, Ring Road, Surat-395002	Call +91-261-2351248, 2346181; +91-9924440695; info@detoxcorp.com; info@sepplindia.com



K	SUPPLIER OF MECHANIZED ROAD SWEEPERS		
S No.	Name of the Company	Contact Person Name & Address	Contact Number & Email Address
1	Dulevo India Private Limited	C-17, SECTOR-88, NOIDA - 201305	Tel: +91-120-2449042/43/46/48, Fax : +91-120-2449047 Email: info@dulevoindia.com; dulevoindia@gmail.com
2	Godrej Material Handling Godrej & Boyce Mfg. Co. Ltd,.	Plant 16, Phirojshanagar, Vikhroli, Mumbai 400079 INDIA .	Tel: +91 22 6796 4660; Fax: +91 22 6796 1519 Email: mhemktg@godrej.com
3	TPS Infrastructure Limited	Jaspreet 84, M-Block, Commercial Complex, Greater Kailash Part-II, New Delhi - 110 048, (INDIA)	Email : tps@tpsmfg.com, tps@tpsmfg.net
4	Amsse Products India	E-76,Ground Floor, Near Hari Kothi, A.F.Enclave, Jamia Nagar, Okhla , New Delhi-110025,	Phone No:- +91-11-29945713, 29947406; Mobile:- +91-9911800614, 9650864684 Email:info@amsseproducts.in; amsseproducts@gmail.com
5	Waste Management Corporation & Fujian Longma Environmental Sanitation Equipment Co., Ltd	#GG-1/1798, Vikas Puri, New Delhi-110 018	Tel: 011-28543080; 9891491365 Email: ajayarora@ wastemanagementcorp.com; akarora8@gmail.com
6	Roots Multiclean Ltd	R.K.G. Industrial Estate, Ganapathy, Coimbatore 641 006 Tamilnadu, India	Phone: 91-0422-4330330 Fax: 91-0422 2332107 Email:rmclsales@rootsemail.com
7	Kärcher India	D -120, Sector - 63, Noida - 201 307, Uttar Pradesh	Toll Free Number 1800 1234 180 Email:info@in.kaercher.com; service@in.kaercher.com

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   (http://www.moef.gov.in/sites/default/files/SWM%202016.pdf)
2. Report of the Task Force on Waste to Energy, Planning Commission, May 12, 2014
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3. Municipal Solid Waste Management Manual, Central Public Health and Environmental Engineering Organization, Ministry of Urban Development, 2016
   (http://cpheeo.nic.in/SolidWasteManagement2016.htm)
4. Construction and Demolition Waste Management Rules, 2016
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5. Plastics Waste Management Rules, 2016
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6. Ministry of Power, Tariff Policy under Central Electricity Act, 2003 as amended dated 28.01.2016
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   (http://pib.nic.in/newsite/PrintRelease.aspx?relid=138144)
   (http://www.icpeenvis.nic.in/index1.aspx?lid=1407&mid=4&langid=1&linkid=739)
   (pmgsy.nic.in/ circulars/ GPW.htm)
   (http://www.icpeenvis.nic.in/index1.aspx?lid=1087&mid=4&langid=1&linkid=456)
   (https://www.aphrdi.ap.gov.in/documents/Trainings@APHRDI/2017/4_Apr/Muncipal%20Waste%20Management/Kshitij%20Aditeya.pdf)
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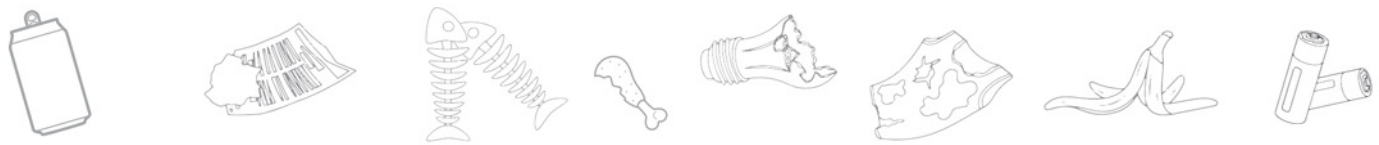
   (http://www.cercind.gov.in/2015/regulation/SOR115.pdf)
9. Notification released on compost policy by Ministry of Chemical and Fertilizers, Department of Fertilizers, 10th February 2016
   (http://fert.nic.in/page/city-compost-policy)
10. Technology Options for Management of Municipal Solid Waste, Technology Information, Forecasting & Assessment Council (TIFAC) & Indian National Academy of Engineering
    (http://www.tifac.org.in/index.php?option=com_content&view=article&id=181&Itemid=217)
11. Waste and Human Health: Evidence and Needs, World Health Organisation, Meeting Report, 2015
    (http://www.euro.who.int/__data/assets/pdf_file/0003/317226/Waste-human-health-Evidence-needs-mtg-report.pdf?ua=1)



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ANNEXURES

1. CERC Notification for RDF based MSW Projects and MSW Projects, 2015

2. Ministry of Power, Tariff Policy under Central Electricity Act, 2003 as amended dated 28.01.2016.

3. Ministry of Road Transport and Highways Notification Use of plastic waste in bituminous mixes in construction of National Highways.

