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TECHNOLOGIES USED IN EXTRICATION OF MUNICIPAL SOLID WASTE

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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 and the 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.**

I 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).

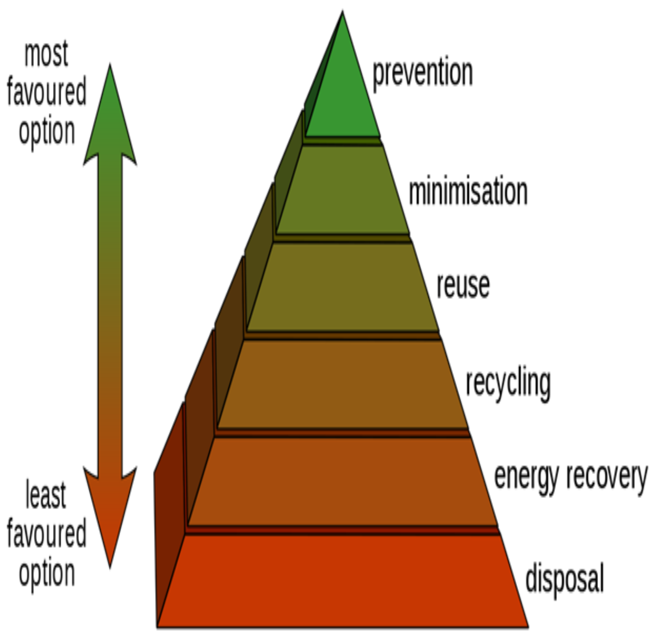


Figure 1: Municipal solid waste management hierarchy

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.

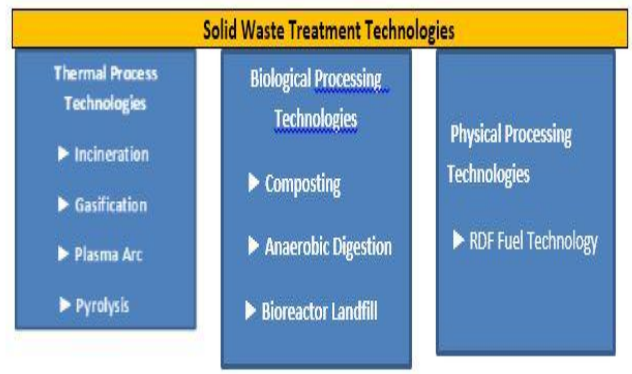
II RESEARCH METHODOLOGY:

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



Thermal processing technologies

The thermal processing technologies involve thermal decomposition of waste into gaseous, liquid and solid conversion products with release of heat energy. These technologies operate at temperatures greater than 200°C and have higher reaction rates. They typically operate in a temperature range of 375°C to 5,500°C. Thermal technologies include advanced thermal recycling (a state-of-the-art form of waste-to-energy facilities) and thermal conversion (a process that converts the organic carbon based portion of the MSW waste stream into a synthetic gas which is subsequently used to produce products such as electricity, chemicals, or green fuels). The main thermal processing technologies adopted internationally for the treatment of municipal waste are:

► Incineration

Mass-burn systems are the predominant form of the MSW incineration. Mass-burn systems generally consist of either two or three incineration units ranging in capacity from 50 to 1,000 tons per day; thus, facility capacity ranges from about 100 to 3,000 tons per day. It involves combustion of unprocessed or minimally processed refuse. The major components of a mass burn facility include: (1) Refuse receiving, handling, and storage systems; (2) Combustion and steam generation system (a boiler); (3) Flue gas cleaning system; (4) Power generation equipment (steam turbine and generator); (5) Condenser cooling water system; and (6) Residue hauling and storage system.

