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Effective methods of waste management in India

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Abstract

Municipal Solid Waste (MSW) is a major concern for all of the world including our country on this date, a lot of solid waste is being produced in India on a daily basis and this waste causes harm to environment and human beings too, so we need to have good methods to reduce the detrimental effect of these wastes to the environment. This paper has discussed some of the methods that are used for waste management in India namely Burying of solid wastes, Incineration of solid waste, The 'R' solution and Biological treatment of organic waste, paper also discusses the different challenges faced by these methods in India and how to minimize the waste produced. Solid waste management is one among the basic essential services provided by municipal authorities in the country to keep urban centers clean. However, it is among the most poorly rendered services in the basket. The systems applied are unscientific, outdated and inefficient; population coverage is low; and the poor are marginalized. Waste is littered all over leading to insanitary living conditions. Municipal laws governing the urban local bodies do not have adequate provisions to deal effectively with the ever- growing problem of solid waste management. With rapid urbanization, the situation is becoming critical. The urban population has grown fivefold in the last six decades with 285.35 million people living in urban areas as per the 2001 Census.
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Keywords: Waste Management, MSW, Land fill Management, Incineration

1. Introduction

In India, a proper waste management system is urgent necessary for the following reasons:

- To control different types of pollution, i.e., air pollution, soil pollution, water pollution etc.
- To stop the spread of infectious diseases.
- To conserve all our environmental resources, including forest, minerals water etc.
- To recycling of hazardous wastes for further production.

For this various waste management methods should be studied so that they can be used for minimising harm from the waste in our country

Although there are alarming predictions that global waste will nearly double to 2.2 billion annual tonnes by 2025 [1], and although almost all the cities in the world have problems to meet their waste reduction goals [2], urban waste has not get the required attention as much as water or energy in city planning are getting [3], nor has commensurate attention been given to the manifold infrastructures required to contend with this mounting problem and also waste consumes space, the problem of waste and its negative impacts have yet to be fully studied in planning and environmental design [4]. MSW, which refers to the materials disposed in urban areas which includes pre-dominantly household waste and commercial waste which is collected and disposed by municipalities, has long posed hostility to environmental quality and human health [5]. In past following years, rigorous growth of population, fast economic development and constant urbanization have led to a very large amount of wastes generation from industrial activities and household consumption, especially in capitals and major urban centres [6]. These urban wastes can be classified as municipal solid waste (MSW), industrial and domestic waste water and animal waste, etc [7]. Waste management is very important for sustainable development of a country and this paper have reviewed some of waste management techniques used in India.

Solid waste is any unwanted or discarded material we produce that is not a liquid or gas or any garbage, refuse, sludge from a waste treatment plant or air pollution control facility, and other discarded material (including solid, liquid, semi-solid or

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contained gaseous material) generated from any industrial, commercial or community activities, mining or agricultural operations which can be categorized in two types i.e. Municipal Solid Waste and Industrial Solid Waste which is produced indirectly by industries that supply people with goods and services.

India is experiencing high urbanization, currently 31 percent as per Census 2011, contributing to 11 percent of the world population and having 53 metropolitan cities which may jump to 87 in 2031 [8]. It was estimated in 2014 by Planning Commission that urban India will generate 2,76,342 TPD by 2021, 4,50,132 TPD by 2031 and 11,95,000 TPD of MSW by 2050. (Planning Commission, 2014). The report showed that MSW then contained 51 percent of organic waste, 32 percent inert and non-organic waste collectively. Plastics, paper, and glass constitute 17 percent of waste which can be classified as recyclable wastes [9].

The improper disposal of municipal waste has a serious and dangerous impact on a wide range of areas. Garbage thrown in the street or in open spaces creates a public health hazard, while waste dumped near rivers, lakes and streams contaminates the water supply. Rubbish that is burned in the open rather than disposed of properly creates pollution and releases toxic fumes into the environment. Non-biodegradable materials thrown into open drains make their way into the sewerage system, clogging pipelines and damaging infrastructure. The hazards posed by the dumping of untreated hospital and industrial waste are even greater, with the release of pathogens and toxic compounds posing a grave threat not just to human life but also to plants and animals. Garbage dumped in the countryside is not simply an eyesore; entire landscapes are ruined and unique habitats for flora and fauna are lost.

All of these problems are common in India, where vast quantities of solid waste remain uncollected in the streets, along major roads, in empty plots of land, downhill slopes and in illegal dumps. Table 1 shows the composition of the MSW produced in India in different year.

The main obstacles in the way of growth in wide use of waste management methods are

- Lack of awareness among the population.
- Segregation of MSW is difficult in India.
- Lack of appropriate level funding.
- Lack of implementation of rules at ground level.
- Lack of coordination among Centre and State.

The report of the Task Force on Waste to Energy (Vol.I), 2014 shows that out of 29 only 22 states/UTs have sufficient infrastructure for processing and disposing waste and the rest of the States/UTs had made no progress till 2013. Of the 279 conventional composting, 138 vermi composting facilities, 172 biomethanation,29 RDF and 8 Waste to Energy plants which were established many are either closed or not performing on their potential [9].

Drawbacks in present solid waste management services

1.1 No Storage of Waste at Source

There is no practice of storing the waste at source in a scientifically segregated way. Citizens have not been educated to keep domestic, trade, and institutional bins for storage of waste at source and stop littering on the streets.

1.2 No System of Primary Collection from the Doorstep

There is no public system of primary collection from the source of waste generation. The waste discharged here and there is later collected by municipal sanitation workers through street sweeping, drain cleaning, etc. Street sweeping has, thus become the principal method of primary collection.

1.3 Irregular Street Sweeping

Even street sweeping is not carried out on a day-to-day basis in most cities and towns in India. Generally commercial roads and important streets are prioritized and rest of the streets are swept occasionally or not swept at all. Generally, no sweeping is done on Sundays and public holidays and a back log is created on the next working day.

The tools used for street sweeping are generally inefficient and out -dated. For instance, the broom with a short handle is still in use forcing sweepers to bend for hours resulting in fatigue and loss of productivity.

Traditional handcarts/tricycles are used for collection, which do not synchronize with the secondary storage systems. Waste is deposited on the ground necessitating multiple handling.

