Feasible Technologies for Municipal Solid Waste Management: A Special Study of Rewari City

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ABSTRACT *Municipal Solid Waste Management plays an important role in sustainable development. Zero waste is a latest visionary concept for confounding waste problems of our society. The idea has been implemented in various sectors including municipal waste, mining and construction. The zero waste concept has been embraced by policy makers, as it is a step forward towards sustainable development. To implement the concept Municipal solid waste department need to be efficient. Recently Municipal solid waste management practices have incorporated with updated technologies to tackle modern challenges in the field of municipal solid waste management. This paper is briefly described latest municipal solid waste management technologies and parameters, which should be kept in consideration while choosing the technology for implementation andthe feasible technology of Rewari city. The paper is very useful, as it explore the latest, efficient and environmentally sound technologies in the sector of municipal solid waste.*

Introduction

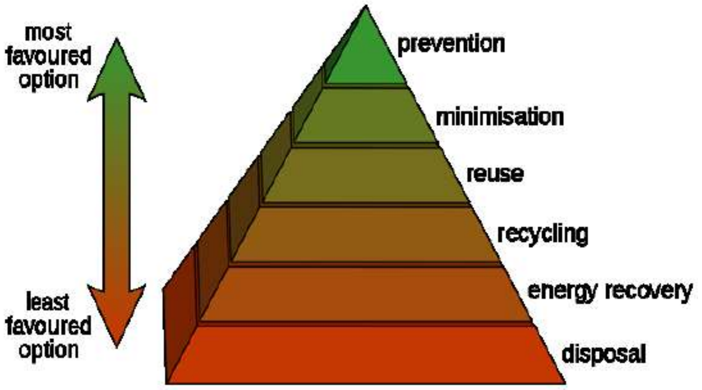
The problems associated with improper waste disposal could be significantly mitigated by requiring material recovery. Source separation of inert and high moisture content fractions would maximize the potential for thermal recovery and other treatment options in India. The waste processed in thermal recovery is residual waste that remains after all commercially viable recyclable materials have been extracted. Technologies produce energy, recover materials and free land that would otherwise be used for dumping. The composition of residual waste is important for energy recovery and waste composition is changing in India, with the amount of high calorific waste generally increasing . A significant increase in the use of technologies has been proposed, but this depends on location, climate, demographics and other socioeconomic factors .

The most widely used technology for residual waste uses combustion to provide combined heat and power . Adopting maximum recycling with waste-to-energy in an integrated waste management system would significantly reduce dumping in India. Technologies are available that can process unsegregated low-calorific value waste, and industry is keen to exploit these technologies in India. Several waste-to-energy projects using combustion of un-segregated low-calorific value waste are currently being developed. Alternative thermal treatment processes to combustion include gasification, pyrolysis, production of refuse derived fuel and gas-plasma technology.

Waste-to-energy development in India is based on a build, operate and transfer model. Increased waste-to-energy would reduce disposal to land and generate clean, reliable energy from a renewable fuel source, reducing dependence on fossil fuels and reducing GHG emissions. In addition, generation of energy from waste would have significant social and economic benefits for India. However, the track record of waste-to-energy in India highlights some of the difficulties. The vast majority of facilities have not worked effectively due to various operational and design problems. For example, the first large-scale MSW incinerator built at Timarpur, New Delhi in 1987 had a capacity to process 300 tonnes per day and cost Rs. 250 million (US$ 5.7 million). The plant failed because of poor waste segregation, seasonal variations in waste composition and properties, inappropriate technology selection and operational and maintenance issues. Despite this experience, waste-to-energy will have a key role in future waste management in India.