► Pyrolysis

In pyrolysis, at high temperatures of 700°C to 1200 °C, thermal degradation of organic carbon-based materials is achieved through the use of an indirect, external source of heat, in the absence or almost complete absence of free oxygen. This thermally decomposes and drives off the volatile portions of the organic materials, resulting in a syngas composed primarily of hydrogen (H2), carbon monoxide (CO), carbon dioxide (CO2), and methane (CH4). Some of the volatile components form tar and oil, which can be removed and reused as a fuel. Most pyrolysis systems are closed systems and there are no waste gases or air emission sources (if the syngas is combusted to produce electricity, the power system will have air emissions which needs to be treated through a stack and air emission control system). After cooling and cleaning in emission control systems, the syngas can be utilized in boilers, gas turbines, or internal combustion engines to generate electricity or used as raw stock in chemical industries. The balance of the organic materials that are non-volatile or liquid that is left as a char material, can be further processed or used for its adsorption properties (activated carbon). Inorganic materials form a bottom ash that requires disposal, although some pyrolysis ash can be used for manufacturing brick materials.

► Gasification

In the gasification process, thermal conversion of organic carbon based materials is achieved in the presence of internally produced heat, typically at temperatures of 660°C to 1800°C, and in a limited supply of air/oxygen (less than stoichiometric, or less than what is needed for complete combustion) to produce a syngas composed primarily of H2 and CO. Inorganic materials are converted either to bottom ash (low temperature gasification) or to a solid, vitreous slag (high temperature gasification that operates above the melting temperature of inorganic components). Some of the oxygen injected into the system is used in reactions that produce heat, so that Pyrolysis (endothermic) gasification reactions can initiate; after which, the exothermic reactions control and cause the gasification process to be self-sustaining. Most gasification systems, like Pyrolysis, are closed systems and do not generate waste gases or air emission sources during the gasification phase. After cooling and cleaning in emission control systems, the syngas can be utilized in boilers, gas turbines, or internal combustion engines to generate electricity, or to make chemicals.

Biological processing technologies

Biological treatment involves using microorganisms to decompose the biodegradable components of waste. Biological processing technologies operate at lower temperatures and lower reaction rates. Biological processing technologies are focused on the conversion of organics in the MSW. MSW consists of dry matter and moisture. The dry matter further consists of organics (i.e., whose molecules are carbon-based), and minerals, also referred to as the ash fraction. The organics can be further subdivided into biodegradables or refractory organics, such as food waste, and non-biodegradables, such as plastic. Biological technologies can only convert biodegradables component of the MSW. By-products can vary, which include: electricity, compost and chemicals. Biological process can be aerobic and anaerobic. Biological technologies adopted for treatment of solid waste include:

► Composting

Composting is a natural micro-biological process, where bacteria break down the organic fractions of the MSW stream under controlled conditions to produce a pathogen-free material called “Compost” that can be used for potting soil, soil amendments (for example, to lighten and improve the soil structure of clay soils), and mulch. The microbes, fungi, and macro-organisms that contribute to this biological decomposition are generally aerobic. A mixture of organic materials is placed into one or more piles (windrows), and the natural microbial action will cause the pile to heat up to 60 - 70°C, killing most pathogens and weed seeds. A properly designed compost heap will reach 70°C within 6 to 10 days, and slowly cool off back to ambient temperatures as the biological decomposition is completed. Systematic turning of the material, which mixes the different components and aerates the mixture, generally accelerates the process of breaking down the organic fraction, and a proper carbon/nitrogen balance (carbon to nitrogen or C/N ratio of 20:1) in the feedstock ensures complete and rapid composting. The composting process takes from 30 to 90 days.

There are two fundamental types of composting techniques: a.) open or windrow composting, which is done out of doors with simple equipment and is a slower process, and b.) enclosed system composting, where the composting is performed in some enclosure (e.g., a tank, a box, a container or a vessel).

► Anaerobic digestion

In anaerobic digestion, biodegradable material is converted by a series of decomposition process by different bacterial groups into methane and CO2. A first group breaks down large organic molecules into small units like sugar. This step is referred to as hydrolysis. Another group of bacteria converts the resulting smaller molecules into volatile fatty acids, mainly acetate, but also hydrogen (H2) and CO2. This process is called acidification. The last group of bacteria, the methane producers or methanogens, produce biogas (methane and CO2) from the acetate and hydrogen and CO2. This biogas can be used to fuel boilers or reciprocating engines with minimal pre-treatment. In addition to biogas, anaerobic bioconversion generates a residue consisting of in-organics, non-degradable organics, and bacterial biomass. If the feedstock entering the process is sufficiently free of objectionable materials like colourful plastic, this residue can have market value as compost. Anaerobic digestion process is also referred to as Bio-methanation process.