4. Central Public Works Department notification for use of manufactured aggregates from C&D waste.

CENTRAL ELECTRICITY REGULATORY COMMISSION
NEW DELHI

Date : 07th October , 2015

Coram: Shri Gireesh B. Pradhan, Chairperson

Shri A. K. Singhal, Member

Shri A. S. Bakshi, Member

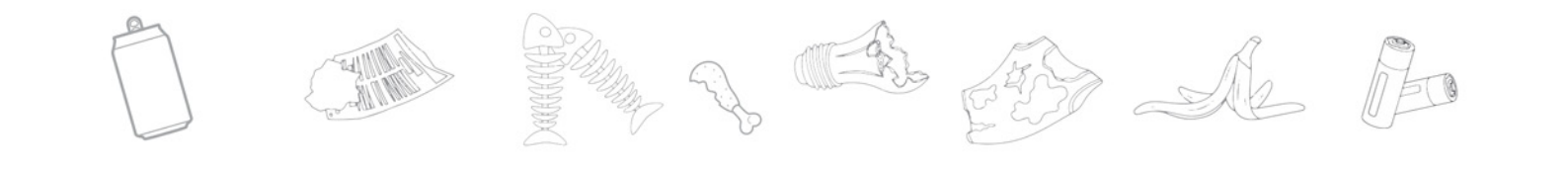
Dr. M.K.Iyer , Member

STATEMENT OF REASONS

The Central Electricity Regulatory Commission (Terms and Conditions for Tariff determination from Renewable Energy Sources) (Fourth Amendment) Regulations, 2015(Norms for determination of generic tariff for Municipal Solid Waste/Waste to Energy projects and indicative tariff for 2015-16)

1. Introduction

1.1 The Commission received references from the Ministry of Urban Development (MoUD) informing the non operation of many WtE plants in the past due to issues such as non-purchase of power by DISCOMs at preferred tariff and, sought the intervention of CERC to determine generic tariff for Waste to Electricity. MoUD also referred to the key objective of Swachh Bharat Mission of processing 100% solid waste generated in cities/towns by 2nd October 2019. MoUD also requested the Commission for determination of generic tariff for waste to electricity to bring about substantial improvement in solid waste management sector. To aid this objective, the Ministry of Power (MoP) was also in the process of amending the tariff policy to include a provision for State DISCOMs to ***"mandatorily purchase all power generated from municipal solid waste".***



1.2 Taking cognizance of the fact that management of waste is a serious issue in India as also to promote stakeholders to play their role in contributing to a cleaner environment by setting up WtE plants, Central Electricity Regulatory Commission notified draft amendment to Central Electricity Regulatory Commission (Terms and Conditions for Tariff determination from Renewable Energy Sources) Regulations , 2012 vide public notice No. L-1/94/CERC/2011 on 10TH August 2015 . Comments were invited from all stakeholders till 10th September 2015. Written comments were received from the following stakeholders :

a) JITF Urban Infrastructure Ltd , New Delhi (JITF)

b) The Tata Power Co. Ltd, Noida, U.P. (Tata Power)

c) Waste Management Association, New Delhi (WMA)

d) Abellon Clean Energy Ltd, Ahmedabad (Abellon)

e) Essel Infraprojects Ltd, Mumbai. (Essel Infra)

f) NN Back Office Services Pvt. Ltd. (Nexus Novus), Benguluru

g) IL &FS Environment Infrastructure & Services Ltd, New Delhi. (ILFS)

h) Power Exchange India Ltd , Mumbai

i) A2Z Infrastructure Ltd, New Delhi (A2Z)

1.3 Subsequently, a public hearing was held on 18th Sept, 2015, where presentations and oral submissions were made by following stakeholders:-

a) A2Z Infrastructure Ltd.

b) Essel Infraprojects Ltd.

c) IL &FS Environment Infrastructure & Services Ltd

d) JITF Urban Infrastructure Ltd

e) KPMG Advisory Services (KPMG)

f) Ramky

1.4 The important issues raised by the stakeholders and Commission's analysis and decisions thereon are presented in the subsequent sections

A. AMENDMENTS TO REGULATIONS

1. Amendment to Regulation 2 - Definitions and Interpretation

1.1 Commission's Proposal in Draft Regulation

a) After sub-clause (o) under clause (1) of Regulation 2 of the Principal Regulations, a new clause (oa) shall be added as under:-

"Municipal solid waste' means and includes commercial and residential wastes generated in a municipal or notified areas in either solid or semi-solid form excluding industrial hazardous wastes but including treated bio-medical wastes"

b) After sub-clause (s) under clause (1) of Regulation 2 of the Principal Regulations, a new clause (sa) shall be added as under:-

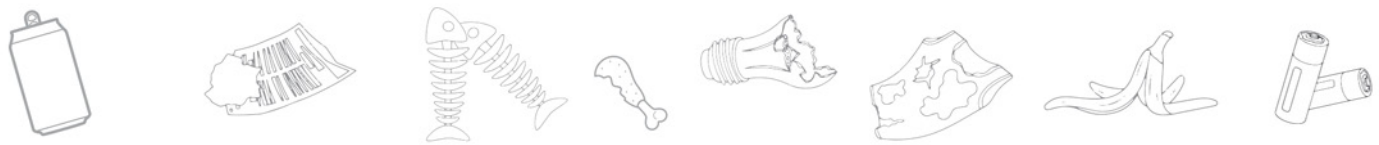
''Refuse Derived Fuel' means segregated combustible fraction of solid waste other than chlorinated plastics in the form of pellets or fluff produced by drying, shredding, dehydrating and compacting combustible components of solid waste that can be used as fuel;"

c) After sub-clause (g) under clause (1)(aa) of Regulation 2 of the Principal Regulations, a new sub-clause (h) shall be added as under:-