Integrated Municipal Solid Waste Management (IMSWM) proposes a waste management hierarchy with the aim to reduce the amount of waste being disposed, while maximizing resource conservation and resource efficiency. The IMSWM hierarchy ranks waste management operations according to their environmental, economic and energy impacts. Source reduction or waste prevention, which includes reuse, is considered the best approach (tier 1) followed by recycling (tier 2) and composting of organic matter of waste, resulting in recovery of material (tier 3). The components of waste that cannot be prevented or recycled can be processed for energy recovery (tier 4). Tier 5 is disposal of waste in sanitary landfill, which is the least preferred option. Moreover, solid waste management system shall be compliant with Solid Waste Management Rules, 2016 (and to amendments thereto).

Figure 1: Municipal solid waste management hierarchy



Objectives:
The overall objectives of the MSWM technologies are summarised below:

- To assess the activities involved for the proposed technology and determine the type and nature of selected technology.
- To analyse any potential environmental impacts from the technologies.
- To recommend appropriate technology for municipal solid waste management in Rewari city.

Research Methodology:
As regards the methodology, the tools and technique employed has been determined in consonance with the set objectives. During the course of the study both the descriptive and analytical technique have been used.To achieve the goals of the study on the other hand, the significant part of the study is based on the secondary data obtained from the official websites and other websites. The data is also obtained from research papers, articles and newspapers.

General technologies & trends:
A judicious choice of technological options is mandatory to address treatment of municipal solid waste. A choice of more than one technology or combination of technologies (according to ISWM) has many-a-times proved beneficial. The available technologies to treat MSW can be broadly categorized into 3 broad sections:

Table1 : MSW Treatment Technologies

Municipal Solid Waste Treatment Technologies		
Thermal Process Technologies	**Biological Processing Technologies**	**Physical Processing Technologies**
► Incineration	► Composting	► RDF Fuel Technology
► Gasification	► Anaerobic Digestion	
► Plasma Arc	► Bioreactor Landfill	
► Pyrolysis		

Assessment of technologies/ Technology selection criteria
The selection of best available technology (BAT) for any waste processing facility depends upon a number of factors such as:

- ► Indian experience
- ► Nature of waste
  - I. Quantity of waste
  - II. Quality of waste
- ► Cost considerations
  - I. Capital investments required
  - II. Recurring expenditure of Economy of operation
  - III. Cost of end products

- ► Manpower Requirement
- ► Level of skill required
- ► The capability of the ULBs to manage such facility departmentally or through private sector participation
- ► Scale of operation
- ► Environmental impact of such technology
- ► Process aesthetics
- ► Compatibility of cycle of nature

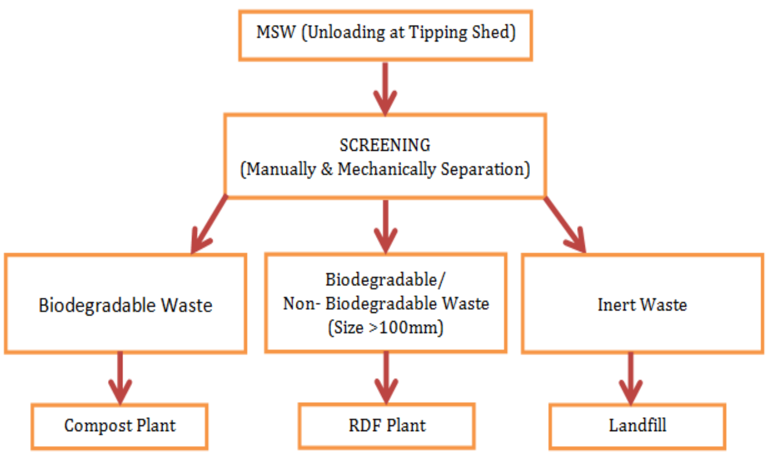
The following criteria are to be considered in order to assess the suitability of technology in Indian context as per MSW CPEEHO Manual:

- ► Technology reliability
- ► Waste suitability
- ► Waste supply chain approach

Recommended MSW processing technology for Rewari:
This concept has been developed keeping into considerations the following design criteria, for the design period of 20 years.
1. Compliance to the MSW handling rules (2016) for waste collection, transportation, treatment & disposal;
2. Providing Door to door collection of waste from source in segregated manner with the introduction of 2-binsystem (for green waste and dry waste);
3. Introduction of an efficient secondary waste collection & transportation system.
4. Adapting the 4R's principal of waste minimization through reduction, reuse, recycle and recover.
Hence, proposed a mechanism for recovery of recyclables at the Processing facility and waste reuse through composting of food waste and other green waste
5. Final disposal of only rejects/inerts at the scientifically developed sanitary landfill with an attempt to dispose not more than 25% of the generated waste quantity at the landfill.
The municipal waste received at the site is processed at waste management facility by segregating the waste into recyclable and composting material. After separation of recyclables the compostable material will be diverted to compost plant. The plant is designed to process approx. 197 TPD municipal solid wastes (MSW) on per day basis and is able to process different kind of waste types. MSW processing unit would comprise of the following: Bio methanation plant Composting facility RDF processing facility RDF to power.
The plant is designed to process approx. 200 TPD municipal solid waste (MSW) on per day basis and is able to process different kind of waste types. MSW processing unit would comprise of the following:

A.Sanitary Landfill **C.** RDF processing facility
B. Composting facility **D.**Bio-methanation plant

Flow chart1: for MSWM



A. Sanitary Landfill:
Currently, the total waste generated by Rewari and other cities of the cluster is being transported to the designated disposal sites in the respective cities where waste is being dumped crudely or indiscriminately. In light of the above, as a part of the development of MSW management project for the Rewari cluster, it is proposed to develop the common sanitary landfill site. Common sanitary waste disposal facility would be

planned for the safe disposal of processing rejects and non-biodegradable components of solid waste and it is envisaged that common sanitary landfill site would receive/accommodate about 20% of processing rejects and inert per day from the total MSW processed at processing plant.

As per the requirements of the Solid waste management rules, 2016, land filling should be restricted to non-biodegradable, inert waste and other waste that are not suitable for further recycling or biological processing. Land filling, amounts ranging from 15-20% shall also be carried out as residues of waste processing facilities (composting plant). Land filling of mixed waste shall be avoided unless the same is found unsuitable for waste processing. The process of land filling must be performed by adhering to proper norms and landfill sites should meet the specifications as given in these rules.

As per solid waste management rules, 2016 , it is mandatory to design, construct and operate Sanitary landfill in addition to waste processing facilities. The provision for adequate land availability which can last for 20 years and 15 years post closure maintenance are required. After the installation of integrated MSW processing facility the quantity of remnants going to sanitary land fill will be greatly minimized.

B. Compost Plant:

Aerobic composting is the decomposition of organic material by microorganisms to produce humus-like material called compost. It is suitable for the organic fraction of the MSW and agricultural waste such as garden waste, waste from slaughter houses and dairy waste. The compost is most commonly used as soil conditioning. Farmers in India have been using composting for many years to process agricultural waste and cow dung, for the purpose of soil conditioner improvement. The application for MSW has been proven successful and demonstrated in numbers of cities in India. Windrow composting has been found most relevant for large-scale applications in organic solid waste disposal. The compostable fraction mixed with inert material is used for aerobic composting in windrows. The waste is processed for 35 days with regular stir and mixing with bio-culture, which accelerates the degradation,

Elements of composting facility:

a) Yard Management System: The < 50 mm fraction of MSW screened in the trammel of pre- processing section is conveyed to the designated areas of compost pad for windrow preparation. In windrow type aerobic composting system, the fresh MSW is stacked in the form of trapezoidal heaps called 'windrows' with sufficient quantity of decomposing microbial cultures, will be inoculated at this point with sprayer to reduce odour and repel vectors. Moisture will also be supplemented at required levels before windrow preparation. The thoroughly mixed waste is then made to windrows of convenient dimensions and kept for the biologic decomposition. The windrows are periodically turned (normally once a week) using hydraulic excavators to provide proper aeration and temperature control. The composting heap is stabilized in about 6 weeks, when it is shifter to the screening plant for removal of the inert and non-composted matter. Inside temperature of the windrow may go up to 650 C.

