A REVIEW ON TECHNOLOGICAL OPTIONS FOR TREATMENT OF MUNICIPAL SOLID WASTE MANAGEMENT OF DEHRADUN CITY

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Abstract : Municipal solid waste (MSW) is one of the serious problem for Dehradun city. Dehradun city is blessed by nature, good environmental conditions and remarkable history. Now, the problem of solid waste acts as a barrier in living beings and city's development. With urbanization waste generation increases and with this increase of solid waste, critical challenge of municipal solid waste management is faced by city authority. Improper management and inappropriate disposal of waste causes environment's decay. There is a need to work towards a supportable waste management system. The paper deals with analyzation of various technological options in the direction of sustainability.

***Index Terms* – Municipal solid waste (MSW), Composting, Incineration, Biomethanation, Gasification, Landfill, Biodrying**

I. INTRODUCTION

Increase in municipal solid waste (MSW) with the increase in population is the matter of concern for developing countries. In today's scenario, the problem of municipal solid waste drawing everyone's attention. There may be many side effects if proper actions were not taken. Dehradun, capital of Uttarakhand state is one of the developing city in India. Dehradun city is on the way to become smart city and problems like as municipal solid waste creates difficulties in such development projects. The development of any city is based on many factors and it influences the growth of its state. Municipal solid waste management is one of the factor which directly affects growth and development of any city. The municipal solid waste is treated and managed by the municipalities and local authorities of the city or town. In Dehradun, the solid waste is managed by Dehradun Municipal Corporation (DMC) by using different procedure and methods. Solid waste is defined as the unwanted or useless material produced by human activities. Waste is defined as any residual material from industrial and human activities that has no residual value. Solid waste is also known as garbage, refuse, solid or semisolid insoluble material (sometimes including gases and liquid in containers). The solid waste mainly includes municipal (residential, domestic, household organic waste, street sweeping), commercial, industrial, hazardous (medical waste), agricultural and e-waste. Waste is an unavoidable by-product of human activities. Economic development, urbanization and improved living standards in cities increases the quantity and complexity of generated solid waste. If accumulated, it leads to degradation of urban environment, stresses natural resources and leads to health problems (CPCB, 2000; NEERI, 1994; UN, 2000)[1].

Dehradun is densely populated and a growing urban city. Solid waste management of the city is mainly influenced by rapid increasingly population. The city has an area of 300.00 Sq. Kms and population of 5,78,420 as per 2011 census. The growth rate of urban population is more than rural population. As compared to census 2001 records, the population growth rate of Dehradun is seen nearly to 32.48% over the decade 2001-2011 and it is estimated that it will grow continuously over the decades. The present and projected population of the city as adopted under in Water Supply data project report (DPR) for Dehradun city already approved by Government of India is as under[2]:-

Table 1: Projected Population of Dehradun

Year	Permanent Population	Equivalent Floating and Institutional Population	Total Population
2011	823099	82310	905409
2021	1151932	115193	1267125
2031	1508461	150846	1659307
2041	1801864	180186	1982050

Source : Detailed Report on Nagar Nigam Dehradun Solid Waste Management (2007-2008) [2]

The rapid increasing growth of population, urbanization and industrialization tends to generate a number of tons of municipal solid waste daily with a variety of positive and negative both consequences. In many cities, because of improper co-ordination and planning, management of solid waste fails. Apart from local bodies, public participation is an important key to get rid of this. The management of municipal solid waste is going through a critical phase, due to unavailability of suitable facilities to treat and dispose of the large amount of municipal solid waste generated daily (M. Sharholy et al./waste management, 2008). The process of municipal solid waste management involves activities of generation, storage, collection, transfer and transport, processing and disposal. The management of municipal solid waste requires proper infrastructure, maintenance and upgrade for all activities[3].

As per estimates provided by Dehradun municipal corporation, an average of 200 to 250 MT of municipal solid waste is collected every day within city limits. Until a few months ago, garbage was being thrown in Sahastradhara based open trenching ground (covers area of 800x500 Sq. m.), an area in which there are many residential societies and schools (Times of India, 2017). Improper management of solid waste is increasing an alarm rate, which is dangerous for sustainable development. Due to being in the valley, Dehradun's climate is subtropical humid. Because of which treatment options can fail and raise economic issues. An improved option is required to deal with solid waste properly.