"Municipal solid waste (MSW) and Refuse derived fuel (RDF) based power projects - 20 years"

1.2 Comments Received

As regards definition for RDF, A2Z Infrastructure Ltd suggested De-Stoning operation to be included in RDF preparation as removal of stones from MSW for production of RDF is an important operation before shredding.



f) Others

i) Abellon Clean Energy Ltd. suggested that Urban Local Bodies (ULB) should be able to set-off its aggregate consumption (for consumer points above 415v) for power consumed by ULB from DISCOM by the power injected from waste-to-energy if the project and ULB are in the same DISCOM area.

ii) Waste Management Association & IL&FS Environmental Infrastructure Pvt Ltd commented that as the CDM benefit is very low and highly uncertain and considerable costs are incurred by the generating companies in the process of obtaining CER., net revenue be allowed to be retained by the generating company only in order to incentivize carbon mitigation.

iii) Essel Infraprojects Ltd suggested

- that as a promotional measure, Net metering to be resorted to during shut down and start up instead of charging the consumer as plant is subject to frequent shut downs and maintenance.
- sought allowance of sale of power to the Local Municipal Corporation as a "single consumer/pooled account" with suitable mechanism
- Commission to only notify the Tariff Regulations indicating the principles on which tariff parameters and norms shall be derived while determining project specific tariff for MSW based WtE projects. This is because lack of inadequate data may be an hindrance in actual reflection of scenarios in the generic Tariff Order

5.2 Analysis and Commission's View

The Commission has noted the above comments. However, they are outside the purview of these regulations.

6. All other elements not specifically covered above would be based on the principles stipulated for Biomass power projects on Rankine cycle by this Commission in the CERC RE Tariff Regulations.

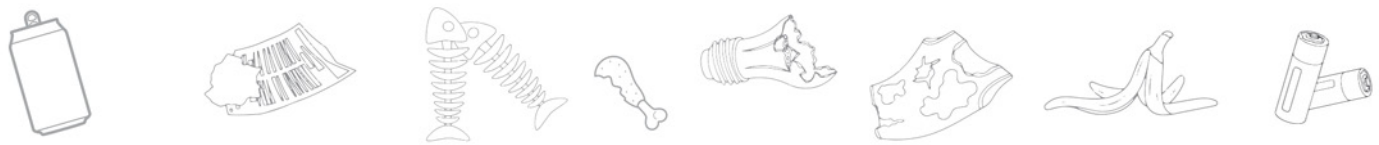
7. Accordingly, Tariff for RDF based MSW Projects and MSW Projects as per the regulations is as below:

Technology	Levellised Fixed Cost	Variable Cost	Applicable Tariff Rate	Benefit of Accelerated Depreciation	Net Levellised Tariff
		(FY 2015-16)	(FY 2015-16)	(if availed)	(upon adjusting for Accelerated Depreciation benefit) (if availed)
	(Rs/kWh)	(Rs/kWh)	(Rs/kWh)	(Rs/kWh)	(Rs/kWh)
MSW	7.04	0.00	7.04	0.54	6.50
RDF based MSW	4.34	3.56	7.90	0.31	7.59

The above tariff will be applicable for entire useful life of 20 years for the MSW / RDF based MSW projects commissioned during FY 2015-16. However, in case of RDF based MSW projects, the variable component of tariff will change each year based on the escalation factor of 5%.

Sd/-	Sd/-	Sd/-	Sd/-
(M.K.Iyer) Member	(A.S. Bakshi) Member	(A.K. Singhal) Member	(Gireesh B. Pradhan) Chairperson

Date : 07.10.2015



b) For aggregates to be used in concrete other than for wearing surfaces	:	In case the aggregate crushing value exceeds 30 percent, then the test for 'ten percent fines' should be conducted and the minimum load for the ten percent fines should be 50 kN

5.4.2 *Aggregates Impact Value*

As an alternative to **5.4.1**, the aggregate impact value may be determined in accordance with the method specified in IS 2386 (Part 4). The aggregate impact value shall not exceed the following values:

a) For aggregates to be used in concrete for wearing surfaces, (such as runways, roads, pavements, tunnel lining carrying water, spillways and stilling basins)	:	30 percent
b) For aggregates to be used in concrete other than for wearing surfaces	:	45 percent

NOTE — For concrete of grades M 65 and above, stronger aggregates are required and hence the maximum aggregate crushing value and aggregate impact value shall not exceed 22 percent.

5.4.3 *Aggregate Abrasion Value*

The aggregate abrasion value, when determined in accordance with IS 2386 (Part 4) using Los Angeles machine, shall not exceed the following values:

a) For aggregates to be used in concrete for wearing surfaces, (such as runways, roads, pavements, spillways, tunnel lining carrying water and stilling basins)	:	30 percent
b) For aggregates to be used in concrete other than for wearing surfaces	:	50 percent

5.5 Soundness of Aggregate

5.5.1 For concrete liable to be exposed to the action of frost, the coarse and fine aggregates shall pass a sodium or magnesium sulphate accelerated soundness test specified in IS 2386 (Part 5), the limits being set by agreement between the purchaser and the supplier.