There are no uniform yardsticks adopted for street sweeping. Though, some states/cities have prescribed work-norms, these are not very scientific. Most of the cities allocate work to sanitation workers on ad hoc basis. The work distribution ranges between 200 metres to 1000 metres of street sweeping each day. Some sanitation workers are found under worked while some overburdened

.

1.4 Waste Storage Depots

As waste is collected through traditional handcarts/tricycles that can carry only a small quantity of waste at a time, there is a practice to set up depots for temporary storage of waste to facilitate transportation through motorized vehicles. Generally, open sites or round cement concrete bins, masonry bins or concrete structures are used for temporary bulk storage, which necessitates multiple handling of waste. Waste often spills over which is both unsightly as well as unhygienic.

1.5 Transportation of Waste

Transportation of waste from the waste storage depots to the disposal site is done through a variety of vehicles such as bullock carts, three-wheelers, tractors, and trucks. A few cities use modern hydraulic vehicles as well. Most of the transport vehicles are old and open. They are usually loaded manually.

Year	Biodegradables	Paper	Plastic/Rubber	Metal	Glass	Rags	Others	Inert
1996	42.21	3.63	0.60	0.49	0.60	-	-	45.13
2005	47.43	8.13	9.22	0.50	1.01	4.49	4.02	25.16
2011	42.51	9.63	10.11	0.63	0.96	-	-	17.00

The fleet is generally inadequate and utilization in optimal. Inefficient workshop facilities do not do much to support this old and rumbling squad of squalid vehicles. The traditional transportation system does not synchronize with the system of primary collection and secondary waste storage facilities and multiple manual handling of waste results.

1.6 Processing of Waste

Generally no processing of municipal solid waste is done in the country. Only a few cities have been practising decentralized or centralized composting on a limited scale using aerobic or anaerobic systems of composting. In some towns un-segregated waste is put into the pits and allowed to decay for more than six months and the semi-decomposed material is sold out as compost. In some large cities aerobic compost plants of 100 MT to 700 MT capacities are set up but they are functioning much below installed capacity. A few towns are practising vermi-composting on a limited scale.

1.7 Disposal of Waste

Disposal of waste is the most neglected area of SWM services and the current practices are grossly unscientific. Almost all municipal authorities deposit solid waste at a dump-yard situated within or outside the city haphazardly and do not bother to spread and cover the waste with inert material. These sites emanate foul smell and become breeding grounds for flies, rodent, and pests. Liquid seeping through the rotting organic waste called leachate pollutes underground water and poses a serious threat to health and environment.
Landfill sites also release landfill gas with 50 to 60 per cent methane by volume. Methane is 21 times more potent than carbon dioxide aggravating problems related to global warming. It is estimated by TERI that in 1997 India released about 7 million tons of methane into the atmosphere. This could increase to 39 million tons by 2047 if no efforts are made to reduce the emission through composting, recycling, etc

1.8 Waste

It is defined as “non-liquid, non-soluble materials ranging from municipal garbage to industrial wastes that contain complex & sometimes hazardous substances”. Solid waste also include.

- Garbage
- Rubbish
- Demolition products
- Sewage treatment residue
- Dead animals
- Manure and other discarded material.

1.8.1 Types of Waste

1. Household waste as municipal waste.
2. Industrial waste as hazardous waste.
3. Biomedical waste or hospital waste as infectious waste.

1.8.2 Municipal Solid Waste

Municipal solid waste consist of
- household waste
- construction and demolition debris
- sanitation residue
- waste from streets

With rising urbanization and change in life style and food habits, the amount of municipal solid waste has been increasing rapidly and its composition changing.
Municipal waste is generated by households, commercial activities and other sources whose activities are similar to those of households and commercial enterprises.
Municipal waste is made up to residual waste, bulky waste, secondary materials from separate collection (e.g., paper and glass), household hazardous waste, street sweepings and litter collections. It is made up of materials such as paper, cardboard, metals, textiles, organics (food and garden waste) and wood. Municipal waste represents approximately 14% of all waste generated.

1.8.3 Hazardous Waste

Industrial and hospital waste is considered hazardous as they may contain toxic substances
Hazardous waste could be highly toxic to humans, animals and plants. They are
- corrosive
- highly inflammable or explosive

In the industrial sector the major generators of hazardous waste are the metal’ chemical’ paper, pesticide, dye and rubber goods industries. Direct exposure to chemicals in hazardous waste such as mercury and cyanide can be fatal.
Hazardous waste is a waste which may pose a substantial present or potential hazard to human health or the environment

when improperly treated, stored or disposed of, or otherwise mismanaged or cause or contribute to an increase in mortality, or an increase in irreversible or incapacitating illness.
Hazardous waste is typically the subject of special legislation and requires special management arrangements to ensure that hazardous waste is kept separate from and treated differently to non-hazardous waste.

1.8.4 Hospital Waste Or Biomedical Waste

Bio-medical waste means "Any waste which is generated during the diagnosis, treatment or immunization of human beings or animals or in research activities pertaining thereto or in the production or testing of biological"
It may includes wastes like sharp waste, pathological waste, pharmaceutical waste, genotoxic waste, chemical waste, and radioactive waste etc.

2. Waste Management Methods

2.1 Burying Solid Waste

Most of the world's MSW is buried in landfills that eventually are expected to leak toxic liquids into the soil and underlying aquifers.

Open dumps: are fields or holes in the ground where garbage is deposited and sometimes covered with soil. Mostly used in developing countries.

Sanitary landfills: method of controlled disposal of municipal solid waste (refuse) on land. The method was introduced in England in 1912 (where it is called controlled tipping). In this method the waste is first collected in thin layers that can be of 1m high and then it is compressed by heavy machines (e.g., bulldozers); many layers of these are then placed on top of one other and compressed again to form a refusal cell which can be up to 3 metres, thick. The compressed cell is then protected with a layer of compressed soil by putting it on top to act as a shield to avoid odours and windblown debris. Modern landfill sites are carefully covered and sealed with impermeable synthetic bottom liners to avoid pollution of groundwater and other environmental pollutions. When the landfill is filled to the top then a layer of clay or synthetic liner is placed over it to prevent water from entering. On top of it a final layer of soil is placed then compressed and graded. After sometimes some plants can be grown on it to increase its usefulness and maybe convert into garden or parks. Chakraborty M, Sharma C, Pandey J and Gupta P.K. Estimated energy potential of incineration process in Delhi's MSW, bomb calorimeter was used to determine calorific values of Delhi's MSW samples. The calorific values was found to be 0.058–0.078 kW/kg for segregated waste containing mixture of kitchen waste, litter with small branch of shrubs, etc. and 0.092–0.126 kW/kg for the bulk waste (excluding plastic, rubber, wooden materials and packing and other inert materials) [10].