II. WASTE MANAGEMENT HIERARCHY

The waste management hierarchy is a sequential order of processes or steps used to minimize the waste. The hierarchy process is a tool used to achieve sustainability goals. Waste hierarchy approaches in the direction of nature's and human's wellbeing. The waste hierarchy helps government bodies or local authorities, environmental agencies and organizations as a guiding principle for managing waste. It is a six step procedure in which prevention as a most preferable option is at top and disposal as a least preferable option is at bottom. One concept of 3R's is also comes under waste management hierarchy, which shows reduce, reuse and recycle. The aim of waste hierarchy is to generate less amount of waste and it encourages the development of green technologies.

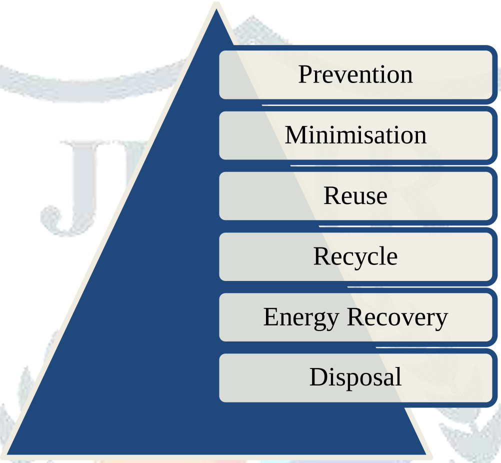

Fig 1: The waste Management Hierarchy

III. MATERIAS AND METHODS

The studies carried out by the National Environmental Engineering Research Institute (NEERI) in Indian cities have revealed that the quantum of municipal solid waste generation varies between 0.21-0.35 Kg/capita/day in large cities[4]. Based on this, municipal solid waste generation of Dehradun city can be taken as 0.323 Kg/capita/day. The consultants carried out independent studies to assess the quantities of wastes generated in the city and transported each day. The studies revealed the following details of projected quantities of waste generation[2]:-

Table 2: Waste Generation as Compared to Previous Years

Year	2007	2011
Projected population including equivalent floating population	789699	905409
Total waste from residential areas/ day in MT/ day (calculated from waste generated from households)	161.89	185.61
Commercial waste in MT/ day	46.67	58.86
Street Sweepings (better SWM systems will reduce the quantity of street sweepings)	48.13	48.13
Total waste generation per day in MT	256.69	292.6
Per capita waste generation in Kg/ day	0.357	0.323

Source : Detailed Report on Nagar Nigam Dehradun's Solid Waste Management (2007-2008) [2]

According to the day to day record maintained by Dehradun Nagar Nigam, It is observed that they transport on an average 200-250 MT/ day waste.

3.1 Waste Treatment Methods

A long ago, municipal waste consists of biodegradable matter. With time municipal waste increases and now it has more non-biodegradable and plastic content, which is responsible for rise in health and environmental problems. There is a need to involve private sector and community participation in waste management[1]. The solid waste management technologies along with the challenges and opportunities of each one in a realistic approach should be analyzed for suggesting a suitable solution[4]. The technology options available for processing the Municipal Solid Waste are based on either bio conversion or thermal conversion (Diaz et al., 2002; Benedict et al., 1988; Corey, 1969; Tchobanoglous, 2003; UNEP, 2005; Salvato, 1992)[6]. In the bio-conversion process, enzymatic microbial action decomposes organic matter to produce methane (waste to energy) or to form compost. Waste to energy (WtE) can be considered as a potential alternative source of energy, which is economically viable and environmentally sustainable[12]. Wastes with high moisture and high organic biodegradable matter are treated by using this process. Thermal decomposition of waste to produce heat energy or gas is done in thermal conversion process. This process is mainly used for high percentage non-biodegradable wastes. The main thermal conversion technology option is incineration.

Table 3: Parameters Governing Various Processes For Energy Recovery

Waste Treatment Method	Basic Principle	Important Waste Parameters	Desirable Range
Biochemical conversion ➢ Anaerobic digestion ➢ Biomethanation	Decomposition of organic matter by microbial action	Moisture content volatile matter C/N ratio	>50% >40% 25-30
Thermochemical conversion ➢ Incineration ➢ Pyrolysis ➢ Gasification	Decomposition of organic matter by action of heat	Moisture content volatile matter Fixed carbon Total inerts Calorific value (Net CV)	<45% >40% <15% <35% >1200Kcal/Kg

Source: COWI, 2004 [14]

3.1.1 Composting

Composting is a controlled aerobic biological process in which microorganisms decomposes organic waste into a humus-like product, i.e., compost. Composting is highly relevant in India and should be considered in all municipal solid waste management concepts. Composting converts non-toxic biodegradable kitchen and other organic waste into manure. In Indian urban local bodies, it is the most popularly used technology option. It is advantageous and cost effective. A study on combination of vegetable waste, cattle manure and saw dust was utilized for high rate composting in a household rotary drum composter [4]. The rotary drum composting process of mixed organic waste yielded suitable compost with moisture content reduction of 61% to 43% and the BOD/COD ratio reduced from 0.94 to 0.23, within composting period of 20 days[4].