NOTE — As a general guide, it may be taken that the average loss of mass after 5 cycles shall not exceed the following:

a) For fine aggregate	:	10 percent when tested with sodium sulphate (Na_2SO_4), and 15 percent when testing with magnesium sulphate ($MgSO_4$)
b) For coarse aggregate	:	12 percent when tested with sodium sulphate (Na_2SO_4), and 18 percent when tested with magnesium sulphate ($MgSO_4$)

5.5.2 For slag aggregates, following additional tests shall be carried out:

a) *Iron unsoundness* — When chemical analysis of aggregates shows that the ferrous oxide content is equal to or more than 3.0 percent, and sulphur content is equal to or more than 1.0 percent, the aggregate shall be tested for iron unsoundness. The iron unsoundness of the slag aggregate when tested as per the procedure given in Annex D, shall not exceed 1 percent.

b) *Volumetric expansion ratio* — It shall not be more than 2.0 percent. The procedure shall be as given in Annex E.

c) *Unsoundness due to free lime* — Prior to use of iron slag (for production of aggregates) from a new source or when significant changes in furnace chemistry occur in an existing source which may result in the presence of free lime, the potential for pop-out formation shall be assessed by determining the free-lime content of the slag by petrographic examination or quantitative x-ray diffractometry on a representative sample.

If the number of particles containing free lime exceeds 1 in 20, then weathering of the slag stockpile (in moist condition or at/near saturated surface dry condition) represented by the test sample shall be continued until further testing shows that the level has fallen below 1 in 20.

5.6 Alkali Aggregate Reaction

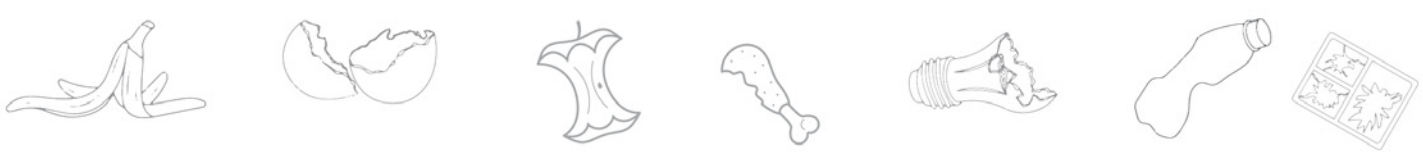
Some aggregates containing particular varieties of silica may be susceptible to attack by alkalies (Na_2O and K_2O) originating from cement and other sources, producing an expansive reaction which can cause cracking and disruption of concrete. Damage to concrete from this reaction will normally only occur when all the following are present together:

a) A high moisture level within the concrete.

b) A cement with high alkali content, or another source of alkali.

c) Aggregate containing an alkali reactive constituent.

NOTE — The aggregates containing more than 20 percent strained quartz and undulatory extinction angle greater than 15°, causing deleterious reaction and also possibly showing presence of microcrystalline quartz is known as slowly reactive aggregates.



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भारत का राजपत्र
The Gazette of India

असाधारण
EXTRAORDINARY
भाग I—खण्ड 1
PART I—Section 1
प्राधिकार से प्रकाशित
PUBLISHED BY AUTHORITY

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No. 39] NEW DELHI, THURSDAY, JANUARY 28, 2016/MAGHA 8, 1937

MINISTRY OF POWER

RESOLUTION

New Delhi, the 28th January, 2016

TARIFF POLICY

No. 23/2/2005-R&R (Vol-IX).—1.0 INTRODUCTION

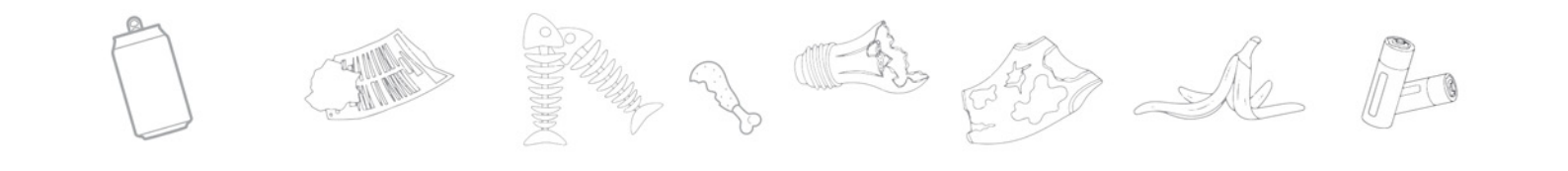
1.1 In compliance with section 3 of the Electricity Act 2003, the Central Government notified the Tariff Policy on 6th January, 2006. Further amendments to the Tariff Policy were notified on 31st March, 2008, 20th January, 2011 and 8th July, 2011. In exercise of powers conferred under section 3(3) of Electricity Act, 2003, the Central Government hereby notifies the revised Tariff Policy to be effective from the date of publication of this resolution in the Gazette of India.

Notwithstanding anything done or any action taken or purported to have been done or taken under the provisions of the Tariff Policy notified on 6th January, 2006 and amendments made thereunder, shall, in so far as it is not inconsistent with this Policy, be deemed to have been done or taken under provisions of this revised policy.