► Bioreactor landfill

A bioreactor landfill is a wet landfill designed and operated with the objective of converting and stabilizing biodegradable organic components of the waste within a reasonable time frame, by enhancing the microbiological decomposition processes. The technology significantly increases the extent of waste decomposition, conversion rates and process effectiveness over what would otherwise occur in a conventional wet landfill. Stabilization in this context means that landfill gas and leachate emissions are managed within one generation (twenty to thirty years) and that any failure of the containment system after this time would not result in environmental pollution. There is better energy recovery including increased total gas available for energy use and increased greenhouse reduction from reduced emissions and increase in fossil fuel offsets. These factors lead to increased community acceptance of this waste technology. Management of a bioreactor landfill requires a different operating protocol to conventional landfills. Liquid addition and recirculation is the single most important operational variable to enhance the microbiological decomposition processes. Other strategies can also be used, to optimise the stabilization process, including waste shredding, pH adjustment, nutrient addition and temperature management.

Physical processing technologies

Physical technologies involve altering the physical characteristics of the MSW feedstock. The MSW is subjected to various physical processes that reduce the quantity of total feedstock, increase its heating value, and provide a feedstock. It may be densified or palletized into homogeneous fuel pellets and transported and combusted as a supplementary fuel in utility boilers. These technologies are briefly described below.

► Refused Derived Fuel (RDF)

The RDF process typically includes thorough pre-separation of recyclables, shredding, drying, and densification to make a product that is easily handled. Glass and plastics are removed through manual picking and by commercially available separation devices. This is followed by shredding to reduce the size of the remaining feedstock to about eight inches or less, for further processing and handling. Magnetic separators are used to remove ferrous metals. Eddy-current separators are used for aluminium and other non-ferrous metals. The resulting material contains mostly food waste, non-separated paper, some plastics (recyclable and non-recyclable), green waste, wood, and other materials. Drying to less than 12% moisture is typically accomplished through the use of forced-draft air. Additional sieving and classification equipment may be utilized to increase the removal of contaminants. After drying, the material often undergoes densification processing such as pelletizing to produce a pellet that can be handled with typical conveying equipment and fed through bunkers and feeders. The RDF can be immediately combusted on-site or transported to another facility for burning, alone or with other fuels. The densification is even more important when RDF is transported off-site to another facility, in order to reduce volume being transported. RDF is often used in waste to energy plants as the primary or supplemental feedstock, or co-fired with coal or other fuels in power plants, in kilns of cement plants, and with other fuels for industrial steam production.

► Mechanical separation

Mechanical separation is utilized for removing specific materials or contaminants from the inlet MSW stream as a part of the pre-treatment process. Contaminants may include construction and demolition (C&D) debris, tires, dirt, wet paper, coarse materials, and fine materials. Generally, MSW reaching the dumping sites is unsegregated and mixed, containing C&D debris and other contaminants. Therefore, it is essential to remove these contaminants from the incoming MSW by mechanical separation before processing the waste further by either biological, physical and thermal technologies (except Plasma Arc Technology).

► Size reduction

Size reduction is often required to allow for more efficient and easier handling of materials, particularly when the feed stream is to be used in further processes. Sizing processes include vibrating screens and trommels. In order to reduce the size of the entire stream, or portions of it, mechanical equipment, such as shredders, is utilized. This allows for other physical processes, such as dryers, magnetic and eddy current separators, and densification equipment to work more efficiently. Magnetic and eddy current separators may be installed both up- and down-stream of shredders to increase the recovery of metals.