Sanitary landfills are the ultimate means of disposal of all types of residual, residential, commercial and institutional waste as well as unutilized municipal solid waste from waste processing facilities and other types of inorganic waste and inerts that cannot be reused or recycled in the foreseeable future.Its main advantage is that it is the least cost option for waste disposal and has the potential for the recovery of landfill gas as a source of energy, with net environmental gains if organic wastes are land filled. The gas after necessary cleaning, can be utilized for power generation or as domestic fuel for direct thermal applications1. Highly skilled personnel are not required to operate a sanitary landfill.
Major limitation of this method is the costly transportation of MSW to far away landfill sites. Down gradient surface water can be polluted by surface run-off in the absence of proper drainage systems and groundwater aquifers may get contaminated by polluted leacheate in the absence of a proper leacheate collection and treatment system.

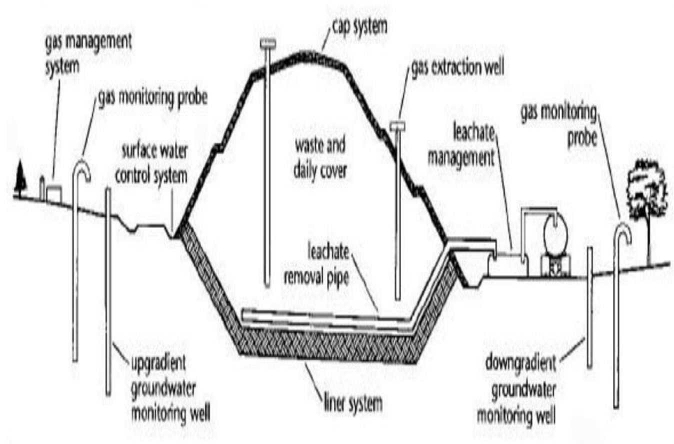

Fig.1- A typical Sanitary landfill [11].

3. Incineration or Burning of Solid waste

This method, commonly used in developed countries is most suitable for high calorific value waste with a large component of paper, plastic, packaging material, pathological wastes, etc. It can reduce waste volumes by over 90 per cent and convert waste to innocuous material, with energy recovery. The method is relatively hygienic, noiseless, and odourless, and land requirements are minimal. The plant can be located within city limits, reducing the cost of waste transportation.
This method, however, is least suitable for disposal of chlorinated waste and aqueous/high moisture content/low calorific value waste as supplementary fuel may be needed to sustain combustion, adversely affecting net energy recovery. The plant requires large capital and entails substantial operation and maintenance costs. Skilled personnel are required for plant operation and maintenance. Emission of particulates, SOx , NOx, chlorinated compounds in air and toxic metals in particulates concentrated in the ash have raised concerns. Combustion is a reaction which occurs between fuel and oxidant to produce heat. The fuel can be of three types

namely gaseous, liquid or solid. Upon combustion, chemical reactions between fuel and oxidant take place and finally the heat released from the reactions makes the process self sustaining [12]. Waste incineration is most appropriate for certain kind of waste which comprises of combustible MSW with non-biodegradable material and low moisture content [13]. In the world there are over 1000 large incinerators which converts waste to energy by using heat energy released from incinerator to boil water to make steam which can be used to produce electricity. Incineration is the process of direct burning of waste in the presence of excess air (oxygen) at temperatures of above 800˚C that liberates heat energy besides generating inert gases and ash. In practice, about 65–80% of the energy content of the organic matter can be recovered as heat energy, which can be utilized either for direct thermal applications, or for producing power via steam turbine generators [14]. This process can reduce the waste volume up to 90% [5] and the capital cost of this process is lower than the cost of biomethanation process.Fig.2 shows the construction and working of a typical incinerator. The main disadvantages of this technology is the high recurring cost of the tune of Rs. 5460/ton of waste processing in which 80% of this cost is spent on fuel to burn the waste [15]. To economically use this technology, the minimum calorific value of MSW required was found to be 0.07 kW/kg which is difficult to get due to presence of high moisture contents. Another major issue associated with this technology is the emission of gases like polychlorinated biphenyl (PCBs), hydrogen chloride, hydrogen fluoride, mercuric chloride, dioxins and furans (PCDD/F) which are extremely toxic and are considered to be carcinogens which are harmful and injurious for the animals and also to human health [16].

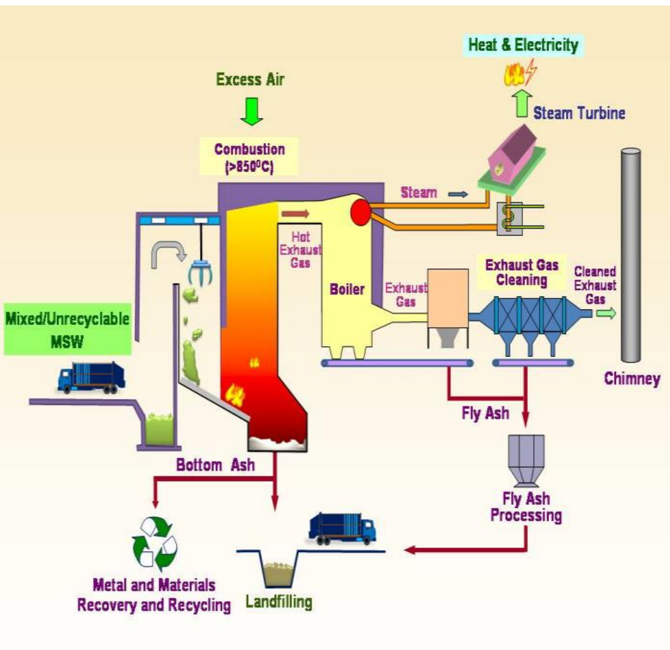

Fig.2- Waste-to-energy incinerator with pollution controls that burns mixed solid waste [17].