1.2 The National Electricity Policy has set the goal of adding new generation capacity and enhancing per capita availability of electricity per year and to not only eliminate energy and peaking shortages but to also have a spinning reserve as specified by the Central Electricity Authority. Development of the power sector has also to meet the challenge of providing access for affordable electricity to all households in next five years.

1.3 It is therefore essential to attract adequate investments in the power sector by providing appropriate return on investment as budgetary resources of the Central and State Governments are incapable of providing the requisite funds. It is equally necessary to ensure availability of electricity to different categories of consumers at reasonable rates for achieving the objectives of rapid economic development of the country and improvement in the living standards of the people.

1.4 Balancing the requirement of attracting adequate investments to the sector and that of ensuring reasonability of user charges for the consumers is the critical challenge for the regulatory process. Accelerated development of the power sector and its ability to attract necessary investments calls for, inter alia, consistent regulatory approach across the country. Consistency in approach becomes all the more necessary considering the large number of States and the diversities involved.



domestic coal supplied by CIL, vis-à-vis the assured quantity or quantity indicated in Letter of Assurance/FSA the cost of imported/market based e-auction coal procured for making up the shortfall, shall be considered for being made a pass through by Appropriate Commission on a case to case basis, as per advisory issued by Ministry of Power vide OM No. FU-12/2011-IPC (Vol-III) dated 31.7.2013.

6.2 Tariff structuring and associated issues

(1) A two-part tariff structure should be adopted for all long-term and medium-term contracts to facilitate Merit Order dispatch. According to National Electricity Policy, the Availability Based Tariff (ABT) is also to be introduced at State level. This framework would be extended to generating stations (including grid connected captive plants of capacities as determined by the SERC). The Appropriate Commission shall introduce differential rates of fixed charges for peak and off peak hours for better management of load within a period of two years.

Power stations are required to be available and ready to dispatch at all times. Notwithstanding any provision contained in the Power Purchase Agreement (PPA), in order to ensure better utilization of un-requisitioned generating capacity of generating stations, based on regulated tariff under Section 62 of the Electricity Act 2003, the procurer shall communicate, at least twenty four hours before 00.00 hours of the day when the power and quantum thereof is not requisitioned by it enabling the generating stations to sell the same in the market in consonance with laid down policy of Central Government in this regard. The developer and the procurers signing the PPA would share the gains realized from sale, if any, of such un-requisitioned power in market in the ratio of 50:50, if not already provided in the PPA. Such gain will be calculated as the difference between selling price of such power and fuel charge. It should, however, be ensured that such merchant sale does not result in adverse impact on the original beneficiary(ies) including in the form of higher average energy charge vis-à-vis the energy charge payable without the merchant sale. For the projects under section 63 of the Act, the methodology for such sale may be decided by the Appropriate Commission on mutually agreed terms between procurer and generator or unless already specified in the PPA.

(2) Power Purchase Agreement should ensure adequate and bankable payment security arrangements to the Generating companies. In case of persisting default on payment of agreed tariff as per PPA in spite of the available payment security mechanisms like letter of credit, escrow of cash flows etc. the generating companies may sell such power to other buyers.

(3) In case of coal based generating stations, the cost of project will also include reasonable cost of setting up coal washeries, coal beneficiation system and dry ash handling & disposal system.

(4) After the award of bids, if there is any change in domestic duties, levies, cess and taxes imposed by Central Government, State Governments/Union Territories or by any Government instrumentality leading to corresponding changes in the cost, the same may be treated as "Change in Law" and may unless provided otherwise in the PPA, be allowed as pass through subject to approval of Appropriate Commission.

(5) The thermal power plant(s) including the existing plants located within 50 km radius of sewage treatment plant of Municipality/local bodies/similar organization shall in the order of their closeness to the sewage treatment plant, mandatorily use treated sewage water produced by these bodies and the associated cost on this account be allowed as a pass through in the tariff. Such thermal plants may also ensure back-up source of water to meet their requirement in the event of shortage of supply by the sewage treatment plant. The associated cost on this account shall be factored into the fixed cost so as not to disturb the merit order of such thermal plant. The shutdown of the sewage treatment plant will be taken in consultation with the developer of the power plant.

6.3 Harnessing captive generation

Captive generation is an important means to making competitive power available. Appropriate Commission should create an enabling environment that encourages captive power plants to be connected to the grid.

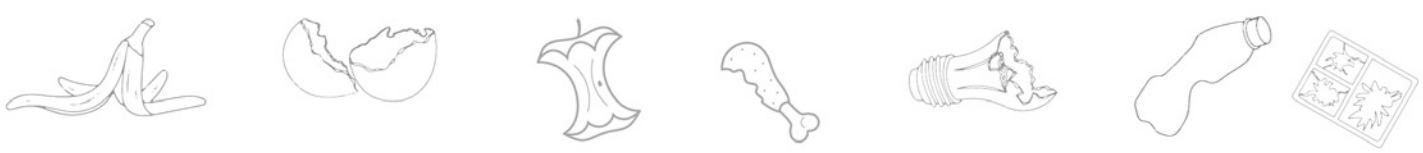
Such captive plants could supply surplus power through grid subject to the same regulation as applicable to generating companies. Firm supplies may be bought from captive plants by distribution licensees using the guidelines issued by the Central Government under section 63 of the Act taking into account second proviso of para 5.2 of this Policy.