The vermicomposting represents an alternative approach in waste management as a process for handling organic residuals, as much as the material is neither landfilled nor burned but is considered a resource that may be recycled. In this sense, vermicomposting is compatible with sound environmental principles that value conservation of resources and sustainable practices[8]. But a case study on heavy metal distribution in soil and plant in municipal solid waste compost amended plots revealed that there was an important load/transfer of metal ions from soils to wheat plants[13]. Hence, the adverse effects of composting should also be analyzed before use.

3.1.2 Biomethanation

The anaerobic process, in which microorganisms converts waste organic matter into biogas and manure. The process is based on anaerobic digestion and is widely used to treat wastewater sludge and organic wastes because it provides volume and mass reduction of the input material (monsal.com, 2007). It produces methane and carbon dioxide rich biogas suitable for energy production and hence, is a renewable energy source[6]. The anaerobic digestion of organic fraction of municipal solid waste had been conducted in pilot-scale reactor based on high-solid combined anaerobic digestion process yielded efficient bio-gas production[4]. The process of biomethanation decreases greenhouse gases emissions and creates organic fertilizer. But many studies have proven that poor design of reactors or digestor issues along with elevated investment and operating costs are the limitations[4].

3.1.3 Incineration

Incineration is a conversion process of waste into ash by combustion. The process converts the waste into ash formed by the inorganic constituent of the waste and the flue gases and heat produced can be used to generate electric power and can also reduce the amount of waste by 85-90%[14]. At present, municipal solid waste incineration in waste-to-energy plants is one of the important technology option in most of the developed countries[7]. The combustion process requires high temperature of the order of 800-1000 ^{o}C and involves essentially, drying, volatilization, and ignition and desirably, elimination of odors, and combustion of unburned furnace gases and carbon suspended in the gases[6]. Incinerators may reduce the volume of solid waste, but they do not dispose the toxic substances contained in the waste and they create the largest source of dioxins and emit a wide range of pollutants in their stack gases, ashes and other residues[4]. The efficiency of the technology is linked to the waste characteristics and their properties such as moisture content and calorific values[6]. The physical composition studies for incineration are;

Table 4: Physical Composition Studies

S. No.	Composition	Products Included
1	Paper	a) Paper, newspaper, wrappers b) Cardboard, packaging materials
2	Plastics	a) Plastic bags, bottles

		b) Plastic packaging material c) Wires, etc.
3	Rubber	Rubber tires
4	Vegetable/ organic matter	a) Vegetable matter b) Food waste c) Garden waste d) Wood
5	Hazardous material	a) Biomedical syringes b) Discarded medicines, bottles containing pesticides, dry cells, electronic circuits
6	Metals	a) Ferrous cables b) Non ferrous foils, cables, etc.
7	Glass	Glass bottles
8	Ceramics	Pottery
9	Soil	Soil, sand, ash, dust, stones, construction wastes, bricks
10	Miscellaneous	Cloth and material not covered under above categories

Source: COWI, 2004 [14]

The special benefit of incineration is destruction and detoxification of particular wastes (e.g. combustible carcinogens, pathologically contaminated materials, toxic organic compounds and biologically active materials), rendering them more suitable for final disposal[4]. The incinerator plants generates large amount of flue gases and toxic emissions. For which air pollution control (APC) system (comprises electrostatic precipitators; bag house filters; dry, semi-dry, and wet acid gas removal systems; catalysts; and the like) are used[7].

3.1.4 Gasification Technology

The objective of gasification has generally been to produce fuel gas, which would be stored and used when required, and incineration of solid waste under oxygen deficient conditions is called gasification[15]. The technology can process any carbonaceous material, changing it into types of usable vitality that can be wiped or sold effectively. Gasification is an alternative process for energy recovery and disposal of municipal solid wastes. Gasification technology transforms variety of less importance feedstock into high importance materials, it can changes over any carbon-containing material into a syngas (synthesis gas). The advantage of gasification is that using the syngas (synthesis gas) is more efficient than direct combustion of the original fuel; as it may be burned directly in internal combustion engines, used to produce methanol and hydrogen, or converted via the Fischer-Tropsch process into synthesis fuel[6].