4. The R Solution

- *Refuse*: It means one should refuse to buy items that they don't need.
- *Reduce:* If refers to consume less and live a simpler and less stressful life by practicing simplicity.
- *Reuse*: use those items that can be used over and over.
- *Repurpose:* use the previously used item for another purpose instead of throwing it away.
- *Recycle*: paper, glass, cans, plastics and buy items made from recycled materials.

Reusing products is an important way to reduce resource use, waste, and pollution in developed countries. In developing countries where there are open dumps this can be dangerous as the scavengers are exposed to various toxins and harmful materials.

4.1 Primary (closed loop) recycling

In this type of recycling materials are turned into new products of the same type in other words primary recycling means that the recyclable material/product is recovered and reused without being changed in any way and usually for the very same purpose.

4.2 Secondary recycling

In this type of recycling materials are converted into different products. Used tires shredded and converted into rubberized road surface. Newspapers transformed into cellulose insulation. Composting biodegradable organic waste mimics nature by recycling plant nutrients to the soil. Recycling paper has a number of environmental (reduction in pollution and deforestation, less energy expenditure) and economic benefits and is easy to do. Many types of plastics are very hard to recycle due to their chemical composition and cost of appropriate recycling technique. Not very much material can be yielded from collecting individual plastic resin. The cost of new plastic resins in much less than recycled plastic resins which is due to low fossil fuel costs. There are new technologies in world that are making plastics biodegradable.

4.3 Tertiary recycling

Tertiary recycling can be defined as a process that involves chemical modification of the material used in order to use it again for a purpose.

5. Biological treatment of organic waste

5.1 Aerobic Composition

Roughly half of household waste is made up of food and garden waste. Most of this material could be composted to save landfill, improve soil condition and provide fertiliser in the garden at no cost. Composting is the method of breaking down

waste organic materials in a large container or heap. The decomposition occurs because of the naturally occurring micro-organisms, such as bacteria and fungi.
Aerobic composting is a process where adequate ventilation should be provided to allow respiration of microorganisms that release carbon dioxide into the atmosphere, therefore aeration of composting material is necessary for efficient decomposition. The oxygen saturation in the medium should not be lower than 5%, whereas 10% is the optimal level for efficient decomposition. Excessive aeration will cause a temperature drop and a great loss of moisture by evaporation, causing the decomposition process to stop. On the other hand, low aeration prevents enough water evaporation, generating excessive moisture and an anaerobic environment [18]. Most composters are designed to provide adequate aeration of the waste. In the event of insufficient aeration, it is necessary to stir the material.

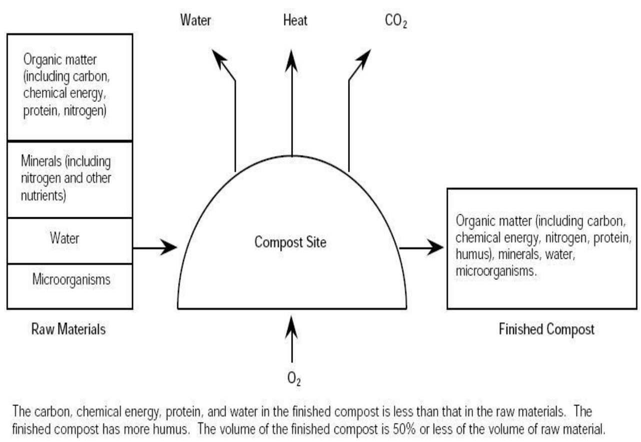

Figure 3. Aerobic Composting [20].

Composting is a technology known in India since times immemorial. Composting is the decomposition of organic matter by microorganism in warm, moist, aerobic and anaerobic environment. Farmers have been using compost made out of cow dung and other agro-waste. The compost made out of urban heterogeneous waste is found to be of higher nutrient value as compared to the compost made out of cow dung and agro-waste. Composting of MSW is, therefore, the most simple and cost effective technology for treating the organic fraction of MSW. Full-scale commercially viable composting technology is already demonstrated in India and is in use in several cities and towns. Its application to farm land, tea gardens, fruit orchards or its use as soil conditioner in parks, gardens, agricultural lands, etc., is however, limited on account of poor marketing.
Main advantages of composting include improvement in soil texture and augmenting of micronutrient deficiencies. It also increases moisture-holding capacity of the soil and helps in maintaining soil health. Moreover, it is an age-old established concept for recycling nutrients to the soil. It is simple and straightforward to adopt, for source separated MSW. It does not require large capital investment, compared to other waste treatment options. The technology is scale neutral. Composting is suitable for organic biodegradable fraction of MSW, yard (or garden) waste/waste containing high proportion of lignocelluloses materials, which do not readily degrade under anaerobic conditions, waste from slaughterhouse and dairy waste.
This method, however, is not very suitable for wastes that may be too wet and during heavy rains open compost plants have to be stopped. Land required for open compost plants is relatively large. Also, issues of methane emission, odour, and flies from badly managed open properly carried out there is possibility of toxic material entering the stream of MSW.

5.2 Vermi Composting

It is process in which earthworms are spread on semi-decomposed organic waste. Earthworms can eat upto five times of organic matter per day as compared to their body weight. Initially, biodegradable organic matter is decomposed through microbial enzymatic activity. 100 Million Tons/day capacity vermin-composting plant is located in Bangalore which is India's largest, while there are smaller plants in Hyderabad, Bangalore, Mumbai, and Faridabad.
Vermi-compost is the natural organic manure produced from the excreta of earthworms fed on scientifically semi-decomposed organic waste. A few vermi composting plants generally of small size have been set up in some cities and towns in India, the largest plant being in Bangalore of about 100 MT/day capacity. Normally, vermi-composting is preferred to microbial composting in small towns as it requires less mechanization and it is easy to operate. It is, however, to be ensured that toxic material does not enter the chain which if present could kill the earthworms.