The prices should be differentiated for peak and off-peak supply and the tariff should include variable cost of generation at actual levels and reasonable compensation for capacity charges.

Wheeling charges and other terms and conditions for implementation should be determined in advance by the respective State Commission, duly ensuring that the charges are reasonable and fair.

Grid connected captive plants could also supply power to non-captive users connected to the grid through available transmission facilities based on negotiated tariffs. Such sale of electricity would be subject to relevant regulations for open access including compliance of relevant provisions of rule 3 of the Electricity Rules, 2005.

6.4 Renewable sources of energy generation including Co-generation from renewable energy sources:



(1) Pursuant to provisions of section 86(1)(e) of the Act, the Appropriate Commission shall fix a minimum percentage of the total consumption of electricity in the area of a distribution licensee for purchase of energy from renewable energy sources, taking into account availability of such resources and its impact on retail tariffs. Cost of purchase of renewable energy shall be taken into account while determining tariff by SERCs. Long term growth trajectory of Renewable Purchase Obligations (RPOs) will be prescribed by the Ministry of Power in consultation with MNRE.

Provided that cogeneration from sources other than renewable sources shall not be excluded from the applicability of RPOs.

(i) Within the percentage so made applicable, to start with, the SERCs shall also reserve a minimum percentage for purchase of solar energy from the date of notification of this policy which shall be such that it reaches 8% of total consumption of energy, excluding Hydro Power, by March 2022 or as notified by the Central Government from time to time.

(ii) Distribution Licensee(s) shall compulsorily procure 100% power produced from all the Waste-to-Energy plants in the State, in the ratio of their procurement of power from all sources including their own, at the tariff determined by the Appropriate Commission under Section 62 of the Act.

(iii) It is desirable that purchase of energy from renewable sources of energy takes place more or less in the same proportion in different States. To achieve this objective in the current scenario of large availability of such resources only in certain parts of the country, an appropriate mechanism such as Renewable Energy Certificate (REC) would need to be promoted. Through such a mechanism, the renewable energy based generation companies can sell the electricity to local distribution licensee at the rates for conventional power and can recover the balance cost by selling certificates to other distribution companies and obligated entities enabling the latter to meet their renewable power purchase obligations. The REC mechanism should also have a solar specific REC.

(iv) Appropriate Commission may also provide for a suitable regulatory framework for encouraging such other emerging renewable energy technologies by prescribing separate technology based REC multiplier (i.e. granting higher or lower number of RECs to such emerging technologies for the same level of generation). Similarly, considering the change in prices of renewable energy technologies with passage of time, the Appropriate Commission may prescribe vintage based REC multiplier (i.e. granting higher or lower number of RECs for the same level of generation based on year of commissioning of plant).

(2) States shall endeavor to procure power from renewable energy sources through competitive bidding to keep the tariff low, except from the waste to energy plants. Procurement of power by Distribution Licensee from renewable energy sources from projects above the notified capacity, shall be done through competitive bidding process, from the date to be notified by the Central Government.

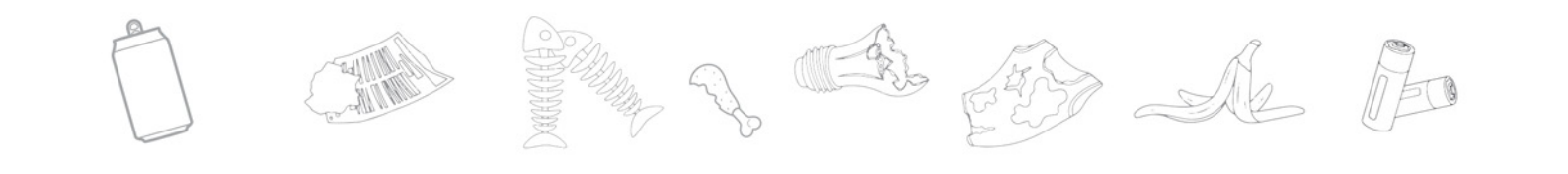
However, till such notification, any such procurement of power from renewable energy sources projects, may be done under Section 62 of the Electricity Act, 2003. While determining the tariff from such sources, the Appropriate Commission shall take into account the solar radiation and wind intensity which may differ from area to area to ensure that the benefits are passed on to the consumers.

(3) The Central Commission should lay down guidelines for pricing intermittent power, especially from renewable energy sources, where such procurement is not through competitive bidding. The tariff stipulated by CERC shall act as a ceiling for that category.

(4) In order to incentivize the Distribution Companies to procure power from renewable sources of energy, the Central Government may notify, from time to time, an appropriate bid-based tariff framework for renewable energy, allowing the tariff to be increased progressively in a back-loaded or any other manner in the public interest during the period of PPA, over the life cycle of such a generating plant. Correspondingly, the procurer of such bid-based renewable energy shall comply with the obligations for payment of tariff so determined.

(5) In order to promote renewable energy sources, any generating company proposing to establish a coal/lignite based thermal generating station after a specified date shall be required to establish such renewable energy generating capacity or procure and supply renewable energy equivalent to such capacity, as may be prescribed by the Central Government from time to time after due consultation with stakeholders. The renewable energy produced by each generator may be bundled with its thermal generation for the purpose of sale. In case an obligated entity procures this renewable power, then the SERCs will consider the obligated entity to have met the Renewable Purchase Obligation (RPO) to the extent of power bought from such renewable energy generating stations.