b) Coarse segregation system: Stabilized material from monsoon shed is then fed to the 'coarse segregation section' using a Skid Steer Loader for intermediate screening. Two stage screening system is adopted to achieve maximum screening efficiency using trommel of different hole sizes. Cascading action inside the trommel ensures better screening of the lumpy and highly heterogeneous municipal solid waste. These days equipment in this section are hydraulically driven to ensure greater safety against breakdowns and to lower power consumption. Hydraulic drive alsointroduces features like on-load starting, centralized control etc. PLC based controlsallows automatic shutdown in case of any emergency. Screened material coming outof this section is uniform in texture and contains semi–stabilized organic compost. This material needs further stabilization so it is transferred to the curing section.

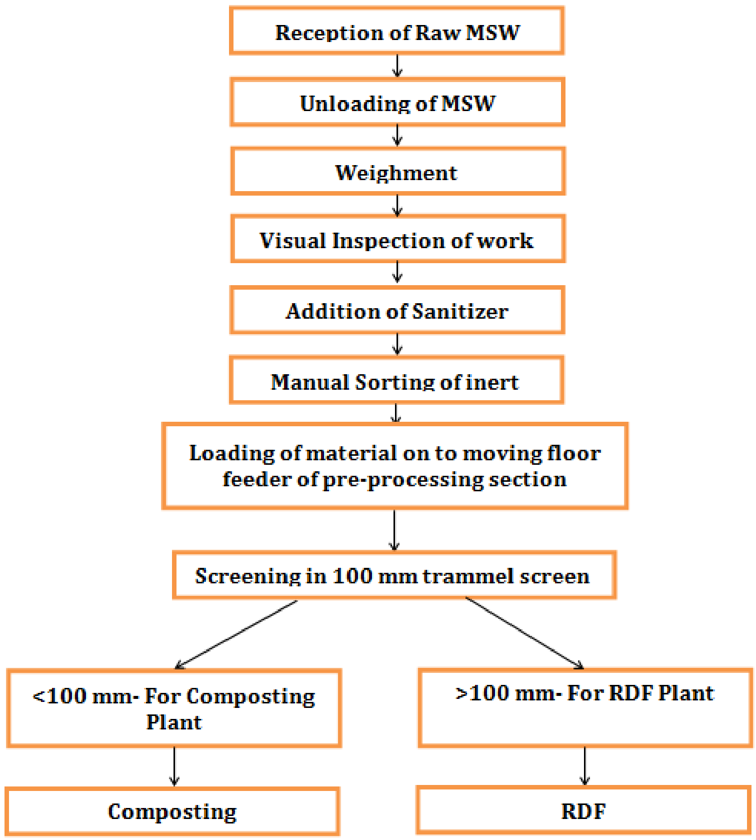
c) Curing system: Material coming out of the coarse segregation section is stored in curing section for 15 days for further stabilization and moisture control. Some additives, such as, as rock phosphate may be added at this stage to improve quality of final product. Curing area can hold up to 20 days of material coming to the curing section on daily basis.

d) Refinement system: As per compost quality norms nationally (FCO) and internationally, the compost should be below 4 mm average particle size and it should not contain impurities such as glass, plastic, other inert material etc. which spoils the overall appearance and creates suspicion in the mind of the end user about quality of the final product. This section consists of a trommel screen 4 mm. which contains the hole size of 4mm. The screened material coming out of the trammel screen is sent to the gravity separator which removes heavy impurities such as glass, metals, sand, silica etc. from the organic manure. The magnetic separator in the production line will take care of all kinds of ferrous impurities in the compost. Organic Manure free from major impurities is passed through a liquid add mixer where quality enhancer in powder or liquid form is added. High quality organic manure is then passed through the packing spout and final packing of the product takes place.