5.3 Anaerobic digestion

Anaerobic decomposition of waste is also known as biomethanation process. It is one of the important and sustainable techniques for treatment of the biodegradable part of MSW in subtropical climates. In this process, stabilization occurs and biogas is liberated by the conversion of organic matter, which in turn can be used as energy. The biogas has 55–60% methane and it can be used as fuel for power generation. Government of India encourages biomethanation technology by utilizing industrial, agricultural and municipal wastes. Biomethanation has advantage due to low capital and operating costs compared to other methods but the main problem with this method is of amount space it uses for, as it requires the covering of waste for developing anaerobic conditions and that cover cannot be opened for next few years thereby making that space unavailable for further dumping of MSW and after 4–7 years, the methanation process becomes unviable due to low carbon content in the remaining waste. Therefore, very large space is required to operate biomethanation plants for treatment of city's daily MSW generation [10].

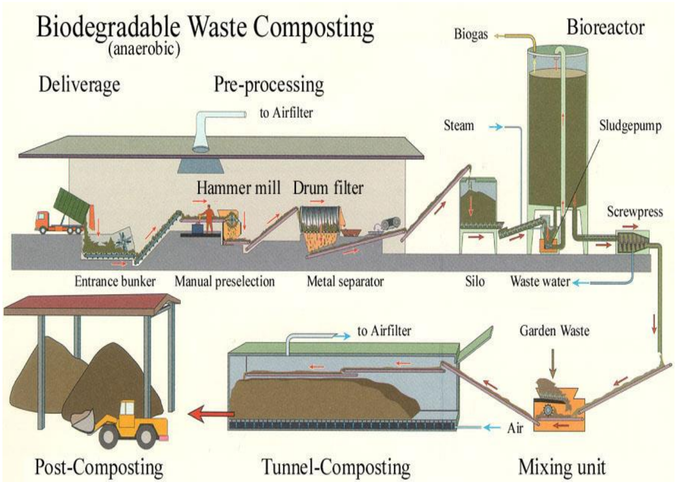

Figure 4. Anaerobic Composting [21].

Biomethanation is a comparatively well-established technology for disinfections, deodorization and stabilization of sewage sludge, farmyard manures, animal slurries, and industrial sludge. Its application to the organic fraction of MSW is more recent and less extensive. It leads to bio-gas/power generation in addition to production of compost (residual sludge). This method provides a value addition to the aerobic (composting) process and also offers certain other clear advantages over composting in terms of energy. This method is suitable for kitchen wastes and, other putrescible wastes, which may be too wet and lacking in structure for aerobic composting. It is a net energy-producing process (100–150 kWh per tonne of waste input). A totally enclosed system enables all the gas produced to be collected for use. A modular construction of plant and closed treatment needs less land area. This plant is free from bad odour, rodent and fly menace, visible pollution, and social resistance. It has potential for co-disposal with other organic waste streams from agro-based industry. The plant can be scaled up depending on the availability of the waste.

6. Refused derived fuel (RDF)

This is one of WTE process where installation costs as well as maintenance costs are lowest among all the available methods. Other benefits associated with this technology are the higher heating value (0.145–0.194 kW/kg) which also remains fairly constant in the presence of 3–8% moisture content [19], the homogeneity of physio-chemical composition, the ease of storage, handling, and transportation, the lower pollutant emissions and a reduced excess air requirement during combustion.

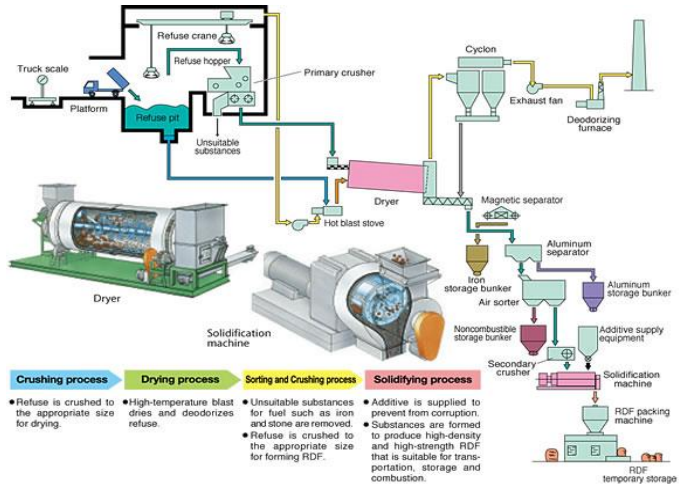

Figure 5. Refuse Derived Fuel Plant [22].

The high calorific value of RDF is due to its higher density (700 kg/m3) compared to the other forms of waste. It has been estimated that 160–180 ton of garbage are required to produce 40 ton of pellets [19]. Chakraborty M, Sharma C, Pandey J and Gupta P.K. found that the WTE generation potentials for RDF process range from 9 to 19, 8 to 18, 6 to 15 MW/day for Ghazipur (GL), Bhalswa (BL) and Okhla (OL) landfills respectively [10]

7. Literature Review

S.N	Paper Title	Journal	Author	Summary
1	Feasibility, health and economic impact of generation biogas from human excreta for the state of Tamil Nadu, India	Renewable and Sustainable Energy Reviews, 2017	Arunaachalam Muralidharan	Authors used human excreta to produce biogas, hence tackling both fuel and sanitation simultaneously by giving a short description about Tamil Nadu: Population density; Health & sanitation; culture; common village layout. A constant supply of bio fuel everyday can be provided with 13.1 million ton LPG replaced per year. Thus 75% of current consumption f LPG in India can be replaced by generation of biogas using human excretion. Challenges and concerns: like social taboo; risk of pathogens. Hence concluding biogas generation from human excreta can full fill future demand in India but require involvement of Government.