Provided further that in case any existing coal and lignite based thermal power generating station, with the concurrence of power procurers under the existing Power Purchase Agreements, chooses to set up additional renewable energy generating capacity, the power from such plant shall be allowed to be bundled and tariff of such renewable energy shall be allowed to be pass through by the Appropriate Commission. The Obligated



Government of India
Ministry of Road Transport & Highways

Parivahan Bhawan
1, Parliament Street,
New Delhi- 110001.

No. RW-NH- 33044/24/2015-S&R (R) Dated the 09th November, 15

To

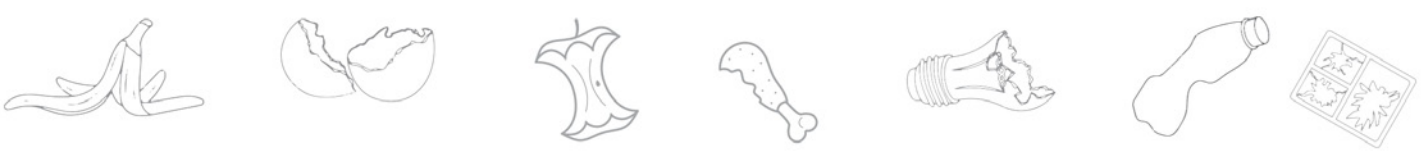
1. The Chief Secretaries of all State Governments/Union Territories
2. The Principal Secretaries /Secretaries of all States/U.Ts. Public Works Department dealing with National Highways, other Centrally Sponsored Schemes and State Schemes.
3. The Engineers-in-Chief and Chief Engineers of Public Works Departments of States/U.Ts dealing with National Highways, other Centrally Sponsored Schemes and State Schemes.
4. The Chairman, National Highways Authority of India, G-5&6, Sector-10, Dwarka, New Delhi-110 075
5. Managing Director, NHIDCL, Room No 101, Parivahan Bhavan, 1.Parliament Street, New Delhi. 110001
6. Director General (Border Roads), Seema Sadak Bhawan, Ring Road, New Delhi-110 010.

Sub: Use of plastic waste in bituminous mixes in construction of National Highways

With the rapid urbanization, a large quantum of plastic waste is being generated. Safe disposal of the plastic waste is a serious environmental problem. Studies have revealed that use of waste plastic improves the desirable properties of bituminous mixes leading to improved longevity and pavement performance. The Indian Roads Congress (IRC) has already published IRC: SP: 98-2013 "Guidelines for the use of waste plastic in hot bituminous mixes (dry process) in wearing coats". However, this technology continues to receive lukewarm response by the Project Engineers, Designers as also the Consultants. Its adoption needs to be encouraged.

2. Therefore, the Ministry has decided to encourage use of plastic waste in the hot mix bituminous wearing coat. Accordingly it is decided that;

a) Bituminous mix with waste plastic shall be the default mode for periodic renewal with hot mixes within 50 kms periphery of urban area having population more than 5



lakhs. Any relaxation on ground of non-availability of waste plastic, cost etc shall involve approval of the Ministry.

b) All the agencies responsible for preparation of project reports / estimates for the National Highways and Centrally sponsored works are expected to analyse and clearly bring out reasons of inclusion or otherwise of provision of use of waste plastic in wearing coats in the proposal.

3. The contents of this Circular may be brought to the notice of all concerned in your Organization. Feedback on these guidelines is solicited.

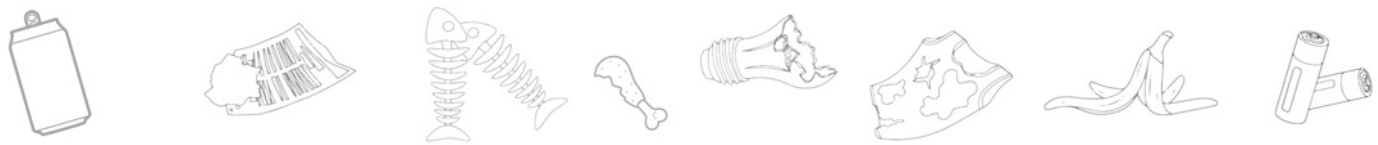
4. This issues with the approval of competent authority.

Yours faithfully,

Assistant Executive Engineer (S,R&T) (Roads)
For Director General (Road Development) & Spl Secy

Copy to:

1. PS to Hon'ble Minister (RTH&S) – for kind information
2. Sr. PPS to Secretary (RT&H) – for kind information
3. PS to DG (RD) & SS
4. PPS to SS&FA– for kind information
5. All Technical officers in the Ministry of Road Transport & Highways
6. All ROs and ELOs of the Ministry of Road Transport & Highways
7. The Secretary General, Indian Roads Congress
8. The Director, IAHE
9. Technical Circular File of S&R Section
10. NIC for placing on the website under "What's New"



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डीजी/विनिर्देश (सि0)/07
निर्माण भवन, नई दिल्ली–110011
महानिदेशक के0 लो0 नि0 वि0 द्वारा प्रदत्त अधिकारों से जारी किया गया

निर्माण भवन नई दिल्ली **दिनांक 22/03/2016**

कार्यालय ज्ञापन

CORRIGENDUM

Sub:- Use of manufactured aggregates as per IS : 383: 2016 in CPWD Works.