e) Packing and Storage System: The mechanized packing section can do the bagging, weighment and stitching of 50 kg bags and finally stacked in the finished product store by using a stacking conveyor.

f) Leachate, litter and Odour Management System: During composting some dark coloured thick fluid may get generated. This fluid is known as 'leachate'. It should not get percolated in the soil or else it will pollute the ground water. To avoid this, proper concreting of the 'compost pad' is done and a peripheral drain is provided to collect the leachate generated during the process. The leachate so collected has to be suitably treated or recycled over the windrows. The air-borne litter is controlled by providing a high wire mesh. A green belt is provided around the plant.

Flow chart2: Process flow at the processing facility



C. RDF processing plant:

RDF (Refuse Derived Fuel) is a fuel that is normally produced from waste with high calorific value. The larger fractions of MSW, which are separated in the first segregation step, consist of larger burnable waste such as paper, plastic, textiles, coconut shells, rubber etc. The large inert fractions and the recyclable plastic and metals are sorted out manually and the remaining burnable waste is passed on to a mechanical separation unit. Air is added from below and the heavy non-combustible material, such as glass and inert material are separated from the light combustible fractions. Finally, the combustible material is mechanically crushed and chopped into a small fluffy fraction.

In order to produce refuse derived fuels with defined qualities and guaranteed specifications, multi-level processing is required that mainly includes the following stages:

1. Primary shredding
2. Separation of ferrous metal and non-ferrous metal
3. Separation of extraneous material (by e.g. air-steam or ballistic separators)
4. Secondary shredding
5. Pelleting(briquetting)

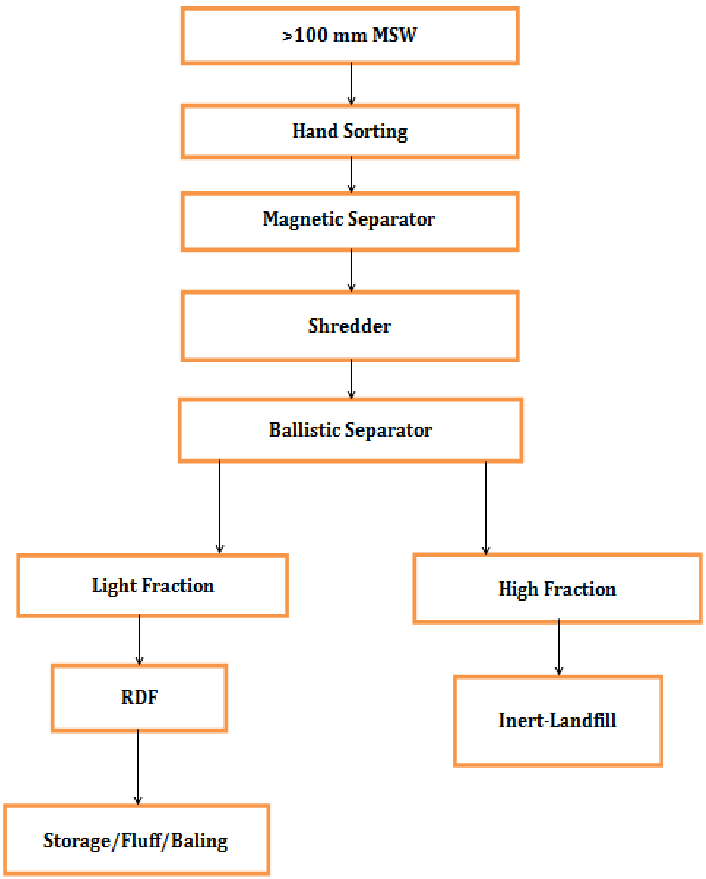
The RDF processing unit would receive MSW of > 50 mm size and produce RDF through various processes.