III 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:

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
B. Composting facility
C. RDF processing facility
D. Bio-methanation plant

A. Sanitary Landfill:

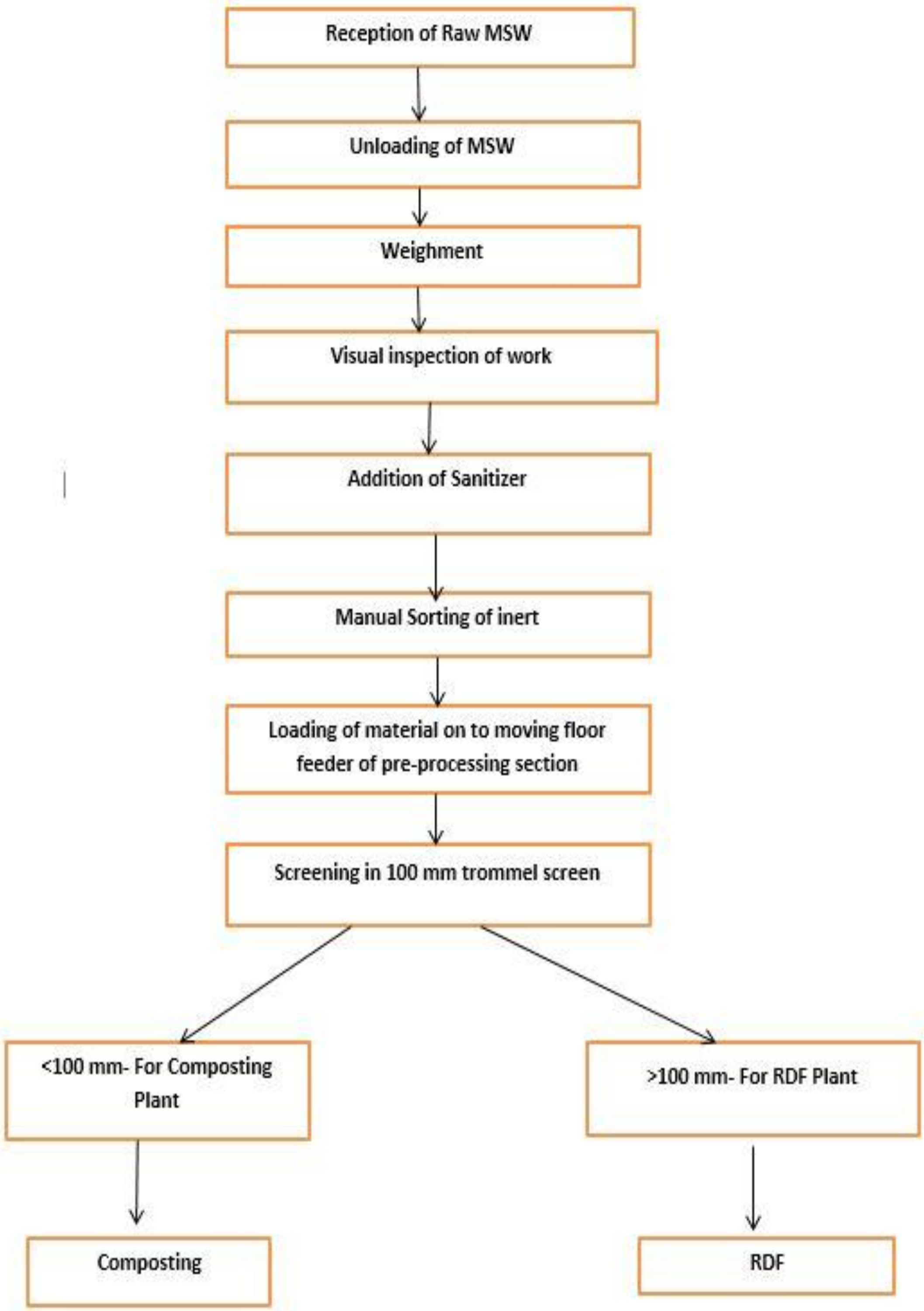
Currently, the total waste generated by Rewari and other cities of the cluster is being transported to the designated disposal sites in the respective cities where waste is being dumped crudely or indiscriminately. In light of the above, as a part of the development of MSW management project for the 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.