2	Quantification and Characterization of size-segregated Bioaerosols at municipal solid waste dumping site in Delhi	International Conference on Solid Waste Management, 5IconSWM 2016	Smita Agarwal et. al.	Delhi has four landfill sites: Bhalswa (North Delhi), Ghazipur (East Delhi), Okhla (South Delhi) and Narela-Bawana. And 3 are overflowing. The size-segregated aerosol were carried out during 2013-14 at Okhla landfill and collected on quart filters using an Andersen impactor sampler having 9 stages. And a low-volume handy sampler was also used to measure total cultural microbial concentrations. It was found that major concentration peaks during winter due to high PM concentration. Low during summer due to high temperature and solar radiation. Concentration (cfu/m3) = Number of colonies/flow rate (m^3/min)*sample duration (min). Bacterial range : 8.3*10^5 to 1.8*10^7 (cfu/m^3) Fungal range : 1.2*10^3 to 2.5*10^5 (cfu/m^3) Size distribution analysis shows that bacteria were mostly abundant in fine particle size. The result confirmed that close to the waste dumping ground bacterial and fungal aerosol may deposit in the nasal and oral cavities.
3	Biogas system in rural China : Upgrading from decentralized to centralized?	Renewable and Sustainable Energy Reviews, 2017	Qiu Chen et. al.	Author tried to balance the development of the two systems to enhance the contrasting strengths of them and reducing their weaknesses and discussed the construction of house hold base biogas digester from 1973 to 2014 and its output. Due to urbanization, large scale migration towards major city had lead to shortage in rural areas and thus increasing the labor cost. Hence life span of the household based biogas digesters is becoming shorter and shorter. The installation of centralized biogas plant in rural areas is beneficial since storage and transportation cost is fulfilled by the centralized body. Since energy demand of rural households is increasing constantly, the concept of centralized biogas plant is more successfully than decentralized plant. With the help of govt. policies and individual effort, enhancement of both centralized and decentralized biogas plant.
4	Mechanical characterization of municipal solid waste from two waste dumps at Delhi, India	Waste Management, 2017	Smita Agarwal et. al.	Author calculated the physical and mechanical properties of the emplaced municipal solid waste (MSW) located at Delhi. Ranging age – 2 to 12 years. Mechanical compressibility and shear strength were collected using a 300*300 mm direct shear box. Compression ratio varied from .11 to .17 Near the surface MSW consists of 60-80 % soil like or soil sized fraction. Solid waste specimens prepared with fibrous materials exhibited a continued increase of shear stress without any peak stress or failure even up to 55 mm displacement.

5	Municipal Solid Waste Management in India-Current State and Future Challenges : A Review	International Journal of Engineering Science and Technology (IJEST), 2012	Rajendra Kumar Kaushal et al.	Author estimated quantity and characteristics of municipal solid waste and its forecasting for successful management plan. This study analyses the changing trend in MSW quantities over the last 4 decades. Describing the relation between the amount of municipal waste and the GDP of the country. Higher the GDP, higher the quantity of waste produced. Studies have indicated that for every Indian Rs. 1000 increase in income the solid waste generation increases by one kilogram per month [23]. In low-income group of cities municipal bodies dispose MSW in low lying areas in the outskirt of the city and fill these areas one after the other haphazardly due to limited knowledge and awareness regarding contamination, waste reduction techniques and other aspects of MSW management. It suggests that MSW components like paper, plastic, glass are having the increasing trend from 4.1%, 0.7% and 0.4% respectively in 1971 to8.18%, 9.22% and 1.01% respectively in 2005.
6	Selection of appropriate biogas upgrading technology-a review of biogas cleaning, upgrading and utilization	Renewable and Sustainable Energy Reviews, 2015	Qie Sun et al.	Author discussed the various biogas technology, cleaning, upgrading and utilization for proper site-specific and dependence on biogas utilization. Biogas cleaning technology. Water scrubbing: water used as a solvent. Methane solubility is in water is much lower than that of CO and H_2. Water scrubbing can achieve a CH_4 purity of 80-99% depending on non-condensable gases like N_2 and O_2.Cryogenic Separation: Due to different condensing temperature of CH_4 and CO_2. CO_2 can be separated from CH_4 through condensation and distillation. This process needs to compress raw gas to high pressure up to 200bar, a large amount of energy is required, accounting to 5-10% of bio methane produced.
7	A Review on Organic Waste to Energy Systems in India	Bioresource Technology, 2017	Hiya Dhar et al.	The author identified the potential from the organic waste to energy conservation in India and its associated challenges. The biomass energy from firewood, crop residues, animal dung still used in rural parts of developing countries like India to meet the energy requirement. In India, the organic waste fraction varies between 40 to 60 % of the total solid waste streams. The calorific value of urban solid waste is 7.3 MJ/Kg and the moisture content is around 47% (Annnepu 2012). According to the database of Swachh Bharath Mission (SBM) only 21.45% of the MSW is treated and the remaining is still going to the landfills (SBM 2016). 2nd largest producer of paddy. India is producing 98 million metric ton (MT) of paddy and around 130 million MT of rice straw out of which 50% is used as fodder and remaining is thrown away.

8	Municipal solid waste: Generation, composition and GHG emissions in Bangalore, India	Renewable and Sustainable Energy Reviews, 2017	T.V. Ramachandra et. al.	Municipal solid waste in developing countries mainly consists of degradable materials (>70%), which plays a significant role in GHG emission in urban localities. Study revealed that per capita waste generation is about 91.01 g/day with per capita organic waste generation of 74 g/person/day. The household per capita waste generation was positively related with income and education levels, while negative related with family size. More than 90% of the MSW generated in India is disposed on land in unscientific and unacceptable way. Out of which major portion (70-75%) of municipal solid waste is organic. Most of the households (64%) in the study area have the facility of door to door collection of solid waste and about 78.34% of city population do not segregate the waste at source (households) Study also revealed that 82% of household wastes were organic. According to this study, the total organic waste generated from houses was 231.01 tons/year and total emission is about 604.8 t/year.
9	Does the construction of biogas plants affect local property values?	Economic Letters, 2017	Marco Modica	Although biogas is considered a renewable source of energy, the social acceptability of biogas plants is controversial due to resistance from communities. Author investigated this claim by using evidence from the housing market of Piedmont, where 167 biogas plants were opened between 2006 to 2015. The social acceptance of biogas plant is controversial due to resistance from local communities because of smell, heavy traffic and noise. Also opening of biogas plants had no effect on house prices.
10	A review on current status of municipal solid waste management in India	Journal of Environmental Sciences, 2015	Neha Gupta et. al.	Mismanagement of municipal solid waste can cause adverse environmental impacts, public health risk and other socio-economic problem. Author presented an overview of current status of solid waste management in India which can help the competent authorities responsible for municipal solid waste management and researchers to prepare more efficient plans. Treatment and disposal of municipal solid waste management. The composition of municipal solid waste at generation sources and collection points was determined on a wet weight basis and it consists mainly of a large organic fraction (40%–60%), ash and fine earth (30%–40%), paper (3%–6%) and plastic, and glass and metals (each less than 1%). The C/N ratio ranges between 800 and 1000 kcal/kg. In urban areas, the major fraction of municipal solid waste is compostable materials (40%-60%) and inerts (30%-50%).