(i) The MSW from tipping floor or MSW pit will be conveyed to a trammel screen with 50 -70 mm screen size (depending upon the Physical Characterization of waste). The below 50 mm size will be taken for composting and above 50 mm size will be further conveyed to the main shredder for size reduction. Trommel screens are mechanical segregation devices.

(ii) Shredder The shredder cuts the material to a size of less than 70 mm, (can be adjusted by means of changeable bottom screens). Shredders are programmed in such a manner that in case the un-shreddable material is detected, the shredder will be stopped automatically. The foreign object is also automatically discharged to a dedicated container by means of reversible belt conveyor after the following conveyor. In good quality shredders MIPS (Massive Impact Protection System) protects the knives of the shredder incase of un-shreddable material enters the shredder. The shredded material is discharged from the shredder by means of chain/belt conveyor.

(iii) Ballistic Separator The ballistic separator is used to segregate the heavy inert,
glass and metal pieces.

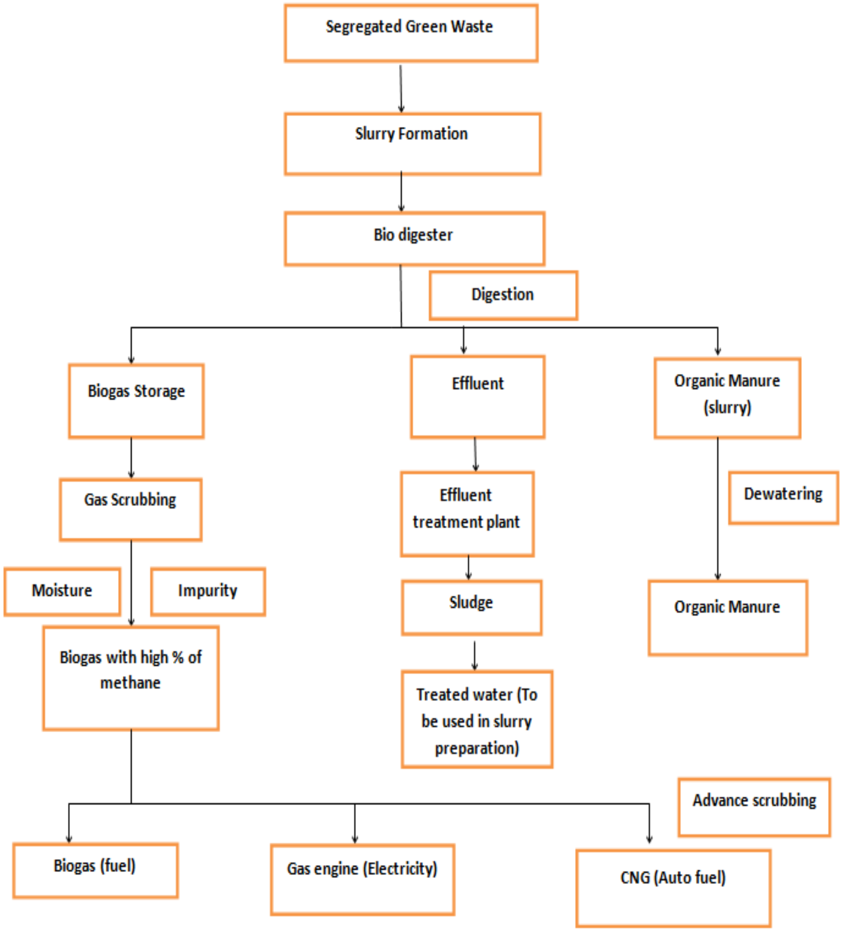
Flow chart3: MSW to RDF process flow



D. Bio-methanation:

Bio-methanation is a process by which organic material is microbiologically converted under anaerobic conditions to biogas. Three main physiological groups of microorganisms are involved: fermenting bacteria, organic acid oxidizing bacteria, and methanogenic archaea. Microorganisms degrade organic matter via cascades of biochemical conversions to methane and carbon dioxide. Syntrophic relationships between hydrogen producers (acetogens) and hydrogen scavengers (homoacetogens, hydrogenotrophic methanogens, etc.) are critical to the process. Determination of practical and theoretical methane potential is very important for design for optimal process design, configuration, and effective evaluation of economic feasibility. A wide variety of process applications for bio-methanation of wastewaters, slurries, and solid waste have been developed. They utilize different reactor types (fully mixed, plug-flow, biofilm, UASB, etc.) and