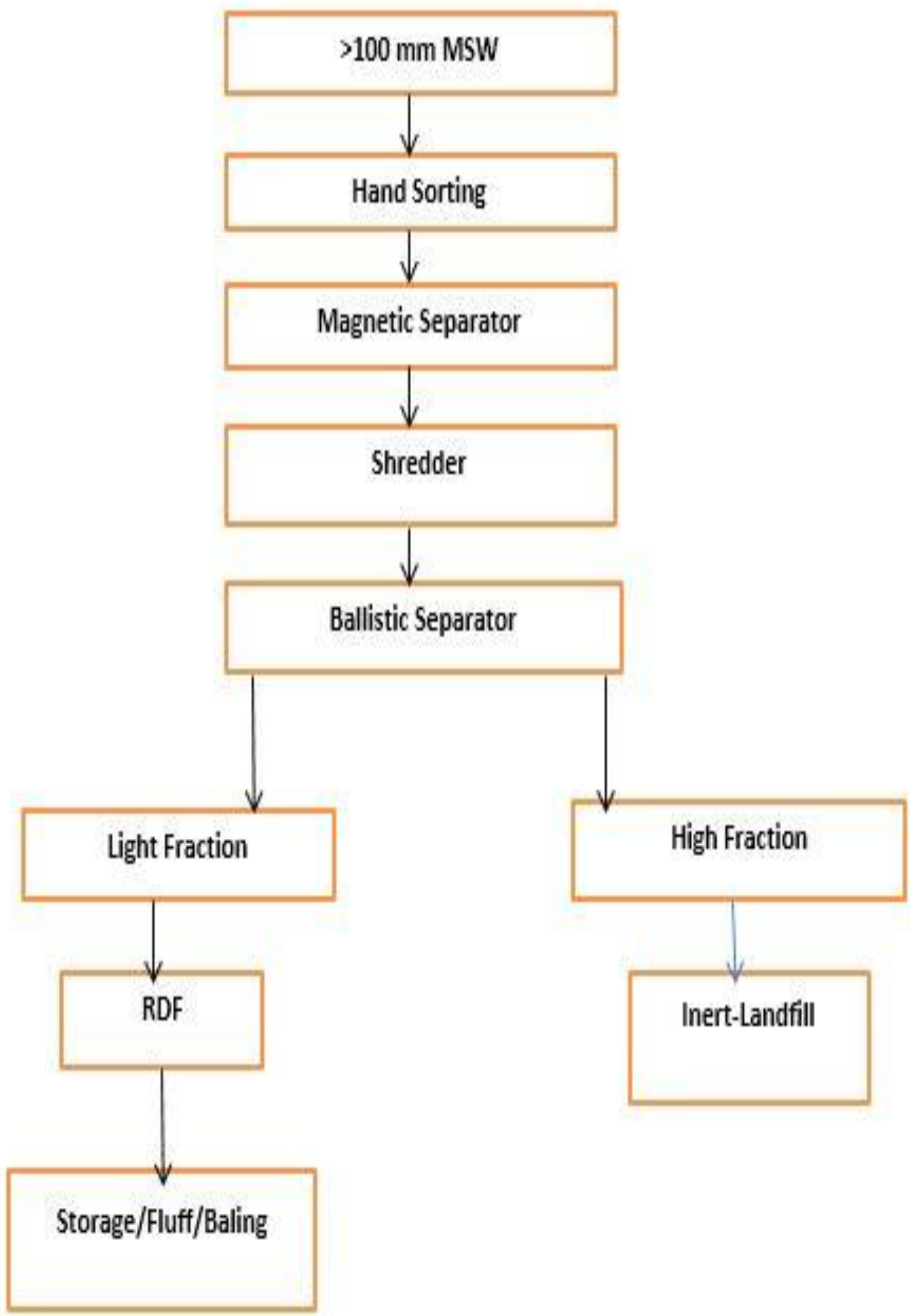
B. Compost Plant:

Flow chart 2: Process flow at the processing facility



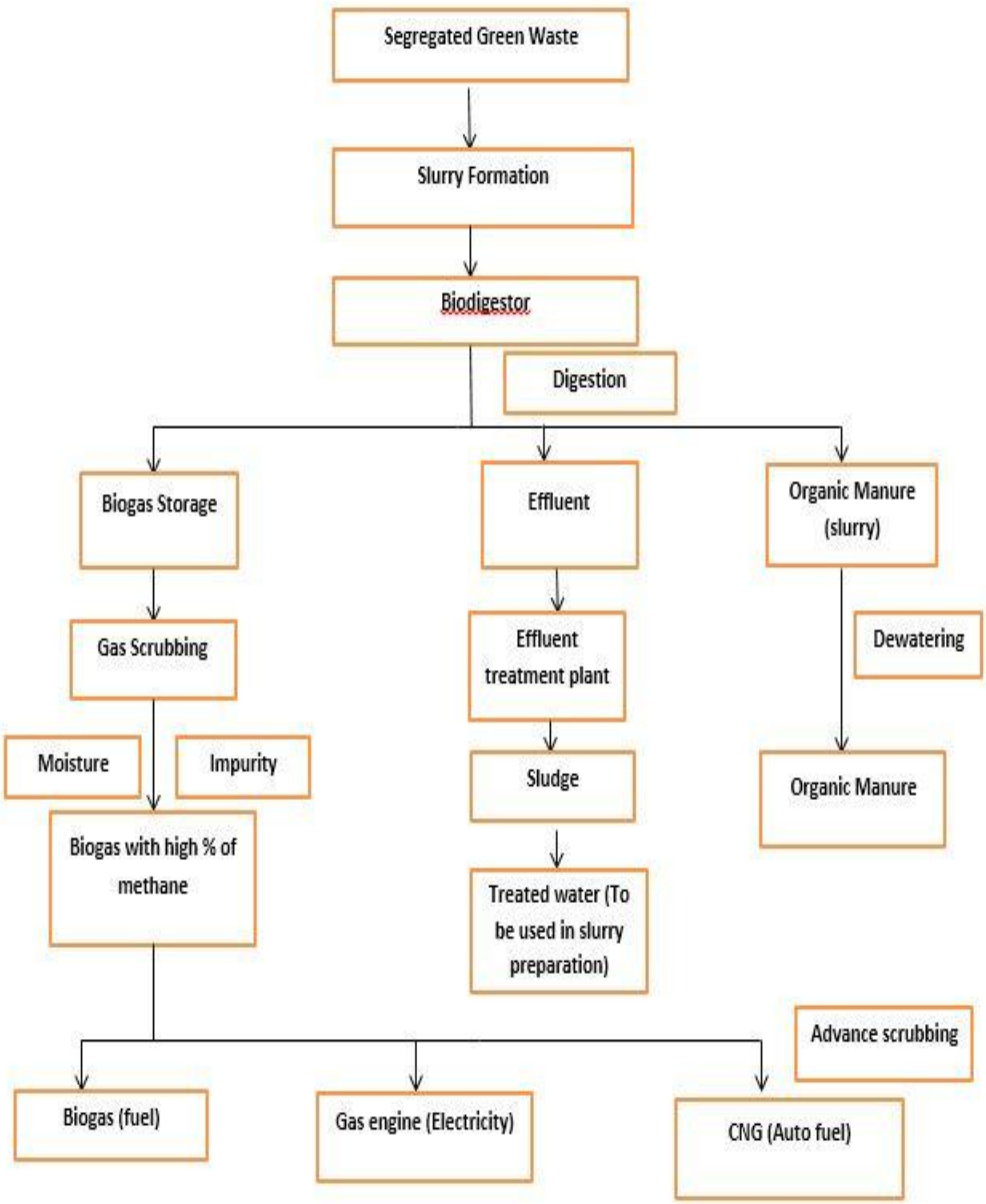
C. RDF processing plant:

Flow chart 3: MSW to RDF process flow



D. Bio-Methanation:

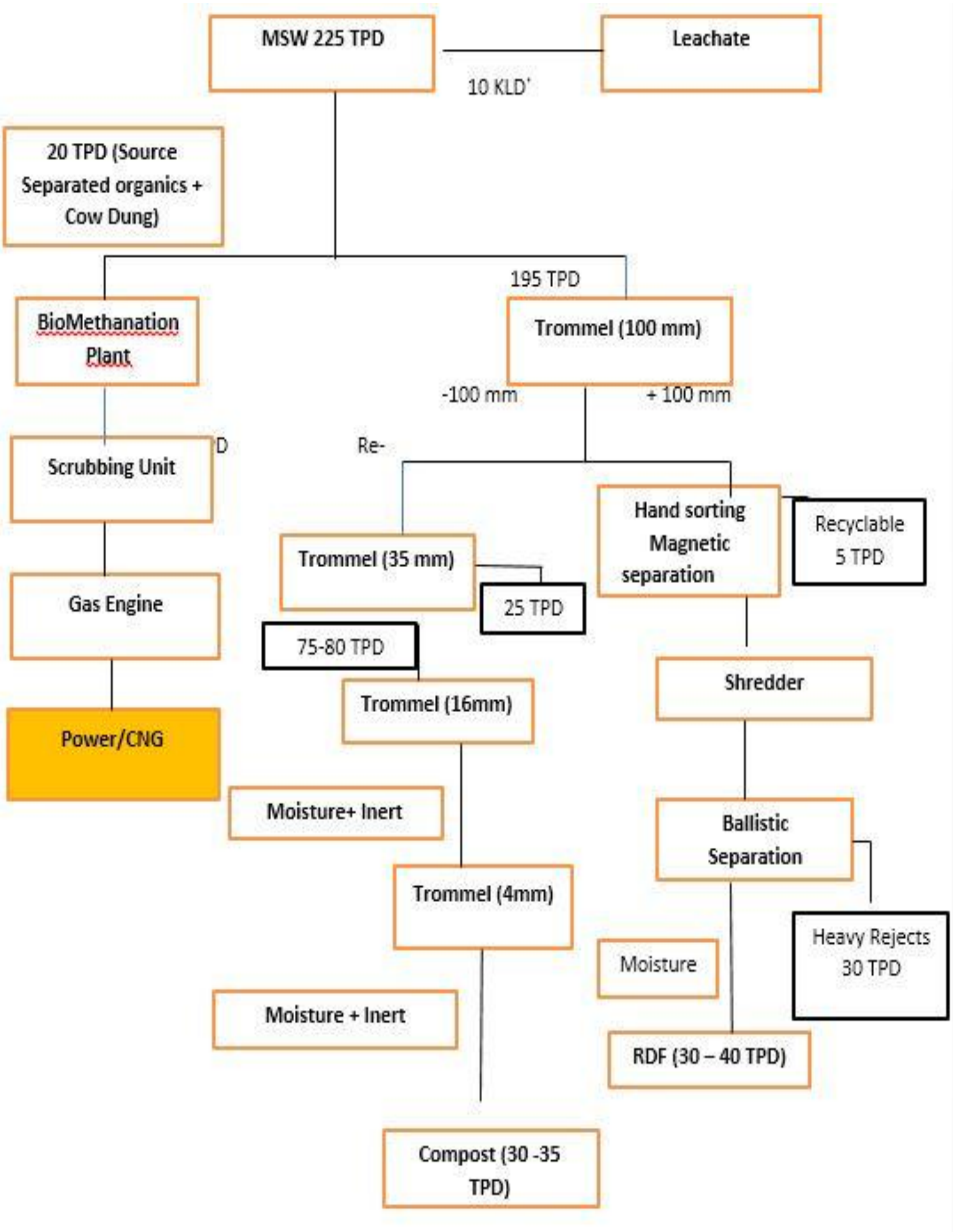
Flow Chart 1: Flow chart for Bio-methanation



Mass balance:

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

Flow Chart 4 – Material Balance of 225 TPD Rewari MSW Plan



IV 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, vermi-composting and biomethanation 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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