11	Sustainable Municipal Solid Waste Management in India: A Policy Agenda	Procedia Environmental Sciences, 2016	Shyamala Mani and Satpal Singh	The Author reviewed the comprehensive review of the solid waste management system and most importantly highlight some major points of the government's policies and programs required to overcome the challenges of municipal solid waste management in India. 1. Greater emphasis on recycling is required. ULBs especially smaller ones can easily form cooperatives etc. with waste collectors initiatives and collectives for recycling rather than tie-ups with large companies for setting up incineration plants. 2. Recycling technologies for making structural from plastics or converting waste plastics and non-recyclables to Light Diesel Oil as mentioned in the Planning Commission report 2014 should be delineated and their standards prescribed. This is feasible in smaller ULBs also. 3. Much greater emphasis on ULBs working with waste pickers collectives and NGOs for setting up door to door collection of segregated waste, Material Recovery Facilities (MRFs) and secondary segregation while providing personal protective equipment (PPE) to them is required.
12	An empirical model for prediction of household solid waste generation rate – A case study of Dhanbad, India	Waste Management, 2017	Atul Kumar and S.R.Samadder	Accurate prediction of the quantity of household solid waste generation is very much essential for effective management of municipal solid waste (MSW).Author proposed, two models that established the relationships between the household solid waste generation rate and the socioeconomic parameters. The results of the two models showed that the coefficient of determinations (R2) were 0.782 for biodegradable waste generation rate and 0.676 for non-biodegradable waste generation rate using the selected independent variables. Validation of the developed models with a new set of data indicated a good fit for actual prediction purpose with predicted R2 values of 0.76 and 0.64 for biodegradable and non-biodegradable MSW generation rate respectively.
13	Qualitative determination of energy potential and methane generation from municipal solid waste (MSW) in Dhanbad (India)	Energy, 2017	Drake Mboowa et.al.	Methane generation from waste landfills is one of the biggest contributors to global warming. The purpose of this study was twofold: (i) to investigate methane concentration from Municipal Solid Waste (MSW) at three landfills in Dhanbad city, India (ii) to evaluate the amount of energy that could be recovered based on the MSW characteristics if it were to be incinerated. Results from MSW characterization revealed that the main component of Dhanbad MSW is organic waste, which made up to 75% of the waste by weight. Methane concentration and moisture content from Railway station (site

				1) and Memco-more (site 2 and site 3) measured as 140.53, 18.18 and 20.28 ppm methane/g waste and 25.49, 3.40 and 2.96% dry weight respectively. The calorific value for the waste samples ranged between 10.7 to 13.0 MJ/kg.
14	Innovation in solid waste management through Clean Development Mechanism in India and other countries	Process Safety and Environmental Protection, 2016	Aditee Potdar et. al.	Author discussed the potential of Clean Development Mechanism (CDM) for Municipal Solid Waste (MSW) management in India. About 350 MSW projects are implemented through CDM across 56 countries. The maximum MSW management CDM projects are implemented in China (102) followed by Brazil (45) and Mexico (28). About 22 CDM projects for MSW management are registered in India. The annual estimated emission reduction from these 22 projects is 1,467,371 ton CO2e/annum. The highest numbers of projects are registered in the state of Delhi. These CDM projects use technologies viz. refuse-derived fuel palletization, landfill capture, biogas generation, and composting. Though physical, operational regulatory, and socio-economic challenges exist for MSW management, India should make the best use of the opportunity that CDM offers and develop projects to benefit in terms of finance, technology and sustainable development.
15	Energy recovery from waste in India: An evidence-based analysis.	Sustainable Energy Technologies and Assessments, 2017	J.D.Nixon et. al.	The uptake of Waste-to-Energy (WTE) in India has not been successful and the majority of plants have failed to sustain operations. There is a lack of detailed on-the-ground research examining the causes of plant failures and the issues regarding the Waste to Energy supply chain. Local government officers, industry practitioners and academics involved in waste management in India were consulted. Quantitative data were collected on three case study plants: an incinerator, a gasification plant and a plant co-firing waste with coal. In comparison to the European incinerators, the WtE plants in India had a low capital cost (around 1–2 million €/MW), but total particulate matter emissions were a hundred times higher, ranging from 65-75 mg/Nm^3.
16	Municipal solid waste as a valuable renewable energy resource: a worldwide opportunity of energy recovery by using Waste-To-Energy Technologies.	9th International Conference on Sustainability in Energy and Buildings, SEB-17, 5-7 July 2017, Chania, Crete, Greece	Diego Moya et. al.	The generation rate of Municipal Solid Waste is expected to increase to 2.2 billion tonnes per year by 2025 worldwide. Author assessed the different waste-to-energy technologies developed to date. This work is divided into four groups: biological treatment of waste; thermal treatment of waste; landfill gas utilization; and bio refineries. Furthermore, integrated solid waste management systems with waste-to-energy technologies are studied and some worldwide examples are provided.

The improper disposal of municipal waste has a serious and dangerous impact on a wide range of areas. Garbage thrown in the street or in open spaces creates a public health hazard, while waste dumped near rivers, lakes and streams contaminates the water supply. Rubbish that is burned in the open rather than disposed of properly creates pollution and releases toxic fumes into the environment. Non-biodegradable materials thrown into open drains make their way into the sewerage system, clogging pipelines and damaging infrastructure. The hazards posed by the dumping of untreated hospital and industrial waste are even greater, with the release of pathogens and toxic compounds posing a grave threat not just to human life but also to plants and animals. Garbage dumped in the countryside is not simply an eyesore; entire landscapes are ruined and unique habitats for flora and fauna are lost.

There are various methods for mitigating the effect of municipal solid waste has been discussed in the above papers, the methods which are discussed in the papers above are landfills, incineration, composting, RDF, recycling and waste to energy plants. Some of these methods are being applied across various cities and better government policies across the country and better implication of these policies.