process conditions (retention times, loading rates, temperatures, etc.) in order to maximize the energy output from the waste and also to decrease retention time and enhance process stability. Bio-methanation has strong potential for the production of energy from organic residues and wastes. It will help to reduce the use of fossil fuels and thus reduce CO2 emission.

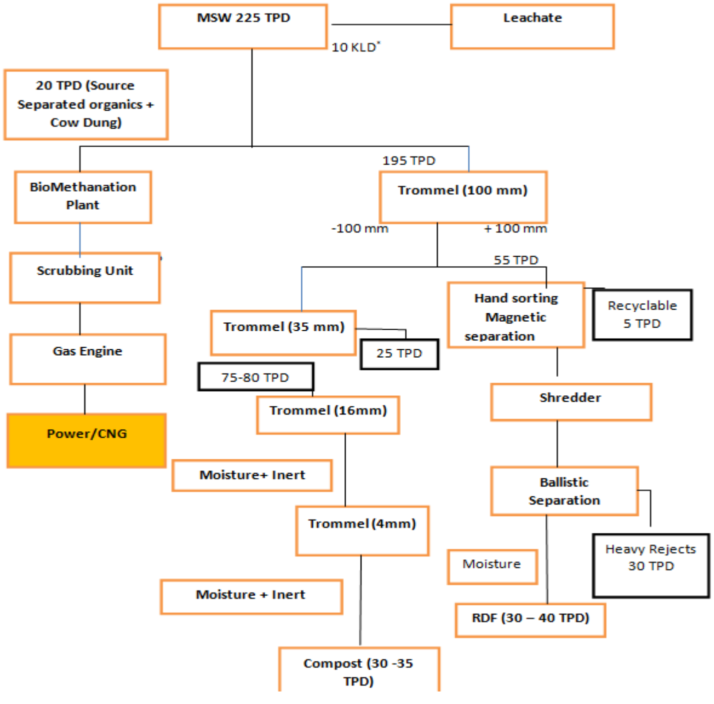
Flow Chart 4: Flow chart for Bio-methanation



Mass balance:

The MSW processing facility can be summarised in the following mass balance flow chart:

Flow Chart 5 – Material Balance of 225 TPD Rewari MSW Plan



Conclusion:

All the technological options are analysed, their salient features and cost implications are taken into consideration. Study of environmental implications and suitability to biophysical environment of India is carried out. The research shows that composting, vermin-composting and bio-methanation are the preferred techniques.

Choice of technology depends on the type of waste. Composting and biogas generation is for slaughter house and fish market wastes, Vermi composting for homogeneous wastes such as fruits and vegetable wastes and windrow for heterogeneous wastes. Precaution has to be kept near thermal conversion plants so that the fuel gas emitted does not pollute the environment.

Sanitary land filling is the easiest option. However in India pyrolysis, plasma pyrolysis and pelletization are rare technologies and not in use at large scale. The analysis indicates that no technology is perfect. All of them have merits and demerits. Therefore, the choice of technology has to be done judiciously.

In this paper we describe a possible design for integrated municipal waste management system in the cluster and identify feasible technologies for processing and disposal of MSW. On the basis of the analysis and all the studies, it is proposed that processing of MSW into compost and RDF is the most feasible technology based on quantity of waste generation, land availability, waste characteristics and volume reduction of waste in Rewari.

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