The syngas is a combustible gas mixture and one of the source to generate electricity. Gasification includes partial oxidation of a substance, it lies amongst burning and pyrolysis at 750 °C. Gasification is a reliable option as it meets the present emission standards and is helpful in maintaining the sustainability of landfills[9]. The gasification lessens MSW transfer expenses and landfill space with decay of methane emanations from landfills. With gasification, MSW are no longer but they become feedstock for a gasifier. In India, there are few gasifiers in working, yet most of them are to burn of biomass, for example, agro-residues, sawmill residue, and forest wastes.

3.1.5 Landfill

In many metropolitan cities, open, uncontrolled and poorly managed dumping is commonly practiced, giving rise to serious environmental degradation[15]. More than 90% of MSW in cities and towns are directly disposed of on land in an unsatisfactory manner and such dumping activity in many coastal towns has led to heavy metals rapidly leaching into the coastal waters[15]. Landfill is the structure built up on ground for disposal of waste. With minimum nuisance to human health, it is the oldest form of waste treatment. Landfills are designed in layers covered by soils. Waste is buried in that depression in order to avoid any hydraulic connection between trash and environment including air and water[9]. Flexible design is required for the treatment of leachate. Rainwater percolating through the solid waste carry large amount of pollutants to the ground water aquifers. Hence the sanitary landfill design should include expensive and carefully constructed impermeable layers which prevent the leachate from contaminating the ground water resources[4].

Landfills are considered to be one of the major sources of methane generation[14]. According to Climate Change Congress, 1995, methane emissions from landfills are twenty times more responsible for global warming than the same quantity of carbon dioxide. And for this, the new technique of phytocapping is used as a remedial action. The study conducted at Rockhampton's Lakes Creek Landfill in Australia concluded that phytocaps can reduce surface methane emissions 4 to 5 times more than the adjacent un-vegetated site[4].

3.1.6 Biodrying

Biodrying is a variation of aerobic decomposition used for the mechanical–biological treatment organic substances to dry and partially stabilize residual municipal waste[11]. Biodrying is a type of natural biological treatment of solid waste that reduces dampness through the creation of inner warmth. The term biodrying was coined by Jewell et al (1984), whilst reporting on the operational parameters relevant for drying dairy manure. The process removes moisture (dampness) content from waste material and prepares waste as moisture less material to use in waste to energy[10]. The biodrying (biological drying) process completes working in a reactor called as biodrying reactor. In biodrying, in addition to forced aeration when organic substances degrades aerobically, heat is generated which results in the removal of water from bio-wastes. It is a possibility for the bioconversion reactor in mechanical biological treatment (MBT) plants, an option for treating leftover waste. Within biodrying reactors, waste is dried by air convection. The biodrying reactor aims to pre-treat waste at the lowest possible residence time in order to produce a high quality solid recovered fuel (SRF). Optimal biodrying can be accomplished through viable reactor design and conditioning of the material, joins with suitable process monitoring and control. In biodrying, the fundamental drying instrument is convective evaporation utilizing heat from the aerobic bio degradation of waste segments and encouraged by the mechanically supported airflow. The process is different from composting in that the output of the composting process is stabilized organic matter, but the output of the biodrying process is only partially stabilized, which is useful for energy production from the biodried MSW[4]. Biodrying helps in reducing the volume, size and weight of waste particles.

This process decreases the waste water content in waste materials about 30-40 %, due to which waste going to landfill lessens. Biodrying is a good alternative option to incineration and prepares waste to use it in refuse derived fuel (RDF) and relatively a new sustainable technology for MSW treatment, used in many developing nations with advantage of socio-economic limitations reduction.

IV. RESULTS

The generation of waste increases with time in Dehradun. The waste material contains many chemical composition. Because of which if waste is not treated or managed in proper time duration, then this leads to ground water and environment's harm. In present, municipal waste of Dehradun city is treated by using the process of composting and landfilling. Keeping in mind the point of future, with the idea of sustainability and for more betterment of waste treatment gasification and biodrying recycling processes can be used. The process of recycling converts waste into usable products. Recycling is the key component of modern waste reduction[3].

V. CONCLUSION

In the study, analysis of various technological treatment options for municipal solid waste has been carried out. At present, the concerned authority dealing with the issue of solid waste. Dehradun is moving on the path of development and continuously increasing solid waste may be creates some problem. Keeping in mind Dehradun's weather conditions, composting, vermicomposting, landfilling, biomethanation and biodrying are the appropriate technological options for city's solid waste treatment. According to studies among all the options, can believe that Biodrying will be able to meet requirements of sustainable development. Every technology has advantages and disadvantages, therefore the selection of technology option for treatment should be done carefully and sensibly. Apart from these, general awareness in society related to solid waste is also necessary to fight with the problem of solid waste because public participation plays an important role in effective ecological and economical management.

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