In order to evaluate existing knowledge gaps and barriers associated with institutional, social, legal and financial aspects, four major issues should be covered which are as follows: (1) lack of integrated sustainable waste management concepts in academic programmes, (2) lack of demonstration activities concerning SWM technologies and services, (3) lack of institutional capacity (referring to trained personnel, insufficient funds, policy constraints) and (4) insufficient access to know-how.

So the main obstacles in the success of these waste management methods are the government policies and their implications across the country.

8. Results and Discussions

While SWM was completely neglected in past and is now receiving some attention at the highest levels in several cities and states, many are lagging behind and several have not bothered to make any improvement at all. The national and state solid waste management missions need to be created to ensure that municipal authorities perform their obligatory duties regularly in compliance with MSW Rules 2000 within a predetermined time frame.

Though levels of SWM services in the country have started improving on account of active monitoring by the Supreme Court of India, the central and state pollution control boards and finance and technical support from proactive state governments there still is a long way to go. Save the formalization of the MSW Rules 2000, state action in this regard at many levels has been fairly uninspiring thus far. While MSW Rules 2000 is a watershed document in India's history of effective SWM, implementation issues still overwhelm the system.

A comprehensive nationwide program needs to be actively implemented keeping in mind possible future scenarios. Key individuals within the governing system and the bureaucracy need to be educated to the magnitude of the crisis and motivated to use their power to influence the system and appropriately channelize resources to actively promote effective and progressive SWM projects and practices.

From the above data we can see that waste management faces many problems in India to improve the situation the most important is to educate the population of India about potential negative effects of solid waste. The people should be educated to realize the importance of source segregation at generation point as biodegradables, inert and recyclable material for proper waste management. Moreover, manufacturing of non-recyclable polyethylene bags should be banned or research should be initiated to develop biodegradable polyethylene. Protection of groundwater contamination from leachate percolation from open dump/landfill site should be made compulsory. Appropriate technological solution should be adopted to achieve this goal.

9. Conclusion

The following conclusions were made**.**

1. There are various waste management techniques in India some of the main techniques used are landfills, incineration, composting, RDF, recycling and waste to energy plants.
2. Though there are these methods present but their implementation has not been done properly in our country.
3. The main concerns for the development of these methods across the country are the government policies and their implementation across the country.

References

[1] Hoornweg D. and Bhada-Tata P. What a waste: a global review of solid waste management, 2012.

[2] Ali M. (2006). Editorial: urban waste management as if people matter. Habitat International 30, p. 729–730.

[3] Zaman A.U., & Lehmann S. Urban growth and waste management optimization towards 'zero waste city'. City, Culture and Society 2, (2011). p. 177–187.

[4] Chan J.K.H. The ethics of working with wicked urban waste problems: The case of Singapore's Semakau Landfill. Landscape and Urban Planning 154, 2016, p. 123–131.

[5] Cheng H & Hu Y. Municipal solid waste(MSW) as a renewable source of energy: current and future practices in China. Bioresour Technol, 2010, p. 16–24.

[6] 6.Lino F.A.M., Ismail K.A.R. Energy and environmental potential of solid waste in Brazil. Energy Policy 39, 2011, p. 3496-3502.

[7] Singh R.P., Tyagi V.V., Allen T, Ibrahim M.H., Kothari R. An overview for exploring the possibilities of energy generation from municipal solid waste (MSW) in Indian scenario. Renew Sustain Energy Rev 15, 2011, p. 4797-4808.

[8] Census of India, 2011, General Population Table.

[9] Singh S & Mani S. Sustainable Municipal Solid Waste Management in India: A Policy Agenda, Procedia Environmental Sciences 35, 2016, p. 150-157.

[10] Chakraborty M, Sharma C, Pandey J, Gupta P.K. Assessment of energy generation potentials of MSW in Delhi under different technological options, Energy Conversion and Management 75, 2013, p. 249–255.

[11] https://www.sswm.info/sites/default/files/toolbox/UNEP%2020 02%20Sanitary%20Landfill.jpg, accessed on 08.11.2017, 20:00.

[12] Cleveland C.J., Morris C.G., Dictionary of energy. Elsevier, 2006.

[13] Tan S.T., Ho W.S., Hashim H., Lim J.S., Ho W.S., Lee C.T., Yan J.Y. Energy and emissions benefits of renewable energy derived from municipal solid waste: analysis of low carbon scenario in Malaysia. Applied Energy 136, 2016, p. 797-804.

[14] Manual on municipal solid waste management, Central Public Health and Environmental Engineering Organisation (CPHEEO), Ministry of Urban Development, New Delhi; 2000.

[15] MGBEPS (Malaysian Green and Blue Environment Protection Society), MSW Manual; 2012. [Cited 01.03.13]. <http://greenbluegroup.blogspot.in/2012/04/ incinerator-for-municipal-solid-waste.html>.

[16] Karagiannidis A, Bilitewski B, Tchobanoglous G, Themelis NJ, Wittmaier M, Tsatsarelis T. Waste to energy: on thermal treatment & energetic utilization of solid wastes. In: Golish TV, editor. Waste management research trends. New York: Nova Science Publisher, 2008, p. 105–163.

[17] http://www.epd.gov.hk/epd/sites/default/files/epd/english/environmentinhk/waste/prob_solutions/images/IWMF_shcematic_eng.jpg, accessed on 08.11.2017, 20:03.

[18] Roman P., Martinez M.M., Pantoja A. Farmer's compost handbook. Experiences in Latin America. Santiago FAO, 2015.

[19] Sikka P. Energy from MSW RDF Pelletization a Pilot Indian Plant; 2000. [Cited 01.03.13]. <http://www.environmental-expert.com/articles/energy-from-msw-rdf-pelletization-a-pilot-indian-plant-2080/view-comments>.

[20] http://www.climatetechwiki.org/sites/climatetechwiki.org/files/images/extra/composting_process.jpg, accessed on 20:04, 04/11/2017.

[21] http://biophysics.sbg.ac.at/waste/organic/step-1.jpg, accessed on 20:40, 04/11/2017.

[22] http://global.kawasaki.com/en/upload_images/img_rdf.jpg, accessed on 22:50,04/11/2017.

[23] Nixon J.D., Dey P.K., Ghosh S.K., Energy recovery from waste in India: An evidence-based analysis, In Sustainable Energy Technologies and Assessments, Volume 21, 2017, Pages 23-32, ISSN 2213-1388.