सदर्भः– स0 37/अधि0 अभि0(टास)/सी0 एस0 - विनिर्देश /2015–16/52(H) दिनांक 25/02/2016

The Office Memorandum No. DG/Specifications(Civil)/2007 dated 25.02.2016 issued vide above referred letter is modified and the corrected Office Memorandum is as under:

BIS has revised IS 383 and published IS 383: 2016 to permit the use of manufactured aggregate namely recycled aggregate (RA) and recycled concrete aggregate (RCA) in lean concrete, PCC and RCC. The use of BIS certified manufactured aggregates as mentioned in para 10.3 of BIS 383:2016, recycled aggregate (RA) and recycled concrete aggregate (RCA) I shall be used in CPWD works if available within 100 Km from the site of the work. The extent of Utilization of manufactured aggregates as given in the table below.

Sl. No.	Type of aggregate	Maximum Utilization		
		Plain Concrete	Reinforced Concrete	Lean Concrete
		Percent	Percent	(Less than M 15 Grade) Percent
(1)	(2)	(3)	(4)	(5)
i) Coarse aggregate:				
a)	Recycled concrete aggregate" (RCA) (See Note I)	25	20 (Only upto M25 Grade)	100
b)	Recycled aggregate" (RA)	Nil	Nil	100
ii) Fine aggregate:				
d)	Recycled concrete aggregate"(RCA) (See Note 1)	25	20 (Only upto M25 Grade)	100

See A-3 for brief information on recycled aggregates (RA) and recycled concrete aggregates (RCA).

NOTES

1. It is desirable to source the recycled concrete aggregates from sites being redeveloped for use in the same site.
2. In any given structure, only one type of manufactured coarse aggregate and one type of manufactured fine aggregate shall be used.

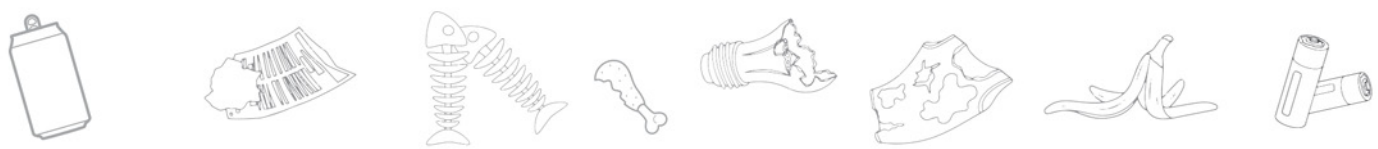
(आर.बी. गर्ग) 22/3/2016
कार्यपालक अभियंता (टास -II)

स0 37/अधि0 अभि0(टास)/सी0 एस0 - विनिर्देश /2015–16/ 71–हि० **दिनांक 22/03/2016**

प्रतिलिपि : के लो नि वि की वेबसाईट htpp://cpwd.gov.in के माध्यम से के0 लो0 नि0 वि0 / लो0 नि0 वि0 (दिल्ली सरकार) के विशेष महानिदेशक/ अतिरिक्त महानिदेशक/ मुख्य अभियंता/ अधीक्षण अभियंता/ कार्यपालक अभियंताओं को सूचनार्थ एवं आवश्यक कार्यवाही हेतु !

22/3/2016
कार्यपालक अभियंता (टास -II)

NOTES



NOTES

स्वच्छता शपथ

महात्मा गांधी ने जिस भारत का सपना देखा था उसमें सिर्फ राजनैतिक आजादी ही नहीं थी, बल्कि एक स्वच्छ एवं विकसित देश की कल्पना भी थी ।

महात्मा गांधी ने गुलामी की जंजीरों को तोड़कर मों भारती को आजाद कराया ।

अब हमारा कर्तव्य है कि गंदगी को दूर करके भारत माता की सेवा करें ।
मैं शपथ लेता हूं कि मैं स्वयं स्वच्छता के प्रति सजग रहूंगा और उसके लिए समय दूंगा ।

हर वर्ष 100 घंटे यानी हर सप्ताह 2 घंटे श्रमदान करके स्वच्छता के इस संकल्प को चरितार्थ करूंगा ।

मैं न गंदगी करूंगा न किसी और को करने दूंगा ।

सबसे पहले मैं स्वयं से, मेरे परिवार से, मेरे मुहल्ले से, मेरे गांव से एवं मेरे कार्यस्थल से शुरुआत करुंगा ।

मैं यह मानता हूं कि दुनिया के जो भी देश स्वच्छ दिखते हैं उसका कारण यह है कि वहां के नागरिक गंदगी नहीं करते और न ही होने देते हैं ।

इस विचार के साथ मैं गांव-गांव और गली-गली स्वच्छ भारत मिशन का प्रचार करुंगा ।

मैं आज जो शपथ ले रहा हूं, वह अन्य 100 व्यक्तियों से भी करवाऊंगा ।

वे भी मेरी तरह स्वच्छता के लिए 100 घंटे दें, इसके लिए प्रयास करुंगा ।

मुझे मालूम है कि स्वच्छता की तरफ बढ़ाया गया मेरा एक कदम पूरे भारत देश को स्वच्छ बनाने में मदद करेगा ।